

**Table 5-4. Effects of short-term exposure to SO<sub>2</sub> on respiratory symptoms among children.**

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED ODDS RATIO (95% CI) <sup>a</sup>
<b>UNITED STATES</b>							
Schildcrout et al. (1965) Multicity, North America Seattle, WA; Baltimore, MD; St. Louis, MS (Nov 1993–Aug 1995); Denver, CO; San Diego, CA (Nov 1993–Jul 1995); Toronto, ON (Dec 1993–Jul 1995); Boston, MA (Jan 1994–Sep 1995) No SO <sub>2</sub> data available in Albuquerque, NM	Asthmatic children (n = 990)	24-h avg: 2.2-7.4 (range of city-specific medians)	NR	NR	NR	75th: 3.1, 10.7 90th: 4.4, 14.2 (range in city specific estimates)	Asthma symptoms: SO <sub>2</sub> alone: 1.04 (1.00, 1.08), 3-day sum SO <sub>2</sub> & NO <sub>2</sub> : 1.04 (1.00, 1.09), 3-day sum SO <sub>2</sub> & PM <sub>10</sub> : 1.04 (0.99, 1.08), 3-day sum
Schwartz et al. (2006) Multicity, United States Watertown, MA (Apr-Aug 1985); Kingston-Harriman, TN; St. Louis, MO (Apr-Aug 1986); Steubenville, OH; Portage, WI (Apr-Aug 1987); Topeka, KS (Apr-Aug 1988)	Children in grades 2-5 (n = 1,844)	24-h avg: 4.1 (median)	NR	NR	NR	75th: 8.2 90th: 17.9 Max: 81.9	Cough incidence: SO <sub>2</sub> alone: 1.15 (1.02-1.31), 4-day avg SO <sub>2</sub> , adjusting for PM <sub>10</sub> : 1.08 (0.93, 1.25), 4-day avg SO <sub>2</sub> , adjusting for NO <sub>2</sub> : 1.09 (0.94, 1.30), 4-day avg
Neas et al. (1995) Uniontown, PA Summer 1990	Children in grades 4-5 (n = 83)	12-h avg: 0.2 5.9 overnight 14.5 daytime	NR	NR	IQR: 11.1	Max: 44.9	Evening cough: 1.19 (1.00, 1.42), lag 12-h
Delfino et al. (2003) Los Angeles, CA Nov 1999 – Jan 2000	Hispanic children w/asthma, age 10-16 yrs (n=22)	1-h max: 7.0 ppb	NR	NR	2-26	90th: 11.0	OR or symptom score >1: 1-h max SO <sub>2</sub> : Lag 0: 1.31 (1.10, 1.55) OR or symptom score >2: 1=h max SO <sub>2</sub> : Lag 0: 1.37 (0.87, 2.18)
Mortimer et al. (2002) Multicity, United States Bronx, NY; East Harlem, NY; Baltimore, MD; Washington, DC; Detroit, MI; Cleveland, OH; Chicago, IL; St. Louis, MO (Jun-Aug 1993)	Asthmatic children, aged 4-9 (n = 846)	3-h avg: 22 (shown in figure)	NR	NR	0-75 ppb (shown in graph)	NR	Asthma symptoms: SO <sub>2</sub> alone (8 cities): 1.19 (1.06, 1.35), lag 1-2 SO <sub>2</sub> , adjusting for O <sub>3</sub> & NO <sub>2</sub> (7 cities): 1.19 (1.04, 1.37), lag 1-2 SO <sub>2</sub> , adjusting for O <sub>3</sub> , NO <sub>2</sub> & PM <sub>10</sub> (3 cities): 1.23 (0.94, 1.62), lag 1-2
<b>EUROPE</b>							
Timonen and Pekkanen (1997) Kuopio (urban and suburban) Finland Winter 1994	Children 7-12 yrs with asthma or cough symptoms (n = 169)	24-h avg: 2.3	NR	NR	NR	75th: 2.7 Max: 12.3	Upper respiratory symptoms: 2.71 (1.19, 6.17), lag 0 3.17 (1.21, 8.78), lag 1

