Web Material

Evidence on Vulnerability and Susceptibility to Health Risks Associated with Short-Term Exposure to Particulate Matter: Systematic Review and Meta-Analysis

Web Table 1. Studies of effect modification for associations between particulate matter and mortality

Note: The results presented show (+) when a higher level of the effect modifier is associated with a higher health risk estimate and a (-) when a higher level of the effect modifier is associated with a lower health risk estimate. Only statistically significant associations are reported in the table. Reference numbers refer to the reference list for the Web Material, which differs from the reference list for the main text.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Aga et al. (2003) [1]	28 European cities (~5yrs within 1990s for most cities)	PM_{10}. Lag 01	Mortality for persons ≥65yrs	**Community level:** NO_2, temperature, humidity, age (% elderly, ≥65yrs vs. all ages), region	Poisson regression. Two-stage hierarchical model for effect modification.	Long-term NO_2 levels (+) Long-term temperatures (+) Long-term relative humidity (-)
Analitis et al. (2006) [2]	29 European cities	PM_{10}. Lag 01	Mortality: CVD, respiratory	**Community level:** temperature, humidity, NO_2, age (% elderly), age-standardized mortality rate, region	City-specific time series. Second stage hierarchical model for effect modification.	*Factors explaining >10% of heterogeneity* for CVD: Temperature (+) Precipitation (-) NO_2 (+) Proportion elderly (+) Age-standardized mortality rate (-) region (higher in South)
Balakrishnan et al. (2011) [3]	Chennai, India (formerly Madras) and Delhi, India (2002-2004)	PM_{10}. Lag 0, 1	Mortality	**Individual or daily level:** sex, age (0-4, 5-44, 45-64, ≥65yrs), season (Mar.-Aug., Sep.-Feb.)	Generalized additive models. Stratification for effect modification.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Bateson and Schwartz (2004) [4]	Cook County, IL (1988-1991)	$PM_{10.}$ Lag 01	Mortality: persons with history of hospitalization for heart or lung disease, for persons ≥35yrs	**Individual or daily level:** prior hospital admissions (myocardial infarction (MI), diabetes, congestive heart failure (CHF), COPD, conduction disorders), age, sex **Community level:** income, education (% adults with bachelor's degree), % adults with non-English language	Case-crossover. Interaction terms for effect modification.	Co-morbidities: MI, diabetes, CHF (+)
Bell, et al. (2009) [5]	100 US cities (1987-2000)	$PM_{10.}$ Lag 0	Mortality	**Community level:** long-term levels of $PM_{2.5}$ chemical components (Al, As, Ca, Cl, Cu, EC, Fe, K, Mg, Na^+, NH_4^+, Ni, Nitrate, OCM, Pb, Si, Sulfate, Ti, V, Zn), education (% of those ≥25yrs with high school degree), median household income, race (% of self-identifying as Black/African-American), urbanicity (% of living in urban setting), population	City-specific times series. Bayesian hierarchical modeling to generate overall estimates and for effect modification.	Ni (+): PM_{10} associations with mortality
Bell et al. (2009) [6]	184 US cities (1987-2000)	PM_{10}. Lag 1	Mortality	Community level: Central AC, any AC including window units.	City-specific time series. Bayesian hierarchical analysis to estimate overall associations and investigate effect modification.	Central AC (-)

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Biggeri et al. (2005) [7]	6 Italian cities for mortality (1990-1999). Not all cities had data for all years.	PM_{10}, based on TSP for 2 cities. Lag 0, 1, 2, 3, 01, 12, 03	Mortality: total	**Individual or daily level:** age (0-64, 65-74, ≥75yrs), age (<64, ≥65yrs), season (warm: May-Sep., cool: Oct.-Apr.) **Community level:** time (1990-1994 vs. 1995-1999)), SMR, age (% elderly), SES (deprivation index), mean temperature, long-term NO_2, PM_{10}/NO_2 ratio, log long-term PM_{10}	City-specific time series. Fixed effects, random effects, and Bayesian models to generate overall estimates. Interaction terms in city-specific model to investigate effect modification by season or age. Bayesian random effects model to investigate effect modification by community-level modifiers.	SMR (+) Season: higher in warm season
Cakmak et al (2011) [8]	7 cities in Chile (1997-2007)	PM_{10} , $PM_{2.5}$. Lag 06	Mortality	**Individual or daily level:** Sex, age (<64, 65-74, 75-84, ≥85yrs), employment (unemployed, blue-collar, white-collar), education (<primary school, primary school, high school, some college, university). **Community level:** income (quartiles)	City-specific time series. Random effects model to estimate overall associations. Stratification for effect modification.	Sex (higher in women): $PM_{2.5}$, PM_{10} Age (+): $PM_{2.5}$, PM_{10} Education (-) Age (+):$PM_{2.5}$, PM_{10} Income (-): $PM_{2.5}$ Employment status (-) (higher risk estimates for unemployed than white-collar employment): PM_{10}
Chen et al. (2010) [9]	Anshan, China (2004-2006)	PM_{10}. Lag 01	Mortality: total, cardio-pulmonary	**Individual or daily level:** age (5-64, 65-74, 75+yrs), sex	Case-crossover. Stratification for effect modification.	Age (+)

