Table 6. South Korea Studies*

Citation	Design	Study Location	Study Period	Study Sample	Exposure	Health Outcome	Summary of Published Findings
Cho B, Choi J, Yum YT. 2000. Air pollution and hospital admissions for respiratory disease in certain areas of Korea. J Occup Health 42:185–191.	Time series	Ulsan, Daejeonm suwon	1996	3.6 million people	TSP, SO_2, NO_2, CO, O3	Morbidity: hospitalizations for RespD (bronchial asthma, COPD, bronchitis)	In a single-pollutant model, respiratory admissions were highly correlated with CO in a residential area and with NO_2 and CO in a mixed residential-industrial area. In a multipollutant model, TSP and CO were significantly associated in the residential area, but CO alone was significantly associated in the industrial area.
Ha EH, Hong YC, Lee BE, et al. 2001. Is air pollution a risk factor for low birth weight in Seoul? Epidemiology 12:643–648.	Cohort	Seoul	1996-1997	276,763 births	TSP, SO_2, NO_2, CO, O3	Birth weight (first and third trimester only)	CO, NO_2, SO_2, and TSP exposure during the first trimester of pregnancy were risk factors for low birth weight. O3 exposure during the last trimester was a risk factor, but other pollutants were not. Third trimester correlations were not significant.
Ha EH, Lee JT, Kim H, et al. 2003. Infant susceptibility of mortality to air pollution in Seoul, South Korea. Pediatrics 111:284–290.	Time series	Seoul	1995–1999	1045 children (1 mo–1 yr), 67,597 people (2–64 yr), 100,316 elders (> 65 yr)	TSP, SO_2, NO_2, CO, O3	Daily total and respiratory mortality (excluding accidental deaths)	CO level was significantly associated with respiratory mortality, especially for individual 2–64 yr.
Hong YC, Lee JT, Kim H, et al. 2002. Air pollution: A new risk factor in ischemic stroke mortality. Stroke 33:2165–2169.	Time series	Seoul	1991–1997	10.6 million people	TSP, SO_2, NO_2, CO, O_3	Daily stroke mortality (both hemorrhagic and ischemic)	TSP, SO_2, NO_2, CO, and O_3 levels were significantly associated with mortality from ischemic stroke but not from hemorrhagic stroke.
Hong YC, Lee JT, Kim H, et al. 2002. Effects of air pollutants on acute stroke mortality. Environ Health Perspect 110:187–191.	Time series	Seoul	1995–1998	10.6 million people	PM10, SO_2, NO_2, O_3, CO	Mortality: stroke	Estimated increase in stroke mortality was 1.5% for each interquartile increase in PM10 and ozone in the same day. Stroke mortality increased 3.1% for NO_2, 2.9% for SO_2, and 4.1% for CO in a 2-day lag for each interquartile increase in single-pollutant models. The elderly and women were more susceptible to particulate pollutants.
Hong YC, Leem JH, Ha EH, et al. 1999. PM10 exposure, gaseous pollutants, and daily mortality in Inchon, South Korea. Environ Health Perspect 107:873–878.	Time series	Inchon	1995–1996	2.4 million residents	PM10, SO_2, NO_2, CO, O_3	Mortality: CVD, RespD, and total deaths not due to accidents or violence	PM10 was significantly associated with total, CVD, and RespD mortality. SO_2 and CO were significantly associated with RespD mortality. O_3 was not significantly or linearly associated with any cause of mortality. The combined index of PM10, NO_2, SO2, and CO seemed to better explain exposure–response relation.

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Hong YC, Leem JH, Ha EH. 1999. Air pollution and daily mortality in Inchon, Korea. J Korean Med Sci 14:239–244.	Time series	Inchon	1995	2.2 million residents	TSP, PM_{10}, SO_2, NO_2, CO, O_3	Daily mortality (total)	Total daily mortality increased 1.2% for each 10 μg/m^3 increase in 6-day moving average of TSP and 1.2% for each 10 μg/m^3 increase in 5-day moving average of PM_{10}. Associations between gaseous pollutants and total mortality were not significant. The relative risk of death increased at particulate levels well below the Korean Air Quality Standard at that time.
