Table 23. Studies of Gaseous Pollutants Only*

Citation	Design	Study Location	Study Period	Study Sample	Pollutants	Health Outcomes	Summary of Published Findings
Choi KS, Inoue S, Shinozaki R. 1997. Air pollution, temperature, and regional differences in lung cancer mortality in Japan. Arch Environ Health 52:160–168.	Ecologic	Japan 47 prefectures	1970–1990	Lung cancer deaths	NO_2, SO_2, traffic emissions	Mortality from lung cancer	Regional differences in age-adjusted rates of lung cancer death were explained by NO_2 and temperature. In one region, higher temperatures increased the effect of NO_2 on lung cancer deaths compared with NO_2 alone.
Duki MI, Sudarmadi S, Suzuki S, et al. 2003. Effect of air pollution on respiratory health in Indonesia and its economic cost. Arch Environ Health 58:135–143.	Cross sectional	Indonesia Jakarta Bandar Lampung	1996–1997	16,663 pairs of junior high school students and their mothers	NO_2	Prevalence rate of respiratory symptoms, savings in mean direct out-of-pocket expense per capita for treatment and in decreased average work/school days lost per capita	The prevalence rate of respiratory symptoms was significantly associated with NO_2. It was estimated that the reduction of NO_2 to a proposed concentration of 25 ppb would yield savings of U.S.$6.80 to U.S.$7.90 in mean direct out-of-pocket expense per capita for treatment of respiratory symptoms and would decrease average work/school days lost per capita by 3.1 to 5.5 days.
Honda Y, Nitta H, Ono M. 2003. Low level carbon monoxide and mortality of persons aged 65 or older in Tokyo, Japan, 1976–1990. J Health Sci 49:454–458.	Time series	Japan Tokyo	1976–1990	Elderly residents (≥65 yr)	SO_2, NO_2, NO, CO, oxidant	Mortality (all-cause)	Higher CO concentrations were associated with increased mortality rates in people ≥65 yr even when the concentrations were lower than Japan's National Air Quality Standard.
Hong YC, Leem JH, Lee KH, et al. 2005. Exposure to air pollution and pulmonary function in university students. Int Arch Occup Environ Health 78:132–138.	Cross sectional	South Korea Incheon	2002	298 healthy university students	NO_2	Lung function	Personal exposure to NO_2 was significantly affected by traffic-related air pollution and was associated with decreased lung function.
Jang AS, Yeum CH, Son MH. 2003. Epidemiologic evidence of a relationship between airway hyperresponsiveness and exposure to polluted air. Allergy 58:585–588.	Cross sectional	South Korea Yeocheon	—	670 children (10–13 yr)	Chemical-factory emissions (O_3, SO_2, NO_2, hydrogen fluoride)	Airway hyperresponsiveness	Airway hyperresponsiveness increased significantly in schoolchildren who had normal lung function but lived near a chemical factory.