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
De Leon et al. (2003) [10]	New York, NY, US (1985-1994)	PM_{10}. Lag 01	Mortality: circulatory, cancer	**Individual or daily level:** age (<75, ≥75yrs); contributing cause of death as respiratory, pneumonia (≥75yrs), COPD (≥75yrs)	Poisson regression. Stratification for effect modification.	No statistically significant evidence of effect modification.
Diaz et al. (2012) [11]	Madrid, Spain (2003-2005)	PM_{10} . Lag 1	Mortality: total, respiratory, circulatory, cerebro-vascular	**Individual or daily level:** Saharan dust days (binary variable based backwards trajectory models, dust maps, and satellite imagery), season (warm: May-Sep., cool: Oct.-Apr.)	Case-crossover. Interaction terms for effect modification. Stratification for effect modification by season.	No statistically significant evidence of effect modification.
Dominici, et al. (2007) [12]	69 US urban cities (1987-2000)	PM_{10} . Lag 1	Mortality.	**Community level:** Long-term $PM_{2.5}$ Ni, $PM_{2.5}$ V (average levels for 2000-2005)	City-specific time series. Bayesian hierarchical model incorporating community-level modifiers for effect modification.	$PM_{2.5}$ Ni, V (+). Associations lose statistical significance when New York, NY is removed.
Faustini et al. (2011) [13]	10 Italian cities (2001-2005)	PM_{10} . Lag 02 (total), lag 03 (respiratory)	Mortality: total, respiratory, for persons ≥35yrs	**Individual or daily level:** age, sex, acute conditions based on previous 28 days hospitalizations, chronic conditions based on previous 2yrs hospitalizations, death site, (warm: Apr.-Sep., cool: Oct.-Mar.)	City-specific case-crossover. Random effects meta-analysis for overall associations. Stratification for effect modification.	Warm season (+): respiratory

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Forastiere et al. (2008) [14]	9 Italian cities (1997-2004)	PM_{10}. Lag 01	Mortality, for persons $\geq$35yrs	**Individual or daily level:** age (35-64, 65-74, 75-84, $\geq$85yrs), sex, location of death (out of hospital, discharged 2-28 days before death, in hospital, nursing home), hospitalizations in 2 previous years excluding 28 days before death for primary or secondary diagnosis (malignant neoplasms; disorders or thyroid gland; diabetes mellitus; anemias; coagulation defects; diseases of valves; hypertensive disease; previous acute MI (AMI); other ischemic heart diseases; pulmonary circulation; conduction disorders; heart failure; chronic pulmonary disease; diseases of arteries, arterioles, and capillaries), hospitalization within 28 days before death with primary diagnosis (malignant neoplasms; diabetes mellitus; anemias; hypertensive disease; AMI; other acute ischemic heart disease; pulmonary circulation; cardiac dyshythmias; heart failure; cerebrovascular diseases; diseases of arteries, arterioles, capillaries; pneumonia; chronic pulmonary disease; renal failure)	City-specific case-crossover. Random-effects meta-analysis for overall associations.	Age (+) Previous chronic hospitalization for other ischemic heart disease (+) Previous acute hospitalization for pulmonary circulation (+)

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Forastiere et al. (2005) [15]	Rome, Italy (1998-2000)	PM_{10}. Lag 0, 1, 2, 3, 01	Mortality: out of hospital coronary	**Individual or daily level:** sex, age (<65, 65-74, >74yrs), hospitalizations during preceding 3yrs with primary or secondary diagnosis (diabetes, hypertension, COPD, angina, other ischemic heart disease, conduction disorders, dysrhythmias, or heart failure)	Case-crossover. Interaction terms for effect modification.	No statistically significant evidence of effect modification.
Forastiere et al. (2007) [16]	Rome, Italy (1998-2001)	PM_{10}. Lag 01	Mortality, for persons $\geq$35yrs	**Community level:** income, SES index (based on education, occupation, unemployment, family size, crowding, and proportion of dwellings rented/owned) (4 strata by 20^{th}, 50^{th}, and 80^{th} percentiles), population-weighted traffic emissions (4 strata by 20^{th}, 50^{th}, and 80^{th} percentiles)	Case-crossover. Interaction terms for effect modification.	Income (-) SES (-)
Franklin, et al (2007) [17]	27 US cities (1997-2002)	$PM_{2.5}$. Lag 1	Mortality: all-cause, respiratory, CVD, stroke	**Individual or daily level:** age (≥75 vs. <75) and sex **Community level**: region (east vs. west), $PM_{2.5}$ levels (annual $PM_{2.5}$ concentrations > or $\leq$ 15 $\mu g/m^3$), prevalence of central AC	City-specific case-crossover. Interaction terms in a case-crossover for individual or daily level modifiers and random effects meta-regression for community-level level modifiers.	Age (+): all-cause, stroke

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Franklin, et al. (2008)[18]	25 US cities (2000-2005). Not all cities had data for all years.	$PM_{2.5}$. Lag 01	Mortality	**Individual or daily level:** season **Community level**: region (west vs. east), fraction of $PM_{2.5}$ for components (Al, As, Br, Cr, EC, Fe, K, Mn, Sodium ion, Ni, Nitrate, Ammonium ion, Organic carbon, Pb, Si, Sulfate, V, Zn)	City-speicifc time-series. Random effects meta-regression to generate overall estimate and investigate effect modification. Stratification for effect modification by season.	Season (higher in Spring): total Fraction $PM_{2.5}$ for Al, As, sulfate, Si, Ni (+)
Garrett and Casimiro (2011) [19]	Lisbon, Portugal (2004-2006)	$PM_{2.5}$. Lag 02	Mortality: total, CVD	**Individual or daily level:** age (all ages vs. $\geq$65yrs)	Generalized additive modeling. Stratification for effect modification.	No statistically significant evidence of effect modification.
Goldberg et al. (2000) [20]	Montreal, Canada (1984-1993)	Predicted $PM_{2.5}$ based on COH, sulfate, and visibility data. Lag 0, 1, 02	Mortality: total, neoplasms, lung cancer, CVD, coronary artery disease, other	**Individual or daily level:** age (<65, $\geq$65yrs), pre-existing conditions (cancer, acute upper respiratory disease, chronic upper respiratory disease, acute lower respiratory disease, airways disease, acute coronary artery disease, chronic coronary artery disease, CHF, hypertension, cerebrovascular disease, any coronary artery disease, any CVD disease, none)	Time series. Stratification for effect modification.	Age (+): total mortality for persons with pre-existing chronic coronary artery disease