Hong YC, Leem JH, Lee KH, et al. 2005. Exposure to air pollution and pulmonary function in university students. Intl Arch Occup Environ Health 78:132–138.	Cross section	Inchon	2002	298 healthy university students	NO_2	Lung function and respiratory symptoms	The concentrations of personal exposure to NO_2 were significantly influenced by traffic-related air pollution and were associated with decreased lung function.
Hwang SS, Cho SH, Kwon HJ. 2005. Effects of the severe asian dust events on daily mortality during the spring of 2002, in Seoul, Korea [in Korean]. J Prev Med Pub Health 38:197–202.	Time series (episode)	Seoul	2002	All Seoul residents	PM_{10}	Daily mortality (all, respiratory, cardiovascular, other causes)	The Asian dust events were found to be weakly associated with all-cause mortality. However, the association between dust events and deaths from respiratory causes was stronger.
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 section	Yeochon	–	670 children (10–13 yr)	Chemical factory emission (O_3, SO_2, NO_2, hydrogen fluoride)	Airway hyperresponsiveness	There was a significant increase of airway hyperresponsiveness in schoolchildren with normal lung function but living near a chemical factory.
Kim H, Kim Y, Hong YC. 2003. The lag-effect pattern in the relationship of particulate air pollution to daily mortality in Seoul, Korea. Int J Biometeorol 48:25–30.	Time series	Seoul	1995–1999	Residents	PM_{10}	Daily mortality for non-accidental deaths, respiratory disease, cardiovascular disease, and cerebrovascular disease	Respiratory mortality was more affected by air pollution level on the day of death, whereas cardiovascular deaths were more affected by the previous day's air pollution level. Cerebrovascular deaths were simultaneously associated with the air pollution levels of the same day and the previous day.
Kim H, Lee JT, Hong YC, et al. 2004. Evaluating the effect of daily PM– variation on mortality. Inhal Toxicol 16(Suppl 1):55–58.	Time series	Seoul	1997–2001	Residents	PM_{10}	Daily mortality	Daily mortality was associated with daily mean and daily deviation of PM_{10} level. Each 42.11 μg/m^3 increase of daily mean level of PM10 was associated with 2.1% increase of additional daily mortality. Each 11.93 μg/m^3 increase in daily standard deviation of PM_{10} was also associated with 2.5% increased risk of death.
Kim JH, Lim DH, Kim JK, et al. 2005. Effects of particulate matter (PM10) on the pulmonary function of middle-school children. J Korean Med Sci 20:42–45.	Panel	Inchon, Ganghwa	2000	368 middle-school students	PM_{10}	Lung function	The difference of PM_{10} levels between March and December was significant. The March lung function test values were significantly lower than the December values.

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Kim SY, Lee JT, Hong YC, et al. 2004. Determining the threshold effect of ozone on daily mortality: an analysis of ozone and mortality in Seoul, Korea, 1995–1999. Environ Res 94:113–119.	Time series	Seoul	1995–1999	–	PM_{10}, SO_2, NO_2, O_3, CO	Daily mortality for nonaccidental and nonviolent causes	Each 21.5 ppb increase of daily 1-h maximum ozone, lagged by 1 day, was associated with a 2.6% increase in relative risk in total mortality in a linear model, and a 3.4% increase in a threshold model.
Kwon HJ, Cho SH, Chun Y, et al. 2002. Effects of the Asian dust events on daily mortality in Seoul, Korea. Environ Res 90:1–5.	Time series (episode)	Seoul	1995–1998	Residents	Asian dust event (PM_{10}, SO_2, NO_2, CO, O_3)	Daily mortality for all causes, cardiovascular diseases, and respiratory diseases	Asian dust events were positively, but not significantly, associated with respiratory and CVD mortality. The relationship was stronger in people ≥ 65 yr.