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Kwon HJ, Lee SG, Jee YK, et al. 2007. Effects of personal exposure to nitrogen dioxide on peak expiratory flow in asthmatic patients [in Korean]. J Prev Med Pub Health 40:59–63.	Panel	South Korea	—	28 patients with asthma	NO_2 (daily personal exposure)	PEF	Personal NO_2 exposure had no apparent effect on PEF.
Lee BE, Ha EH, Park HS, et al. 2005. Air pollution and respiratory symptoms of school children in a panel study in Seoul [in Korean]. J Prev Med Pub Health 38:465–472.	Panel	South Korea Seoul	2003	177 elementary school students	NO_2, SO_2, CO	Daily respiratory symptoms	Exposure to air pollution affected daily respiratory symptoms in schoolchildren.
Lee YJ, Lee JT, Ju YS, et al. 2001. Short-term effect of air pollution on respiratory disease in Seoul: A case–crossover study [in Korean]. Korean J Prev Med 34:253–261.	Case–crossover	South Korea Seoul	1995–1996	Residents of Seoul	O_3	Daily emergency-department visits	An increase of 30 ppb in O_3 concentrations was associated with a 91% increase in emergency-department visits for respiratory diseases.
Lee YL, Lin YC, Lee YC, et al. 2004. Glutathione S-transferase P1 gene polymorphism and air pollution as interactive risk factors for childhood asthma. Clin Exp Allergy 34:1707–1713.	Cross sectional	Southern Taipei,China	2001	156 schoolchildren in 4th–9th grades (61 cases, 95 controls)	SO_2, NO_x	GSTP1-105 genotype, asthma	A significant gene–environment interaction was found between GSTP1-105 alleles and air pollution. A dose–response relationship was found between asthma and air pollution in children with the Ile-105 genotype but not in those without it.
Liao Y, Wang W, Zhang L. 2007. GIS-based study on urban NO_x induced health risk assessment [in Chinese]. Progress in Geography 26:44–52.	Health impact	China Fuzhou	—	Residents of Fuzhou	NO_x	Health risks	NO_x exposure, distribution, and health risks were classified using GIS (geographic information systems) models to assess the health risks of urban air pollution.
Lin RS, Sung FC, Huang SL, et al. 2001. Role of urbanization and air pollution in adolescent asthma: A mass screening in Taiwan. J Formos Med Assoc 100:649–655.	Cross sectional	Taipei,China	1995–1996	1,018,031 middle school students	Urban air pollution	Prevalence of asthma	Using questionnaire data, the study found that adolescents living in highly polluted areas were more likely to have asthma than those living in areas with little or no pollution. Boys were more likely to be affected than girls.

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Lin S-L, Lin K-H. 2007. The valuation of health effects caused by stationary sources-related SO_2 emissions: The adaptation of impact pathway approach in Taiwan. Environ Monit Assess 131:163–176.	Health impact	Taipei,China Taichung	2002	—	SO_2	Estimated cost of health effects caused by SO_2	For the Taichung area, the cost of health effects caused by SO_2 in 2002 was estimated at U.S.$28.5 million (range, U.S.$6.61 million to U.S.$72.0 million). Based on 2002 emission data, the cost was estimated to range from U.S.$0.56 to U.S.$7.38 per kg of SO_2.
Mi YH, Norback D, Tao J, et al. 2006. Current asthma and respiratory symptoms among pupils in Shanghai, China: Influence of building ventilation, nitrogen dioxide, ozone, and formaldehyde in classrooms. Indoor Air 16:454–464.	Cross sectional	China Shanghai	2000	1414 schoolchildren	Outdoor NO_2, O_3; classroom NO_2, O_3, CO_2, formaldehyde, mold	Asthma, respiratory symptoms	Outdoor NO_2 was associated with current asthma. Outdoor O_3 was negatively associated with daytime breathlessness. Indoor pollutants and mold were associated with asthma prevalence, incidence of attacks, and use of asthma medication.
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	Residents of India	SO_2, NO_x, CO	Death, asthma, respiratory disease	Air pollution was found to have severe effects on respiratory health in India. Fossil-fuel emissions were the source of the air pollution.
Odajima H, Baba M. 1987. Relation between the incidence of mediastinal and subcutaneous emphysema complicating bronchial asthma and the concentration of NO_2 in the atmosphere [in Japanese]. Nihon Kyobu Shikkan Gakkai Zasshi 25:1278–1283.	Ecologic	Japan Tokyo	1973–1984	Cases of moderate to severe asthma attacks	NO_2, NO_x	Mediastinal and subcutaneous emphysema, asthma	No relationship was found between the incidence of mediastinal and subcutaneous emphysema complications in cases of bronchial asthma and concentrations of NO_2 and NO_x. A significant relationship was found between the incidence of these two complications and cases of asthma attack when NO_2 concentrations were between 0.02 and 0.04 ppm.
Pal K, Bhavnanl HV, Mathur HB. 1982. Air pollution survey of Baroda with special reference to sulphur dioxide and its effects. Indian J Environ Protect 2:96–101.	Cross sectional	India Baroda	—	Residents of Baroda	SO_2	Self-reported health status, prevalence of respiratory symptoms	An increased prevalence of eye irritation, running nose, cough, and tuberculosis was reported in areas with high concentrations of SO_2.