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED ODDS RATIO (95% CI) <sup>a</sup>
Ward et al. (2002) Birmingham and Sandwell, UK Jan-Mar 1997 May-Jul 1997	Children, age at enrollment 9 yrs (n = 162)	24-h avg: Median 5.4, Winter 4.7, Summer	NR	NR	2, 18 Winter 2, 10 Summer	NR	Cough: Winter: 0.59 (0.25, 1.40), Summer: 0.90 (0.49, 1.66)  Shortness of breath: Winter: 0.59 (0.32, 1.09), Summer: 0.81 (0.30, 2.17)  Wheeze: Winter: 0.79 (0.38, 1.63), Summer: 0.77 (0.28, 2.08)  (7-day avg lag for above)
Segala et al. (2004) Paris, France Nov 1992-May 1993	Children 7-15 yrs with physician-diagnosed asthma (n = 84)	24-h avg: 8.3 (5.2)	NR	NR	1.7-32.2	NR	Prevalent asthma: 1.32 (1.08, 1.62), lag 0 1.26 (0.93, 1.71), lag 1  Prevalent shortness of breath: 1.17 (0.53, 2.62), lag 0 1.21 (0.99, 1.49) lag 1  Incident asthma 1.73 (1.15, 2.60), lag 0 1.60 (1.01, 2.53), lag 1  Incident wheeze 1.22 (0.95, 1.58), lag 0 1.13 (0.68, 1.88), lag 1
Boezen et al. (1998) Amsterdam and Meppel (urban and rural), the Netherlands Winter 1993-1994	Children 7-11 yrs, with and w/o BHR and high serum concentrations of total IgE (n = 632)	24-h avg: Means: 1.7, 8.7; Medians: 1.4, 8.3 (range in city-specific estimates)	NR	NR	1.9, 23.6	NR	Among children with BHR and relatively high serum total IgE - lower respiratory symptoms: 1.27 (1.09, 1.49), lag 0 1.25 (1.06, 1.48), lag 1 1.69 (1.26, 2.28), 5-day avg
Roemer et al. (1993) Wageningen, the Netherlands Winter 1990-1991	Children 6-12 yrs with chronic respiratory conditions (n = 73)	24-h avg 1-h max	NR	NR	0, 40.4 (24-h avg)	Max: 56.5 (1-h max)	Asthma attack: 1.79 (1.35, 2.38), 7-day avg Wheeze: 1.97 (1.42, 2.72), 7-day avg  Waken with symptoms: 1.79 (1.12, 2.87), 7-day avg  Shortness of breath: 1.48 (1.06, 2.07), 7-day avg  Cough: 1.97 (1.03, 3.77), 7-day avg
Hoek and Brunekreft (1993) Wageningen, the Netherlands Winter 1991	Children 7-11 yrs, nonurban area (n = 112)	24-h avg	NR	NR	NR	Max: 40.4	Cough: 1.22 (0.20, 7.39), lag 0 0.25 (0.04, 1.65), lag 1 3.67 (0.002, 7.331.974), 7-day avg  Lower resp symptoms: 1.82 (0.14, 24.3), lag 0 0.33 (0.02, 6.05), lag 1 0.005 (0.0, 44.7), 5-day avg

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED ODDS RATIO (95% CI) <sup>a</sup>
Van der Zee et al. (1999) Urban and nonurban areas, The Netherlands 3 winters, 1992-1995	Children 7-11 yrs, with and without chronic respiratory symptoms (n = 633)	24-h avg: 1.4, 8.8 (range in city-specific medians)	NR	NR	NR	Max: 6.5, 58.5 (range in city-specific maximums)	Lower respiratory symptoms, urban, SO <sub>2</sub> alone: 1.22 (1.01, 1.46), lag 0 1.14 (0.95, 1.38), lag 1 1.34 (0.98, 1.82), 5-day avg  Lower respiratory symptoms, urban, SO <sub>2</sub> , adjusting for PM <sub>10</sub> : 1.18 (0.96, 1.45), lag 0 1.03 (0.83, 1.27), lag 1 1.08 (0.72, 1.63), 5-day avg  Lower respiratory symptoms, nonurban: 0.94 (0.79, 1.12), lag 0 0.94 (0.78, 1.13), lag 1 1.10 (0.75, 1.63), 5-day avg  Cough, urban: 0.93 (0.84, 1.03), lag 0 1.08 (0.98, 1.19), lag 1 1.08 (0.89, 1.30) 5-day avg  Cough, nonurban: 1.05 (0.96, 1.15), lag 0 0.98 (0.90, 1.08), lag 1 1.04 (0.83, 1.30), 5-day avg

<sup>a</sup>24-h avg SO<sub>2</sub> and 12-h avg SO<sub>2</sub> standardized to 10- ppb incremental change; 3-h avg SO<sub>2</sub> standardized to 20-ppb incremental change; and 1-h max SO<sub>2</sub> standardized to 40-ppb incremental change.