Kwon HJ, Cho SH, Nyberg F, et al. 2001. Effects of ambient air pollution on daily mortality in a cohort of patients with congestive heart failure. Epidemiology 12:413–419.	Time series, Case crossover	Seoul	1994–1998	1807 patients with congestive heart failure and admission history	PM_{10}, SO_2, NO_2, CO, O_3	Mortality (nonaccidental)	An increase in PM_{10} was associated with an increase in mortality from congestive heart failure. CO, NO_2, SO_2, and O_3 were also associated with mortality from congestive heart failure.
Kwon HJ, Cho SH.1999. Air pollution and daily mortality in Seoul [in Korean]. Korean J Prev Med 32:191–199.	Time series	Seoul	1991–1995	Residents	TSP, SO_2, NO_2, O_3	Daily mortality for all causes, cardiovascular diseases, and respiratory diseases	Daily death counts were associated with ambient level of O3 1-day before, NO_2 1-day before, TSP 2-days before, and SO_2 2-days before. This effect was stronger in persons ≥ 65 yr. The effect on respiratory and cardiovascular deaths was also stronger than all-cause deaths.
Kwon HJ, Hong YC, Lee JT, et al. 2002. Effects of ambient air pollution on daily mortality in a cohort of patients with stroke in Seoul, Korea. Epidemiology 13:S170.	Case crossover	Seoul	1994–2000	Patients with stroke	PM_{10}, SO_2, NO_2, CO, O_3	Daily mortality for all causes	Daily mortality in stroke patients was associated with the increased air pollution.
Lee BE, Ha EH, Park HS, et al. 2003. Exposure to air pollution during different gestational phases contributes to risks of low birth weight. Hum Reprod 18:638–643.	Cohort	Seoul	1996–1998	388,105 singleton births	PM_{10}, SO_2, NO_2, CO	Term low birth weight	CO exposure in the 2nd to 5th months of pregnancy, PM_{10} exposure in the 2nd and 4th months, and SO_2 and NO_2 exposure in the 3rd to 5th months were associated with increased risk of low birth weight.
Lee BE, Ha EH, Park HS, Kim H, Lee HJ, Lee YK, Lee SJ, Hong YC. 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	Seoul	2003	177 elementary-school students	NO_2, SO_2, CO	Daily respiratory symptoms	Exposure to air pollution affected the daily respiratory symptoms in school children.

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Lee JT, Kim H, Cho YS, et al. 2003. Air pollution and hospital admissions for ischemic heart diseases among individuals 64+ years of age residing in Seoul, Korea. Arch Environ Health 58:617–623.	Time series	Seoul	1997–1999	Residents (> 64 yr)	PM_{10}, SO_2, NO_2, CO, O_3	Hospital admissions for ischemic heart disease	Daily ambient SO_2 level was significantly associated with ischemic heart disease–related hospital admissions of the elderly during summer months, as well as with daily variation of air pollutant levels.
Lee JT, Kim H, Hong YC, et al. 2000. Air pollution and daily mortality in seven major cities of Korea, 1991–1997. Environ Res 84:247–254.	Time series	7 cities	1991–1997	22.8 million residents	TSP, SO_2, O_3	Mortality (nonaccidental)	Increase of 50 ppb of SO_2 corresponded to 1–12% more deaths depending on the city assessed. Estimated risk of death by SO_2 was unaffected by adding TSP and O_3 to the model. All ambient levels were below Korea's standards at that time.
Lee JT, Kim H, Song H, et al. 2002. Air pollution and asthma among children in Seoul, Korea. Epidemiology 13:481–484.	Time series	Seoul	1997–1999	6436 children (< 15 yr)	PM_{10}, SO_2, NO_2, CO, O_3	Hospitalization due to asthma attack	Estimated relative risk of asthma hospitalization was 1.07 for PM_{10}, 1.11–1.16 for SO2, NO_2, O3, and CO. In the multipollutant models, control for other pollutants did not change the estimated effect for O_3 or NO_2.
Lee JT, Lee SI, Shin D, et al. 1998. Air particulate matters and daily mortality in Ulsan, Korea [in Korean]. Korean J Prev Med 31:82–90.	Time series	Ulsan	1991–1994	Residents	TSP, SO_2	Daily mortality for nonaccidental cause	Each 100 μg/m^3 increase of TSP was associated with a 3% increase in mortality.