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Goldberg et al. (2006) [21]	Montreal, Canada	PM_{10}, $PM_{2.5}$. Lag 0, 1, 02	Mortality with underlying cause as diabetes, for persons ≥65yrs	**Individual or daily level:** sex, season (warm: Apr.-Sep., cool: Oct.-Mar.), underlying cause of death of diabetes mellitus vs. classified as diabetes 1 yr before death (for death that may or may not have been attributed to diabetes), co-morbidities (chronic coronary artery disease, atherosclerosis, CHF, CVD, airways disease, cancer	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Gouveia and Fletcher (2000) [22]	Sao Paulo, Brazil (1991-1993)	PM_{10}. Lag 0, 1	Mortality	**Individual or daily level:** age (1 month-5yrs, 5-12, 12-40, 40-50, 50-60, 60-65, 65-70, 70-75, 75-80, 80-85, ≥85yrs) **Community level:** SES based on residence (4 groups) for >65yrs	Time series. Interaction term for effect modification.	Age (+)
Huang et al. (2012) [23]	Xi'an, China (2004-2008)	$PM_{2.5}$. Lag 0, 1, 2, 3, 4, 5, 6, 06	Mortality: total, CVD, coronary, respiratory	**Individual or daily level:** season (warm: Nov. 15-Mar. 15, cool: Mar. 16-Nov. 14), age (0-44, 45-64, ≥65yrs, total mortality), sex (total mortality)	Time series. Stratification for effect modification.	Season (higher for cool period): ≥65yrs
Ito and Thurston (1996) [24]	Cook County, IL, US (1985-1990)	PM_{10}. Lag 01	Mortality: total, circulatory, respiratory cancer, for persons ≥15yrs	**Individual or daily level:** race (black, white), sex, age (15-60, ≥60yrs, all ages)	Poisson regression. Stratification for effect modification.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Kan et al. (2008) [25]	Shangai, China (2001-2004)	PM_{10} . Lag 01	Mortality: total, CVD respiratory	**Individual or daily level:** age (5-44, 45-64, $\geq$65yrs, total mortality only), sex (total mortality only), education attainment (illiterate or primary school, middle school or above), season (warm: Apr.-Sep., cool: Oct.-Mar.)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Katsouyanni et al. (1997) [26]	5 European cities (1975-1992). Not all cities had data for all years.	PM_{10} based on TSP for 3 cities, PM_{13} for 2 cities, PM_7 for 1 city. Lag 0, 1, 2, 3, 01, 02, 03	Mortality	**Individual or daily level:** Region (eastern vs. western), season	City-specific times series.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Katsouyanni et al. (2009) [27]	32 European cities (1990-1997), 95 US cities (1987-1996), 12 Canadian cities (1981-1999). For community level modifiers, 21 European cities, 15 US cities. Not all cities had data for all years or pollutants.	PM_{10}. Lag 1, 01 (age), Lag 01 (community level modifiers)	Mortality: total, CVD, respiratory	**Individual or daily level:** age (<74, $\geq$75yrs) **Community level**: NO_2, SO_2, NO_2/PM_{10} , exposure, population, population density, temperature, humidity, crude mortality rate, age-standardized mortality rate, % cardiorespiratory deaths, age (% $\geq$75yrs), region, unemployment (21 European cities, 15 US cities), number of monitors, monitor density, education (% with >12yrs), and others. Not all cities had data on all effect modifiers	City-specific time series. Stratification for effect modification by age. Meta-regression models for effect modification by community level variables.	NO_2 (+): Europe Temperature (+) Humidity (-): Europe Humidity (+): US % of cardiorespiratory deaths (+): US Crude mortality rate (+): US Unemployment (+) Age (+)
Katsouyanni, et al. (2001) [28]	29 European cities (1990-1997). Not all cities had data for all years.	PM_{10}. Lag 01	Mortality	**Community level:** long-term average of other pollutants (e.g., NO_2), temperature, and humidity, age adjusted mortality rate, age adjusted lung cancer mortality rate, region (Central-Eastern, Southern, North Western), location (latitude and longitude), age (% >65yrs)	City-specific time series. Fixed-effects or random effects meta-regression to estimate overall associations and investigate effect modification.	NO_2 (+) PM_{10}/NO_2 (-) Humidity (-) Temperature (+) Age-standardized annual mortality rate (-) Age (-)