NR = Not Reported

BHR = Bronchial Hyperresponsiveness

**Table 5-5. Effects of short-term SO<sub>2</sub> exposure on emergency department visits and hospital admissions for respiratory outcomes.**

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED EXCESS RISK (95% CI) <sup>a</sup>
<b>EMERGENCY DEPARTMENT VISITS – ALL RESPIRATORY</b>							
<b>UNITED STATES</b>							
Wilson et al. (2005) Portland, ME Jan 1998-Dec 2000 Manchester, NH Jan 1996-Dec 2000	≈ 84,000 ED visits	1-h max: Portland: 11.1 (9.1) Manchester: 16.5 (14.7)	NR	NR	NR	NR	Portland: All ages: 8% (3, 11) 0-14: -2.6% (-10.3, 2.7) 15-64: 11% (5.4, 13.9) 65+: 16.8% (8.2, 25.8)  Manchester: All ages: 0% (-3, 5) 0-14: 0% (8, 8) 15-64: 0% (-3, 5) 65+: 8% (-6, 23)
Tolbert et al. (2007) Atlanta, GA Jan 1993-Dec 2004	> 1,000,000 ED visits for all respiratory causes	1-h max: 14.9	NR	NR	1.0 - 149.0 75th: 20.0 90th: 35.0	75th: 20.0 90th: 35.0	0.75% (-0.75, 2.3)
Peel et al. (2005) Atlanta, GA Jan 1993-Aug 2000	484,830 ED visits, all ages from 31 hospitals	1-h max: 16.5 (17.1)	NR	NR	NR	90th: 39.0	1.6% (-0.6, 3.8)
<b>EUROPE</b>							
Atkinson et al. (1999b) London, UK Jan 1992-Dec 1994	98,685 ED visits from 12 hospitals	24-h avg: 8.0 (2.9)	NR	NR	2.8, 30.9 50th: 7.4 90th: 11.7	All Ages: 4.2% (1.1, 7.4) 0-14: 9.0% (4.4, 13.8) 15-64: 4.0% (-0.3, 8.5) 65+: -2.7% (-5.4, 3.3)	
<b>EMERGENCY DEPARTMENT VISITS – ASTHMA</b>							
<b>UNITED STATES</b>							
Ito et al. (2007) New York, NY Jan 1999-Dec 2002	Asthma ED visits, all ages from 11 hospitals	24-h avg: 7.8 (4.6)	NR	NR	NR 75th: 10 95th: 17	35% (23%, 51%)	
NY Department of Health (2006) Bronx & Manhattan, NY Jan 1999-Dec 2000	Asthma ED visits among children from 22 hospitals	24-h avg : 11 (7.2)	NR	NR	NR	NR 5-day moving average: Manhattan: -1% (-12, 12) Bronx: 11% (6, 17)	
Jaffe et al. (2003) Cincinnati, OH Cleveland, OH Columbus, OH Jul 1991-Jun 1996	4,416 ED visits for asthma, age 5-34	24-h avg: Cincinnati: 13.5 (9.4) Cleveland: 14.7 (9.5) Columbus: 4.2 (3.2)	NR	NR Cincinnati: 0.6, 49.6 Cleveland: 0.98, 62.8 Columbus 0, 21.4	NR	Cincinnati: 17.3% (4.7, 30.8) Cleveland: 3.1% (-3.8, 10.7) Columbus: 13.1% (-14.2, 48.6) All Cities: 6.2% (0.5, 11.6)	