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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 sectional	India Ahmedabad	—	Shop-keepers	NO_x	Lung function (VC, FEV_1, $FEF_{25–75}$)	Shopkeepers in an area of heavy air pollution from traffic, where NO_x concentrations were higher than the threshold limit value, had significant impairment of FEV_1 and $FEF_{25–75}$.
Sawaguchi T, Toro K, Sawaguchi A. 1997. Sudden infant death syndrome in relation to climatic temperature, climatic humidity and air pollution in Japan. Rom J Leg Med 5:21–24.	Time series	Japan 47 prefectures	1988–1994	—	SO_2, NO_2	Sudden infant death syndrome (SIDS)	No correlation was found between NO_2 concentrations, SO_2 concentrations, temperature, or humidity and the incidence of SIDS.
Shima M, Adachi M. 2000. Effect of outdoor and indoor nitrogen dioxide on respiratory symptoms in schoolchildren. Int J Epidemiol 29:862–870.	Cross sectional	Japan 7 communities in Chiba prefecture	1991–1993	842 children (9–10 yr)	NO_2	Morbidity (respiratory symptoms)	Questionnaire responses and other data revealed a significant association between outdoor NO_2 concentrations and wheezing and asthma but no association between indoor NO_2 and these respiratory symptoms. Girls might be more susceptible to indoor NO_2 than boys are.
Shinkura R, Fujiyama C, Akiba S. 1999. Relationship between ambient sulfur dioxide levels and neonatal mortality near the Mt. Sakurajima volcano in Japan. J Epidemiol 9:344–349.	Time series	Japan Yamashita public health district of Kagoshima City	1978–1988	Residents	SO_2	Neonatal mortality	Increased ambient SO_2 concentrations were associated with excess neonatal mortality. However, more studies are needed to elucidate the mechanisms.
Son JY, Kim H, Lee JT, et al. 2006. Relationship between the exposure to ozone in Seoul and the childhood asthma-related hospital admissions according to the socioeconomic status [in Korean]. J Prev Med Pub Health 39:81–86.	Time series	South Korea Seoul	2002	Children with asthma	O_3	Hospital admissions for childhood asthma	Exposure to air pollution did not affect the health of all individuals equally, suggesting that biologic sensitivity and socioeconomic status might be confounding factors.