Lee JT, Schwartz J. 1999. Reanalysis of the effects of air pollution on daily mortality in Seoul, Korea: A case-crossover design. Environ Health Perspect 107:633–636.	Case crossover	Seoul	1991–1995	12 million people	TSP, SO_2, O3	Mortality (nonaccidental)	Increases in atmospheric SO_2 level were associated with increases in daily mortality across different analysis methods.
Lee JT, Shin D, Chung Y. 1999. Air pollution and daily mortality in Seoul and Ulsan, Korea. Environ Health Perspect 107:149–154.	Time series	Seoul, Ulsan	1991–1995	10.8 million people in Seoul, 0.8 million in Ulsan	TSP, SO_2, O_3	Mortality (nonaccidental)	An increase of 50 ppb of SO_2 significantly increased all-cause mortality by 12–13%. A 50-ppb increase of O_3 increased all-cause mortality by 14% and 4.6%, respectively, in the 2 study cities.
Lee JT. 2003. Association between air pollution and asthma-related hospital admissions in children in Seoul, Korea: A case-crossover study [in Korean]. Korean J Prev Med. 36:47–53.	Case crossover	Seoul	–	Asthmatic children (< 15 yr)	PM10, SO_2, NO_2, CO, O_3	Hospital admission for asthma	These findings also support the hypothesis that air pollution, at levels below the current ambient air quality standards of Korea, is harmful to asthmatic children.
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	Seoul	1995–1996	Residents	O_3	Daily emergency room visits	A 30 ppb increase of O_3 level was associated with a 91% increase in emergency room visits for respiratory diseases.

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Leem JH, Kaplan BM, Shim YK, Pohl HR, Gotway CA, Bullard SM, Rogers JF, Smith MM, Tylenda CA. 2006. Exposures to air pollutants during pregnancy and preterm delivery. Environ Health Perspect 114:905–910.	Cohort	Incheon	2001–2002	52,113 singleton births	PM_{10}, SO_2, NO_2, CO,	Preterm delivery	Exposure to relatively low concentrations of air pollution (according to current air quality standards) during pregnancy may contribute to an increased risk of preterm delivery.
Leem JH, Lee JT, Kim DG, et al.1998. Short-term effect of air pollution in hospital visits for respiratory disease in Seoul [in Korean]. Korean J Prev Med 10:333–342.	Time series	Seoul	1995–1996	Residents	PM_{10}, O_3	Hospital visits for respiratory problems	A 50 μg/m^3 increase of PM_{10} 2 days before and an 0.01 ppm increase of O_3 were associated with 11% and 8% increased risk of respiratory hospital visits, respectively.
Park H, Lee B, Ha EH, et al. 2002. Association of air pollution with school absenteeism due to illness. Arch Pediatr Adolesc Med 156:1235–1239.	Time series	Seoul	1996-1999	1264 schoolchildren	PM_{10}, SO_2, NO_2, CO, O_3	Illness-related school absenteeism	Exposures to PM_{10}, SO_2, and O_3, but not NO_2 were associated with illness-related absenteeism from elementary school.
Park JW, Lim YH, Kyung SY, An CH, Lee SP, Jeong SH, Ju YS. 2005. Effects of ambient particulate matter on peak expiratory flow rates and respiratory symptoms of asthmatics during Asian dust periods in Korea. Respirology 10:470–476.	Panel	Incheon	2002	64 asthmatic subjects (16–75 yr)	PM_{10}, SO_2, NO_2, CO, O_3	PEF, respiratory symptoms	Asian dust events affected the respiratory symptoms of subjects with bronchial asthma. Elevated PM_{10} might be one of the aggravating factors.
Son JY, Kim H, Lee JT, Kim SY. 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	Seoul	2002	Asthmatic children	Ozone	Hospital admissions (childhood asthma)	Exposure to air pollution does not affect the health status of all individuals equally, suggesting that biological sensitivity and socioeconomic status are potential confounding factors.