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED EXCESS RISK (95% CI) <sup>a</sup>
Wilson et al. (2005) Portland, ME Jan 1998-Dec 2000 Manchester, NH Jan 1996-Dec 2000	≈ 84,000 ED visits	1-h max: Portland: 11.1 (9.1) Manchester: 16.5 (14.7)	NR	NR	NR	NR	Portland: All ages: 11.0% (0.0, 19.7) 0-14: 5.4% (-12.8, 25.8) 15-64: 11% (0, 22.7) 65+: 11.0% (-15.2, 48.4)  Manchester: All ages: 5.4% (-2.6, 16.8) 0-14: 19.7% (-2.6, 51.8) 15-64: 2.7% (-7.8, 13.9) 65+: 11.0% (-28.8, 77.2)
Peel et al. (2005) Atlanta, GA Jan 1993-Aug 2000	Asthma ED visits, all ages and 2-18 yrs from 31 hospitals	1-h max: 16.5 (17.1)	NR	NR	NR	90th: 39.0	0.2% (-3.2, 3.4)
<b>CANADA</b>							
Stieb et al. (2000) St. John, New Brunswick Retrospective: Jul 1992-June 1994 Prospective: Jul 1994-Mar 1996	19,821 ED visits	1-h max: 23.8	NR	NR	Max: 161.0	85th: 62.0	Respiratory visits: 6.6% (P=0.003), Lag 5
<b>EUROPE</b>							
Atkinson et al. (1999b) London, UK Jan 1992-Dec 1994	98,685 ED visits from 12 hospitals	24-h avg: 8.0 (2.9)	NR	NR	2.8, 30.9	50th: 7.4 90th: 11.6	All ages: 7.4% (2.3, 12.8) 0-14: 15.0% (7.1, 23.5) 15-64: 6.3% (-0.8, 13.8)
Hajat et al. (1999) London, UK Jan 1992-Dec 1994	General practitioner visits for asthma	24-h avg: All yr: 8.0 (2.9) Warm: 7.7 (2.4) Cool: 8.3 (3.4)	NR	NR	NR	All yr: 90th: 11.6 Warm: 90th: 10.7 Cool: 90th: 12.4	All ages: 6.6% (1.3, 11.9) 0-14: 6.6% (-1.0, 14.7) 15-64: 5.2% (-1.5, 12.3) 65+: 7.2% (-4.3, 20.1)
Boutin-Forzano et al. (2004) Marseille, France Apr 1997-Mar 1998	549 ED visits for asthma	24-h avg: 8.5	NR	NR	0.0, 35.3	NR	3-49 yrs: 0.6% (-1.4, 2.7)
Galan et al. (2003) Madrid, Spain Jan 1995-Dec 1998	4,827 ED visits for asthma	24-h avg: 8.9 (5.8)	NR	NR	1.9, 45.6	50th: 7.0 75th: 11.8 90th: 16.5	All ages: 4.9% (-4.2, 15.0)