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Levy et al. (2000) [29]	29 estimates from 21 time series studies (19/29 estimates from US). Time frame varies by original study.	PM_{10}, some estimated from TSP as PM_{10} /TSP = 0.55 (lag varies by original study)	Mortality	**Community level:** baseline mortality rate, age (% >65yrs), poverty, prevalence of gas stoves, prevalence of central AC. Most analyses for 19 US risk estimates	Meta-regression random effects model to combine risk estimates from 29 previously conducted time series studies and estimate effect modification. Stratification for effect modification.	No statistically significant evidence of effect modification.
Li et al. (2011) [30]	Tianjin, China (2077-2009)	PM_{10}. Lag 01	Mortality: total, CVD, respiratory, cardio-pulmonary, stroke, ischemic heart disease	**Individual or daily level:** temperature, age (<65, >65yrs)	Poisson regression. Interaction spline models, interaction terms, and stratification for effect modification.	Warm (+): CVD, cardiopulmonary, ischemic heart disease. Stroke for >65 yr). Age (+): total mortality on high temperature days
Ma et al. (2011)[31]	Shenyang, China (8/06-12/08)	$PM_{2.5}$. Lag 01	Mortality: total, respiratory, CVD	**Individual or daily level:** season (warm: May-Oct., cool: Nov.-Apr.), age (5-64, 65-74, >75yrs), sex	Case-crossover. Stratification for effect modification.	Warm (+): total mortality.
Martins et al. (2004) [32]	6 regions in Sao Paulo, Brazil (1997-1999)	PM_{10} . Lag 0, moving averages of lag 2 to lag 7	Mortality: respiratory, for persons >60yrs	**Community level:** college education, age, % of people living in slums, income	Time series. Correlation of SES indicators and PM_{10} risk estimates.	Education (-): respiratory Income (-): respiratory
Nawrot et al. (2007) [33]	Flanders, Belgium (1997-2003)	PM_{10}. Lag 0, 1, 2, 3, 4, 5	Mortality: total, CVD, respiratory	**Individual or daily level:** season (warm: Apr.-Sep., cool: Oct.-Mar.)	Time series. Interaction terms and stratification for effect modification.	Warm(+): total, CVD
Oliveira et al. (2011) [34]	Rio de Janeiro State, Brazil (1/02-12/06)	PM_{10}. Lag 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.	Mortality: respiratory	**Individual or daily level:** age (all, >65years), sex	Poisson regression.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
O'Neill et al. (2004) [35]	Mexico City (1994-1998)	PM_{10}. Lag 0, 1, 2, 3, 4, 5, 05	Mortality	**Community level:** region (5 regions), particle measurement method	Region-specific Poisson regression. Random effects model to estimate overall associations. Stratification for effect modification.	No statistically significant evidence of effect modification.
O'Neill, et al. (2008) [36]	Mexico City, Mexico; Santiago, Chile; Sao Paulo, Brazil (1998-2002)	PM_{10} Lag 0, 1, distributed lag 0-5	Mortality, for persons ≥21yrs	**Individual or daily level**: Education (none, some primary, some secondary, secondary or more), age (>65yrs vs. all adults), sex	City-specific time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Ostro et al. (2008) [37]	6 California counties, US (2000-2003)	$PM_{2.5}$. Lag 0, 1, 2, 3	Mortality: CVD	**Individual or daily level**: sex, race/ethnicity (white, Hispanic, black), education (<high school, ≥high school)	City-specific time-series. Random effects meta-analysis to estimate overall associations. Stratification for effect modification.	No statistically significant evidence of effect modification.
Ou et al. (2008) [38]	Hong Kong (1998)	$PM_{10.}$ Lag 0, 1, 2, 3	Mortality, for persons ≥30yrs	**Individual or daily level:** housing type (private, public government housing for low income), employment (never employed, white collar, blue collar), education (none, primary, secondary)	Time series. Interaction terms and stratification for effect modification.	Employment (-): lower associations for white-collar group than blue-collar or never employed groups Housing (-): lower associations for private housing than public housing Education: lower associations for primary education than those with no education

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Ou et al. (2012) [39]	Hong Kong (mid-Dec. 1997 – mid-Jan.1999)	PM_{10} . Lag 02.	Mortality, for persons ≥30yrs	**Individual or daily level: d**ietary intake 10yrs before death (≥1/week, seldom/never) for fish, meat, vegetables, fruits, soy, dairy.	Case-crossover. Linear odds ratio model for effect modification on additive scale.	Fruit consumption (-) Soy consumption (-) Dairy consumption (+)
Peng et al. (2005) [40]	100 US cities (2000-2005)	PM_{10}	Mortality	**Individual or daily level:** season (summer: June-Aug., etc. or as non-linear function) **Community level:** region (7 regions)	Time series. Stratification and non-linear models for effect modification by season. Bayesian hierarchical modeling to estimate overall associations and investigate effect modification by region.	Season (higher in summer) Geographical region (higher in California), but not tested for statistically significance
Qian et al. (2010) [41]	Wuhan, China (7/00-6/04)	PM_{10}. Lag 0, 1, 01, 02, 04	Mortality: total, CVD, stroke, cardiac, respiratory, cardio-pulmonary, non-cardio-pulmonary	**Individual or daily level**: temperature (<5^{th}, 5-95^{th}, >95^{th} percentile), temperature (normal, extremely cold, extremely hot), sex, age (<65, ≥65yrs)	Time series. Stratification for effect modification by sex and age. Interaction terms for effect modification by lag 01 temperature.	Temperature (+): higher risk estimates at extremely hot days than normal days, total, CVD, cardiopulmonary
Rainham et al. (2005) [42]	Toronto, Canada (1981-1999)	$PM_{2.5}$. Lag 0, 1, 2	Mortality: total, cardio-respiratory, non-cardio-respiratory	**Individual or daily level:** weather (spatial synoptic classification system with 7 levels: one of 6 categories or a transition between categories), season (winter: Dec.-Feb., summer: June-Aug.)	Time-series. Stratification for effect modification.	No statistically significant evidence of effect modification.