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Tango T. 1994. Effect of air pollution on lung cancer: A Poisson regression model based on vital statistics. Environ Health Perspect 102(Suppl 8):41–45.	Time series	Japan Tokyo	1972–1988	Women from 23 wards of Tokyo (40–79 yr)	SO_2, NO_2	Mortality (lung cancer)	NO_2 was positively associated with the rate of increase in mortality from lung cancer. The association with SO_2 was weaker.
Tri-Tugaswati A, Yasuo K. 1996. Effect of air pollution on respiratory symptoms of junior high school students in Indonesia. Southeast Asian J Trop Med Public Health 27:792–800.	Cross sectional	Indonesia Jakarta and surrounding cities	1994	16,187 junior high school students	NO_2	Respiratory symptoms (cough, phlegm, wheezing)	When a self-administered questionnaire was used, it was found that the prevalence of persistent cough was 7.3% to 10.8% and that of persistent phlegm, 4.5% to 5.0%. A significant relation was found between NO_2 exposure and the prevalence of cough, phlegm, and wheezing.
Voorhees AS, Araki S, Sakai R, et al. 2000. An ex post cost-benefit analysis of the nitrogen dioxide air pollution control program in Tokyo. J Air Waste Manag Assoc 50:391–410.	Health impact	Japan Tokyo	1973–1994	All residents of Tokyo	Costs and benefits of Tokyo's NO_2-control programs (1973–1994)	Medical costs, cost of lost wages	Net estimates of the averted medical costs of pollution-related phlegm and sputum in adults and of respiratory illnesses in children were U.S.$6.08 billion and U.S.$775 million, respectively. Net estimates of the averted costs of lost wages in workers and in mothers caring for sick children were U.S.$6.33 billion and U.S.$833 million, respectively.
Wang LH, Xu X, Zhou L, et al. 1994 Relationship between air pollution and changes in children's peak expiratory flow (PEF) [in Chinese]. Chin J Environ Health 11:243–246.	Panel	China Beijing	1993	60 children (9–11 yr)	SO_2, NO_2	Lung function	Ambient NO_2 and coal burning at home were significantly associated with a decrease in children's PEF. Personal exposure to SO_2 was also associated with a decrease in PEF.
Wu BZ, Hsieh LL, Sree U, et al. 2006. Determination and impact of volatile organics emitted during rush hours in the ambient air around gasoline stations. J Air Waste Manag Assoc 56:1342–1348.	Health impact	Taipei,China Taoyuan	2002	People living near 4 gas stations	VOCs	Cancer risk, general health hazard	Higher concentrations of methyl tertiary butyl ether (MTBE) and benzene were observed in proximity to gas stations without vapor-recovery systems. Using published estimates of cancer risk, it was estimated that 8- to 12-fold increases in cancer of the reproductive system would occur among those living near such gas stations. The general-health-hazard index was 3.8 times higher for those living near such gas stations.

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Yanagisawa Y, Nishimura H, Matsuki H, et al. 1986. Personal exposure and health effect relationship for NO_2 with urinary hydroxyproline to creatinine ratio as indicator. Arch Environ Health 41:41–48.	Cross sectional	Japan Suginami Aikawa (communities in Tokyo)	1980–1981	800 mothers of primary school children	NO_2 (personal exposure)	Ratio of urinary hydroxyproline to creatinine (as a biomarker of NO_2)	The ratio of urinary hydroxyproline to creatinine was positively correlated with personal exposure to NO_2 and with cigarette smoking. The effects of NO_2 were independent of cigarette smoking.
Yang CY, Yu ST, Chang CC. 2002. Respiratory symptoms in primary schoolchildren living near a freeway in Taiwan. J Toxicol Environ Health A 65:747–755.	Cross sectional	Taipei,China Taipei	1999	6190 primary school students	NO_2	Chronic respiratory symptoms (asthma, cough, wheezing, dyspnea, bronchitis), upper respiratory symptoms (sneezing, nose irritation, running nose, stuffy nose)	Data from a parental questionnaire indicated that a freeway surrounding a child's school might not be associated with an increased risk for respiratory symptoms.
Zhang YH, Huang W, London SJ, et al. 2006. Ozone and daily mortality in Shanghai, China. Environ Health Perspect 114:1227–1232.	Time series	China Shanghai	2001–2004	Residents of Shanghai	O_3	Mortality (all-cause, respiratory disease, cardiovascular disease)	O_3 was significantly associated with increased all-cause and cardiovascular-disease mortality in the cold season but not in the warm season. In a whole-year analysis, an increase of 10 μg/m^3 in two-day average O_3 (lag 1) corresponded to increases of 0.45% (95% CI, 0.16–0.73%), 0.53% (95% CI, 0.10–0.96%), and 0.35% (95% CI, –0.40 to 1.09%) in all-cause nonaccidental, cardiovascular-disease, and respiratory-disease mortality, respectively. In the cold season, these estimates increased to 1.38% (95% CI, 0.68–2.07%), 1.53% (95% CI, 0.54–2.52%), and 0.95% (95% CI, –0.71 to 2.60%), respectively.

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