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED EXCESS RISK (95% CI) <sup>a</sup>
Tenias et al. (1998) Valencia, Spain Jan 1993-Dec 1995	734 ED visits for asthma	24-h avg: 10.0 Cold: 11.9 Warm: 8.2 1-h max: 21.2 Cold: 24.3 Warm: 18.1	NR	NR	NR	24-h avg: 50th: 9.8 75th: 12.9 95th: 16.0 1-h max: 50th: 19.6 75th: 27.1 95th: 35.8	> 14 yrs: 13.9% (-7.0, 39.4)
Sunyer et al. (1997) Multicity, Europe Barcelona, Spain; Helsinki, Finland; Paris, France; London, UK Jan 1986-Dec 1992	All ED visits for asthma	24-h avg: Barcelona: 15.4 Helsinki: 6.0 London: 11.6 Paris: 8.6	NR	NR	Barcelona: 0.8, 60.2 Helsinki: 1.1, 35.7 London: 3.4, 37.6 Paris: 0.4, 82.3	NR	0-14 yrs: 3.2% (-0.2, 6.8) 15-64: 0.2% (-2.2, 2.6)
Castellsague et al. (1995) Barcelona, Spain Jan 1986-Dec 1989	ED visits for asthma from 4 hospitals	24-h avg: Summer: 15.3  Winter: 19.5	NR	NR	NR	Summer: 50th: 13.5 75th: 20.3 95th: 30.8 Winter: 50th: 18.4 75th: 25.2 95th: 35.3	15-64 yrs, summer: 5.5% (-2.1, 13.8) 15-64 yrs, winter: 2.1% (-4.2, 9.0)
<b>HOSPITAL ADMISSIONS – ALL RESPIRATORY</b>							
<b>UNITED STATES</b>							
Schwartz (1995) New Haven, CT Tacoma, WA Jan 1988-Dec 1990	≈ 13,470 Hospital admissions, ages 65+	24-h avg: New Haven: 29.8 Tacoma: 16.8	NR	NR	NR	New Haven: 75th: 37.6 90th: 59.8 Tacoma: 75th: 21.1 90th: 27.8	New Haven: 1.6% (1.1, 2.6) Tacoma: 3.2% (0.5, 6.2)
Schwartz et al. (1996) Cleveland, OH 1988-1990	Hospital admissions, ages 65+	24-h avg: 35	NR	NR	NR	75th: 45 90th: 61	1.007 (0.997, 1.016), Lag 0-1
<b>CANADA</b>							
Fung et al. (1995) Vancouver, BC Jun 1995-Mar 1999	≈ 41,000 respiratory admissions for elderly (65+ yrs)	24-h avg: 3.46 (1.82)	NR	NR	0.0, 12.5	NR	12.6% (4.1, 22.0)
Cakmak et al. (2006b) Multicity, Canada Calgary, Edmonton, Halifax, London, Ottawa, Saint John, Toronto, Vancouver, Windsor, Winnipeg Jan 1993-Dec 2000	> 200,000 hospital admissions for all respiratory causes	24-h avg: 4.6	NR	NR	2.8, 10.2	NR	2.4% (1.1, 3.9)
Yang et al. (2003) Vancouver, BC Jan 1986-Dec 1998	Respiratory hospital admissions among young children (< 3 yrs) and elderly (≥65 yrs)	24-h avg: 4.84 (2.84)	NR	NR	NR	75th: 6.25 100th: 24.00	< 3 yrs: 3% (-6, 15) 65+ yrs: 5.8% (0.0, 11.9)

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*Burnett et al. (2001) Toronto, ON Jan 1980-Dec 1994	All respiratory admissions for young children (< 2 yrs)	1-h max: 11.8	NR	55	NR	75th: 15 95th: 32 100th: 110	11% (-0.3, 23.6)
Luginaah et al. (2005) Windsor, ON Apr 1995-Dec 2000	All respiratory admissions ages 0-14, 15-64, and 65+ from 4 hospitals	1-h max: 27.5 (16.5)	NR	NR	0, 129	NR	All ages, female: 2.1% (-0.7, 5.0) All ages, male: -2.5% (-5.3, 0.5)  0-14, female: 5.6% (0.6, 10.9) 0-14, male: -2.5% (-6.8, 1.9)  15-64, female: 1.6% (-3.7, 7.2) 15-64, male: -4.5% (-8.4, 5.8)  65+, female: 1.5% (-2.6, 5.8) 65+, male: -3.1% (-7.5, 1.5)
<b>AUSTRALIA</b>							
Barnett et al. (2005) Multicity, Australia/New Zealand  Auckland, Brisbane, Canberra, Christchurch, Melbourne, Perth, Sydney  Jan 1998-Dec 2001	All respiratory hospital admissions	24-h avg: Auckland: 4.3 Brisbane: 1.8 Christchurch: 2.8 Sydney: 0.9  1-h max: Brisbane: 7.6 Christchurch: 10.1 Sydney: 3.7  NA in Auckland, Canberra, Melbourne, and Perth	NR	NR	24-h avg: Auckland: 0, 24.3 Brisbane: 0, 8.2 Christchurch: 0, 11.9 Sydney: 0, 3.9  1-h max: Brisbane: 0, 46.5 Christchurch: 0.1, 42.1 Sydney: 0.1, 20.2		1-4 yrs: 5.1% (0.0, 9.1) 5-14: 3.7% (-9.9, 19.5)
Petroeshevsky et al. (2001) Brisbane, Australia Jan 1987-Dec 1994	33,710 hospital admissions	24-h avg: 4.1 1-h max: 9.2	NR	NR	NR	NR	All ages: -5.9% (-12.4, 1.1) 0-14: 8.0% (-2.9, 20.1) 15-64: -21.6% (-34.4, -6.2)
<b>EUROPE</b>							
Oftedal et al. (2003) Drammen, Norway Jan 1994-Dec 2000	All respiratory hospital admissions	24-h avg: 1.1 (0.8)	NR	NR	NR	NR	All ages: 71.8% (15.5, 152.7)
Fusco et al. (2001) Rome, Italy Jan 1995-Oct 1997	All respiratory hospital admissions	24-h avg: 3.4 (2.2)	NR	NR	NR	50th: 3.0 75th: 4.5	All age: 1.6% (-4.9, 8.8) 0-14: -2.7% (-4.6, 10.8)
Llorca et al. 2005 Torrelavega, Spain Jan 1992-Dec 1995	Hospital admissions from one hospital	24-h avg: 5.0 (6.3)	NR	NR	NR	NR	All ages: 1.0% (-2.8, 4.7)