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Revich and Shaposhnikov (2010) [43]	Moscow, Russia (2003-2005)	PM_{10} . Lag 0, 1, 01	Mortality: total, ischemic heart disease and angina pectoris, cerebro-vascular	**Individual or daily level:** age (all ages vs. $\geq$75yrs), O_3 levels	Time-series. Stratification for effect modification by age. Analysis of PM_{10} and mortality without O_3 adjustment in subset of data with >90th percentile O_3 for in effect modification of PM_{10} by O_3.	No statistically significant evidence of effect modification.
Samoli et al. (2005) [44]	22 European cities (1990-1997). Not all cities had data for all years.	PM_{10} . Lag 01	Mortality: total, respiratory	**Community level:** air pollution levels (e.g., NO_2), geographic region (Southern, Western, Eastern), climate, age-standardized annual mortality rate	City-specific time series. Second stage regression to estimate overall associationsand investigate effect modification.	Different exposure-response curve by region (*in general*, higher in Southern region): total, respiratory Temperature (+): total Standardized mortality rate (-): total NO_2 (+): total

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Samoli et al. (2008) [45]	90 US cities (1987-1996), 32 European cities (1990-1997), 12 Canadian cities (1987-1996). Not all cities had data for all years.	PM_{10} on days with <150µg/m^3. PM_{10} estimated from TSP for 10 European cities. Lag 0, 1, 01, 02	Mortality	**Individual or daily level**: age (<75, ≥75yrs) **Community specific:** unemployment, temperature, humidity, monitor density in relation to population size, health status of population (% of cardiorespiratory deaths, mortality rate, standardized mortality rate), region (Canada, Europe, US) Not all cities had data for all effect modifiers.	City-specific time series. Meta-regression to combine risk estimates across cities and investigate effect modification. Stratification for effect modification by age. Not all cities included in all analyses.	Age (+) Unemployment (+) Temperature (+): Europe only Humidity (-): Europe Crude mortality rate (+): US % of cardiorespiratory deaths among ≥75 people (+) (US only)
Samoli et al. (2011) [46]	Athens, Greece (2001-2006)	PM_{10}. Lag 1	Mortality: total, CVD, respiratory	**Individual or daily level:** windblown desert dust (yes, no), sex, age (<75, ≥75yrs)	Time-series. Stratification for effect modification by sex and age. Interaction terms for effect modification by desert dust.	Desert dust (-): total, CVD, respiratory mortality for ≥75yrs; total mortality for <75yrs
Schwartz et al. (2000) [47]	10 US cities (1986-1993)	PM_{10}. Lag 01	Mortality.	**Community level:** unemployment, % in poverty, education (% with college degree), race (% non-white), location of death (in or out of hospital)	City-specific time series. Second stage meta-regression to estimate overall associations and investigate effect modification.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Serinelli et al. (2010) [48]	8 Italian cities (1997–2004)	PM_{10} . Lag 01	Mortality: out-of-hospital for ischaemic heart disease, for persons >35yrs	**Individual or daily level:** age (35-64, 65-74, 75-84, ≥85yrs), sex, season (cool: Oct.-Mar., warm: Apr.-Sep.), comorbidities: (hospitalization 29 days to 2yrs earlier for malignant neoplasm, diabetes mellitus; anaemias; hypertensive diseases; previous AMI; other ischaemic heart diseases; cardiac dysrhythmias; heart failure; cerebrovascular diseases; pneumonia; chronic pulmonary diseases; diseases of arteries, arterioles, and capillaries) **Community level:** income (<20^{th}, 20^{th}-540^{th}, 51-80^{th}, >80^{th} percentile), region (community)	City specific case-crossover. Meta-regression random effects model to estimate overall associations. Stratification for effect modification by age. Analysis for effect modification other than age for persons >65yrs.	Income (-) Previous hospitalization for cardiac dysrhythmias (-)
Siemiatycki et al. (2003) [49]	US cities from the ACS and Harvard 6 Cities Study	$PM_{2.5}$	Mortality: total, cardio-pulmonary, lung cancer	**Individual or daily level:** sex, occupational "dirtiness score" (7 point scale), smoking status (ever, never), prevalence of exposure to known lung carcinogens (yes, no), education (<high school, high school, >high school, for ACS only)	Cox proportional hazards model. Stratification for effect modification.	No statistically significant evidence of effect modification.