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Anderson et al. 2001 West Midlands conurbation, UK Oct 1994-Dec 1996	Hospital admissions stratified by age	24-h avg: 7.2 (4.7)	NR	NR	1.9, 59.8	90th: 12.3	All ages: 1.4% (-0.8, 3.8) 0-14: 5.1% (1.6, 8.7) 15-64: -1.0% (-5.3, 3.7) 65+: -2.2% (-5.4, 1.2)
Atkinson et al. 1999a London, UK Jan 1992-Dec 1994	165,032 hospital admissions	24-h avg: 8.0 (2.9)	NR	NR	2.8, 30.9	50th: 7.4 90th: 11.7	All ages: 3.0% (0.4, 5.6) 0-14: 7.7% (3.8, 11.7) 15-64: 2.8% (-1.2, 7.0) 65+: 3.3% (-0.1, 6.9)
Schouten et al. 1996 Multicity, The Netherlands Amsterdam, Rotterdam Apr 1977-Sep 1989	All respiratory hospital admissions	24-h avg: Amsterdam: 10.5 Rotterdam: 15.0 1-h max: Amsterdam: 24.4 Rotterdam: 37.2	NR	NR	NR	NR	Amsterdam: 15-64: -2.3% (-5.5, 0.9) 65+: 0.2% (-2.8, 3.3) Rotterdam: 15-64: -2.9% (-6.2, 0.5)
Spix et al. 1998 Multicity, Europe London, UK; Amsterdam & Rotterdam, the Netherlands; Paris, France; Milan, Italy Jan 1977-Dec 1991	All respiratory hospital admissions	24-h avg: London: 10.9 Amsterdam: 7.9 Rotterdam: 9.4 Paris: 8.6 Milan: 24.8	NR	NR	NR	NR	15-64 yrs: 0.5% (-0.4, 1.3) 65+: 1.1% (0.3, 2.4)
Dab et al. 1996 Paris, France Jan 1987-Sep 1992	Hospital admissions from 27 hospitals	All yr: 24-h avg: 11.2 1-h max: 22.5  Warm season 24-h avg: 7.6 1-h max: 16.1  Cold season 24-h avg: 15.1 1-h max: 29.4	NR	NR	NR	All yr: 24-h avg: 99th: 50.0 1-h max: 99th: 87.5  Warm season 99th: 18.5 1-h max: 99th: 50.3  Cold season 24-h avg: 99th: 56.0 1-h max: 99th: 100.9	All ages: 1.1% (0.1, 2.1)
Ponce de Leon et al. (1996) London, England 1987-1988 1991-1992	19,901 hospital admissions	24-h avg: 12.1 (4.7)	NR	NR	NR	50th: 11.7 75th: 14.7 90th: 17.7 95th: 20.3	All ages: 0.8 (-0.7, 2.4) 0-14: 0.9 (-1.5, 3.3) 15-64: 2.0% (-0.5, 4.7) 65+: 2.0% (-0.3, 4.4)
Walters et al. 1994 Birmingham, United Kingdom Jan 1988-Dec 1990	All respiratory hospital admissions	24-h avg: All year: 14.7 Spring: 16.1 Summer: 14.2 Autumn: 15.4 Winter: 12.9	NR	NR	NR	Max: 47.5	All ages: Summer: 1.5% (0.3, 2.7) Winter: 4.5% (2.3, 6.5)

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED EXCESS RISK (95% CI) <sup>a</sup>
Hagen et al. (2000) Drammen, Norway Jan 1994-Dec 1997	Hospital admissions for all respiratory outcomes	24-h avg: Winter: 21 Spring: 18 Summer: 15 Autumn: 19  Number of monitors: 1	NR	NR	Winter: 11, 33 Spring: 13, 29 Summer: 5, 24 Autumn: 16, 23	NR	All ages: 92.8% (16.8, 218.8)
<b>LATIN AMERICA</b>							
Gouveia and Fletcher (2000) São Paulo, Brazil Nov 1992-Sep 1994	All respiratory hospital admissions	24-h avg: 6.9 (3.4)	NR	NR	1.2, 22.9	50th: 6.2 75th: 8.3 95th: 13.5	<5 yrs: 3.7% (-1.7, 9.4)
<b>ASIA</b>							
Wong et al. (1999) Hong Kong Jan 1994-Dec 1995	Hospital admissions from 12 hospitals	24-h avg: 6.4	NR	NR	1.0, 25.7	75th: 9.4	0-4 yrs: 1.3% (-2.4, 4.9) 5-64: 2.1% (-1.1, 5.7) 65+: 6.2% (3.2, 9.9)
<b>HOSPITAL ADMISSIONS – ASTHMA</b>							
<b>UNITED STATES</b>							
Lin et al. (2004a) New York (Bronx County) Jun 1991-Dec 1993	2,629 cases; 2,236 controls, aged 0-14 years	Cases: 24 h avg: 16.78  Controls: 24 h avg: 15.57	NR	NR	2.88-66.35	NR	18% [10, 29.8]
Sheppard et al. (1999; reanalysis 2003) Seattle, WA Jan 1987-Dec 1994	7,837 asthma hospital admissions for patients <65 yrs	24-h avg: 8	NR	NR	NR	75th: 10.0 90th: 13.0	<65 yrs: 4.0% (-4.0, 10.3)
<b>CANADA</b>							
*Burnett et al. (1999) Toronto, ON Jan 1980-Dec 1994	Asthma hospital admissions	24-h avg: 5.35	NR	NR	NR	75th: 8 95th: 17 100th: 57	1.9% (-0.2, 4.0)
Lin et al. (2003) Toronto, ON Jan 1981-Dec 1993	7,319 asthma hospital admissions among 6-12 yr olds	24-h avg: 5.36 (5.90)	NR	NR	0, 57.0	75th: 8.00	Boys: 0% (-7.1, 7.2) Girls: 5.8% (-4.3, 16.1)
<b>AUSTRALIA</b>							
Barnett et al. (2005) Multicity, Australia/New Zealand Auckland, Brisbane, Canberra, Christchurch, Melbourne, Perth, Sydney Jan 1998-Dec 2001	All respiratory hospital admissions	24-h avg: Auckland: 4.3 Brisbane: 1.8 Christchurch: 2.8 Sydney: 0.9  NA in Canberra, Melbourne, and Perth  1-h max: Brisbane: 7.6 Christchurch: 10.1 Sydney: 3.7  NA in Auckland, Canberra, Melbourne, and Perth	NR	NR	24-h avg: Auckland: 0, 24.3 Brisbane: 0, 8.2 Christchurch: 0, 11.9 Sydney: 0, 3.9  1-h max: Brisbane: 0, 46.5 Christchurch: 0.1, 42.1 Sydney: 0.1, 20.2	NR	1-4 yrs: 6.4% (-7.8, 22.5) 5-14: 6.2% (-10.1, 25.4)