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Son et al. (2012) [50]	Seoul, Korea (2000-2007)	PM_{10}. Lag 0, 1, 2, 01, 02	Mortality: total, CVD, respiratory, for persons $\geq$35yrs	**Individual or daily level:** sex, age (35-64, 65-74, $\geq$75yrs), education ($\leq$12, >12yrs, unknown), marital status (never married, married, divorced, widowed, unknown), employment (professional, manual, housewife/unemployed, unknown).	Case-crossover. Interaction terms for effect modification.	No statistically significant evidence of effect modification.
Stafoggia, et al. (2008) [51]	9 Italian cities (1997-2004)	PM_{10}. Lag 01	Mortality: total, CVD, respiratory, non-cardio-respiratory, for persons $\geq$35yrs	**Individual or daily level:** season, apparent temperature (<50th, 50-75th, >75th percentile)	City-specific case-crossover. Random effects meta-analysis to estimate overall associations. Interaction terms within each temperature stratum for effect modification.	Apparent temperature (+) Season (higher in summer): CVD, non-cardiorespiratory, total
Tobias et al. (2011) [52]	Madrid, Spain (2003-2005)	$PM_{2.5}$. Lag 0, 1, 2, 3, 4	Mortality	**Individual or daily level:** Saharan dust days (binary variable based backwards trajectory models, dust maps, and satellite imagery)	Case-crossover. Interaction terms for effect modification.	No statistically significant evidence of effect modification.
Villeneuve et al. (2003) [53]	Vancouver, Canada (1986-1999)	PM_{10}, $PM_{2.5}$. Lag 02	Mortality: total, respiratory, CVD for persons $\geq$65yrs.	**Community level:** income (3 categories)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Wichmann et al. (2000) [54]	Erfurt, Germany (9/95-12/98)	PM_{10}. Lag 0, 1, 2, 3, 4, 5, 05	Mortality	**Individual or daily level:** age (<70, 70-79, ≥80yrs), season (4 seasons), prevalent diseases (CVD or respiratory, CVD but not respiratory, respiratory, other)	Poisson regression.	Season: higher in winter than summer, lag 0
Wilson et al. (2007) [55]	Phoenix, AZ, US (1995-1997)	$PM_{2.5}$, $PM_{10-2.5}$. Lag 05	Mortality: CVD	**Community level:** % in poverty, % with high school education, for 3 zip codes.	Times series. Comparison of risks across 3 SES zones for effect modification.	No statistically significant evidence of effect modification.
Wong et al. (2008) [56]	Hong Kong, China (1996-2002)	PM_{10}. Lag 0, 1, 2, 3, 4	Mortality: total, CVD, respiratory	**Community level:** social deprivation index for 209 town planning units based on unemployment, income, education, one-person household, marital status, subtenancy	Time series. Case only and stratification for effect modification.	No statistically significant evidence of effect modification.
Wong et al. (2010) [57]	Hong Kong (1996-2002)	PM_{10}. Lag 0, 1, 2, 3, 4, 01, 04	Mortality: total, CVD, respiratory. Hospital admissions: CVD, respiratory, ARD, ALRI, COPD, asthma	**Individual or daily level:** age (all ages vs. ≥65yrs, mortality, hospital admissions for CVD, respiratory, COPD), age (all ages vs. 0-14yrs, hospital admissions for ARD, ALRI, asthma), influenza based on virologic data **Community level:** social deprivation index (SDI) (3 groups) (mortality only)	Poisson regression. Interaction terms for effect modification by influenza. Stratification and case-only model for effect modification by SDI. Stratification for other effect modifiers.	No statistically significant evidence of effect modification.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Yang et al. (2012) [58]	Guangzhou, China (2007-2008)	$PM_{2.5}$. Lag 01	Mortality	**Individual or daily level:** age (5-64, ≥65yrs), sex, education (illiterate or primary school, middle school or above)	Case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Zauli et al. (2011) [59]	6 Italian cities (8/02-12/06)	PM_{10}. Lag 1	Mortality: total, CVD, respiratory, persons ≥75yrs	**Individual or daily level:** Saharan dust days (binary variable based on coarse particle count), season (warm: May-Sep., cool: Oct.-April)	Case-crossover. Interaction terms for effect modification. Stratification for effect modification by season.	No statistically significant evidence of effect modification.
Zanobetti, et al. (2000) [60]	4 US cities (Chicago, Detroit, Minneapolis-St. Paul, Pittsburgh) (1986-1993)	PM_{10}. Lag 01	Mortality	**Individual or daily level:** race (white, black), sex, education (<12, ≥12yrs)	City-specific time series. Inverse variance weighting to estimate overall associations. Stratification for effect modification.	Sex (higher in women)
Zanobetti et al. (2009) [61]	112 US cities (1999-2005)	$PM_{2.5}$. Lag 01	Mortality: total, CVD, MI, stroke, respiratory	**Individual or daily level specific:** season (4 seasons) **Community level:** region (6 groups)	City-specific time series. Random effects meta analysis to generate overall estimates. Stratification for effect modification.	Season (higher in spring)

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Zeka, et al. (2005) [62]	20 US cities (1989-2000)	PM_{10}. Lag 0, 1, 2	Mortality: total, heart disease, ischaemic heart disease, MI, dysrhythmias, heart failure, stroke, respiratory disease, pneumonia, COPD	**Community level:** prevalence of central AC, population density, standardized mortality rates, proportion of elderly (>65, >75, or >85yrs), daily minimum apparent temperature (mean and variance) in summer (June-Aug.), daily maximum apparent temperature (mean and variance) in winter (Dec.-Feb.),% PM_{10} from traffic	City-specific Case-crossover. Maximum likelihood meta-regression to estimate overall risk and investigate effect modification.	Population density (+) % PM_{10} from traffic (+) Variance of summer apparent temperature (+)
Zeka, et al. (2006) [63]	20 US cities (1989-2000)	PM_{10}. Lag 0, 01, 02, 03. Different lags by cause of mortality	Mortality: all-cause, heart disease, AMI, respiratory, stroke	**Individual or daily level:** in- vs. out-of-hospital death, sex, diabetes, pneumonia, season (Spring/Fall vs. Winter/Summer), race (white, black), age (<65, 65-75, >75yrs), education (<8, 8-12yrs, >13yrs), contributing cause of death (pneumonia, heart failure, stroke, diabetes), menopause (post menopause, pre-menopause)	Case-crossover for first stage. Second stage of random effects meta analysis. Stratification for effect modification.	Age (+): total, heart disease, stroke Location of death (out-of-hospital higher than in hospital): all-cause, heart disease, stroke Season (higher in Spring/Autumn): respiratory

Web Table 2. Studies of effect modification for associations between particulate matter and hospital admissions or emergency from visits

Note: The results presented show (+) when a higher level of the effect modifier is associated with a higher health risk estimate and a (-) when a higher level of the effect modifier is associated with a lower health risk estimate. Only statistically significant associations are reported in the table. Reference numbers refer to the reference list for the Web Material, which differs from the reference list for the main text.