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED EXCESS RISK (95% CI) <sup>a</sup>
Petroeshevsky et al. (2001) Brisbane, Australia Jan 1987-Dec 1994	33,710 hospital admissions	24-h avg: 4.1 1-h max: 9.2	NR	NR	NR	NR	All ages: 8.0% (3.0, 13.1) 0-4: 22.4% (8.7, 37.7) 5-14: 21.1% (-5.5, 55.1) 15-64: 3.3% (-10.5, 11.8) 65+: 12.1% (1.9, 23.4)
<b>EUROPE</b>							
Fusco et al. (2001) Rome, Italy Jan 1995-Oct 1997	All respiratory hospital admissions	24-h avg: 3.4 (2.2)	NR	NR	NR	50th: 3.0 75th: 4.5	All ages: -5.7% (-23.2, 15.9) 0-14: -9.7% (-34.6, 25.2)
Atkinson et al. (1999a) London, England Jan 1992-Dec 1994	165,032 hospital admissions	24-h avg: 8.0 (2.9)	NR	NR	2.8, 30.9	50th: 7.4 90th: 11.7	All ages: 5.0% (0.6, 9.6) 0-14: 10.1% (4.3, 16.2) 15-64: 6.8% (-0.3, 14.5) 65+: 9.5% (-2.3, 22.7)
Schouten et al. (1996) Multicity, the Netherlands (Amsterdam, Rotterdam) Apr 1977-Sep 1989	All respiratory hospital admissions	24-h avg: Amsterdam: 10.5 Rotterdam: 15.0  1-h max: Amsterdam: 24.4 Rotterdam: 37.2	NR	NR	NR	NR	Amsterdam:  All ages: -6.0% (-10.7, -1.1)
Dab et al. (1996) Paris, France Jan 1987-Sep 1992	Hospital admissions from 27 hospitals	All year: 24-h avg: 11.2 1-h max: 22.5  Warm season 24-h avg: 7.6 1-h max: 16.1  Cold season 24-h avg: 15.1 1-h max: 29.4	NR	NR	NR	All year: 24 h avg: 99th: 50.0  1-h max: 99th: 87.5  Warm season 99th: 18.5  1-h max: 99th: 50.3  Cold season 24-h avg: 99th: 56.0  1-h max: 99th: 100.9	All ages: 1.8% (0.1, 3.6)
Anderson et al. (1998) London, England Apr 1987-Feb 1992	All hospital admissions for asthma	24-h avg: 12.0 (4.4)	NR	NR	3.4, 37.6	50th: 11.6 75th: 14.3 90th: 17.3 95th: 19.5	All ages: 2.8% (1.2, 4.3) 0-14: 0.5% (0.1, 1.0) 15-64: -0.7% (-2.7, 1.3) 65+: 3.1% (-0.7, 7.0)
Walters et al. (1994) Birmingham, United Kingdom Jan 1988-Dec 1990	All respiratory hospital admissions	24-h avg: All year: 14.7 Spring: 16.1 Summer: 14.2 Autumn: 15.4 Winter: 12.9	NR	NR	NR	Max: 47.5	Summer: All ages: 0.4% (-2.8, 9.2)  Winter: All ages: 0.7% (-2.2, 1.6)

STUDY	POPULATION	MEAN CONCENTRATION	SO <sub>2</sub> (ppb) 98TH%	SO <sub>2</sub> (ppb) 99TH%	SO <sub>2</sub> (ppb) RANGE	SO <sub>2</sub> (ppb) UPPER %TILE	STANDARDIZED EXCESS RISK (95% CI) <sup>a</sup>
<b>LATIN AMERICA</b>							
Gouveia and Fletcher (2000) São Paulo, Brazil Nov 1992-Sep 1994	All respiratory hospital admissions	24-h avg: 6.9 (3.4)	NR	NR	1.2, 22.9	50th: 6.2 75th: 8.3 95th: 13.5	<5 yrs: 10.4% (-1.9, 24.2)
<b>ASIA</b>							
Wong et al. (1999) Hong Kong, China Jan 1994-Dec 1995	Hospital admissions from 12 hospitals	24-h avg: 6.4	NR	NR	1.0, 25.7	75th: 9.4	All ages: 4.6% (-0.5, 9.9)
Lee et al. (2006) Hong Kong, China Jan 1997- Dec 2002	26,663 hospital admissions for asthma	24-h avg: 6.6 (4.0)	NR	NR	NR	50th: 5.7 75th: 8.2	<18 yrs: -3.7% (-6.7, -0.6)

<sup>a</sup> 24-h avg SO<sub>2</sub> standardized to 10 ppb incremental change; 1-h max SO<sub>2</sub> standardized to 40 ppb incremental change.

\* Analyses using Poisson GAM with default convergence criteria.

NA: Not Available

NR: Not Reported