Study	Location and timeframe	Exposure and lag structure	Health outcome	Potential effect modifiers	Statistical models	Statistically significant results
Bell et al. (2008) [64]	202 US cities (1999-2005)	$PM_{2.5}$. Lag 0, 1, 2	Hospital admissions: CVD, respiratory, for persons >64yrs	**Individual or daily level:** season (summer: June-Aug., etc. or as non-linear function) **Community level:** region (4 groups)	Time series. Stratification and non-linear models for effect modification by season. Bayesian hierarchical modeling to estimate overall associations and investigate effect modification by region.	Season (higher in winter) Region (higher in northeast than southeast): CVD
Bell et al. (2009) [6]	168 US cities (1999-2005)	$PM_{2.5}$. Lag 0 (CVD), lag 2 (respiratory)	Hospital admissions: CVD, respiratory, for persons >65yrs ($PM_{2.5}$).	**Community level:** Central AC, any AC including window units.	City-specific time series. Bayesian hierarchical analysis to estimate overall associations and investigate effect modification.	Central AC (-): $PM_{2.5}$ and CVD hospital admissions

Bell, et al. (2009) [5]	106 US counties (1999-2005)	$PM_{2.5}$. Lag 0	Hospital admissions: CVD, respiratory	**Community level:** long-term levels of $PM_{2.5}$ chemical components (Al, As, Ca, Cl, Cu, EC, Fe, K, Mg, Na+, NH4+, Ni, Nitrate, OCM, Pb, Si, Sulfate, Ti, V, Zn), education (% of those ≥25yrs with high school degree), median household income, race (% of self-identifying as Black/African-American), urbanicity (% of living in urban setting), population	City-specific times series. Bayesian hierarchical modeling to generate overall estimates and for effect modification.	Ni,V, EC (+): $PM_{2.5}$ risk estimates for CVD and respiratory admission
Belleudi et al. (2010) [65]	Rome, Italy (2001-2005)	PM_{10}, $PM_{2.5}$. Lag 0, 1, 2, 3, 4, 5, 6, 01, 02, 05, 06	Emergency hospital admissions: acute coronary syndrome, heart failure, lower respiratory tract infection, COPD, for persons >35yrs	**Individual or daily level:** age (35-64, 65-74, >75yrs), previous COPD admissions, season (Winter as Dec.-March, summer as June-Sep., Spring/Fall as April, May, Oct., and Nov.)	Case-crossover. Stratification for effect modification.	General trends: Age (+) Season: winter (+)
Bhaskaran et al. (2011) [66]	15 conurbations in England and Wales (2003-2006)	PM_{10}. Lag 1-6, 7-12, 13-18, 19-24, 25-72, 1-71 hrs	Hospital admissions: MI	**Individual or daily level:** age (<60, 60-69, 70-79, >80yrs), prior coronary heart disease, smoking status, season (Summer as June-Aug. vs. non-summer)	Case-crossover. Interaction terms for effect modification.	No statistically significant evidence of effect modification.

Biggeri et al. (2005) [7]	8 Italian cities (1990-1999). Not all cities had data for all years.	PM_{10}, based on TSP for 2 cities. Lag 0, 1, 2, 3, 01, 12, 03	Hospital admissions: cardiac, respiratory	**Individual or daily level:** age (0-64, 65-74, >75yrs) **Community level:** age (% elderly), PM_{10}/NO_2 ratio, log long-term PM_{10}	City-specific time series. Fixed effects, random effects, and Bayesian models to generate overall estimates. Interaction terms in city-specific model to investigate effect modification by age. Bayesian random effects model to investigate effect modification by community-level modifiers.	No statistically significant evidence of effect modification.
Buadong et al. (2009) [67]	Bangkok, Thailand (4/02-12/06)	PM_{10}. Lag 0, 1, 02, 03	Hospital admissions: CVD	**Individual or daily level:** age (<15, 15-64, >65yrs)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Bunch et al. (2011) [68]	Wasatch Front, Utah (1993-2008)	$PM_{2.5}$. Lag 0, cumulative lags up to 21 days	Hospital admissions: atrial fibrillation	**Individual or daily level:** sex, age (<55, 55-64, 65-74, >75yrs), previous or subsequent admissions (MI, asthma, COPD, sleep apnea)	Case-crossover.	No statistically significant evidence of effect modification.
Burra et al. (2009)[69]	Toronto, Canada (1996-2001)	$PM_{2.5}$. Lag 0, 02, 03, 04, 05	Ambulatory physician consultations: asthma, for children (1-17yrs) and adults (18-64yrs)	**Individual or daily level:** age, sex **Community level:** income (quintiles)	Time series. Stratification for effect modification.	Income (-).

Canova et al. (2012) [70]	London (5/08-7/10)	PM_{10}. Lag 03	Hospital admissions: COPD, asthma, for persons >18yrs	**Individual or daily level:** Serum vitamin C, uric acid, vitamin E, or vitamin A (> or < median); 10 antioxidant genes; age (18-34, 35-54, >55yrs); previous diagnosis of asthma, COPD, or both; smoking (current, former/never)	Case-crossover. Stratification for effect modification.	Vitamin C (-) Smoking (+)
Cao et al. (2009) [71]	Shanghai, China (2005-2007)	PM_{10}. Lag 3 for outpatient visits, L0 for emergency room visits	Hospital outpatient and emergency room visits	**Individual or daily level:** season (warm: Apr.-Sep., cool: Oct.-Mar.)	Poisson regression. Stratification for effect modification.	No statistically significant evidence of effect modification.
Cheng et al. (2009) [72]	Kaohsiung, Taiwan (1996-2006)	PM_{10}. Lag 01	Hospital admissions: pneumonia	**Individual or daily level:** secondary diagnosis (hypertension, diabetes, dysrhythmia, COPD, upper respiratory infection, asthma, cerebrovascular disease, CHF, ischemic heart disease), temperature (> or < $25^{o}C$)	Case-crossover. Stratification for effect modification.	Co-morbidities: higher with upper respiratory infection. Temperature (-)

Chiu and Yang (2009) [73]	Taipei, Taiwain (2000-2006)	PM_{10}. L0	Emergency room visits: arrhythmias	**Individual or daily level:** secondary diagnosis (hypertension, diabetes, CHF, COPD, pneumonia, upper respiratory infection, asthma), temperature (> or < 23°C)	Case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Colais et al. (2012) [74]	9 Italian cities (2000-2005	PM_{10}. Lag 0, 01	Hospital admissions: all cardiac, acute coronary syndrome, arrhythmias and conduction disorders, heart failure	**Individual or daily level:** age, sex, hospital diagnosis in previous 2yrs (CVD, respiratory)	City-specific case-crossover. Interaction terms for effect modification in city-specific models. Random effects meta-regression to combine risk estimates across cities.	Sex (higher in men): arrhythmias Sex (higher in women): heart failure Age (+): coronary events
Dales et al. (2009) [75]	7 Chilean urban centers in Santiago Province (2001-2005)	$PM_{2.5}$, PM_{10}. Lag 0	Hospital admissions: headache (migraine; other specified cause, cause not specified)	**Individual or daily level:** age (<64, >64yrs), sex, season (Apr.-Sep., Oct.-Mar.)	City-specific time-series. Random-effects model to estimate overall associations. Stratification for effect modification.	No statistically significant evidence of effect modification.
Dominici et al. (2006) [76]	204 US cities (1999-2002)	$PM_{2.5}$. Lag 0, 1, 2	Hospital admissions: respiratory, CVD, cerebro-vascular disease, peripheral vascular disease, ischemic heart disease, heart rhythm disturbances, heart failure, COPD, respiratory tract infection, for persons >65yrs	**Community level:** region (East vs. West, 7 regions)	City-specific time series. Bayesian hierarchical modeling to estimate overall associations. Stratification for effect modification.	Region: higher in east than west for heart rhythm disturbances

Fung et al. (2005) [77]	Windsor, Ontario, Canada (4//95-12/00)	PM_{10}. Lag 0, 01, 02	Hospital admissions: cardiac	**Individual or daily level:** age (<65, >65yrs)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Haley et al. (2009) [78]	New York, NY, US (2001-2005)	$PM_{2.5}$. Lag 0-2	Hospital admissions: heart failure, for persons >35yrs	**Individual or daily level:** age (35-64, 65-74, 65-84, >85yrs), co-morbidities (atherosclerosis, previous heart failure admissions, ischemic heart disease, conduction disorder, diabetes, COPD), season (warm, cool), year **Community level:** SES (% in poverty as 0-7, 7-20, 20-100%)	Area-specific case-crossover. Inverse variance weighting to generate overall estimates.	Age (+)
Janssen, et al (2002) [79]	14 US counties (1985-1994)	PM_{10}. Lag 01 (CVD), lag 12 (COPD and pneumonia)	Hospital admissions: COPD, CVD, pneumonia, for persons >65yrs	**Community level:** central AC prevalence, long-term temperature, PM10 source (highway vehicles, highway diesels, coal combustion, oil combustion, wood burning, metal processing, fugitive dust), population density, vehicle miles travelled/mile^2	City-specific time series. Meta-regression to combine risk estimates.	AC (-): for CVD, for COPD for cities with non-winter PM10 peaks PM10 from highway vehicles, highway diesels, oil combustion, metal processing (+): for CVD PM10 from fugitive dust (+): for CVD Population density(+): for CVD VMT/mile2 (+): for CVD

Kim et al. (2007) [80]	Seoul, Korea (2002)	PM_{10}. Lag 02	Emergency out-patient hospital visits: asthma	**Individual or daily level:** Korean National Health Insurance premium as SES indicator (quintiles). **Community level:** Korean National Health Insurance premium for 5 regions	Case-crossover. Interaction terms and stratification for effect modification.	No statistically significant evidence of effect modification.
Lanki et al (2006) [81]	3 European cities: Helsinki (1993-1999), Rome (1998-2000), Stockholm (1994-1999)	PM_{10}. Lag 0, 1, 2, 3	AMI hospital discharge for persons >35yrs	**Individual or daily level**: age (<75, >75), season (Apr.-Sep., Oct.-Mar.), death within 28 days after hospitalization (yes, no)	City-specific general additive model. Pooled overall risk weighted by inverse of squared standard errors of risk estimates. Stratification for effect modification.	No statistically significant evidence of effect modification.
Lee et al. (2008) [82]	Taipei ,Taiwan (warm days in 1996-2005)	PM_{10}. L02	Hospital admissions: CHF	**Individual or daily level:** secondary diagnosis (hypertension, diabetes, dysrhythmia, COPD)	Case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Mann et al. (2002) [83]	South Coast Air Basin of California, US (Apr.-Oct. for 1988-1995)	PM_{10}. Lag 0, 1, 2	Hospital admissions: ischemic heart disease	**Individual or daily level**: secondary diagnosis (arrhythmia, CHF)	Poisson regression. Stratification for effect modification.	No statistically significant evidence of effect modification.

Medina-Ramon et al. (2006) [84]	36 US cities (1986-1999)	PM_{10}. Lag 0, 1	Hospital admissions: COPD, pneumonia, for persons >65yrs	**Community level:** season (warm, cool), mean temperature, variance of temperature, % >65yrs in poverty, prevalence of central AC, annual mortality rate for emphysema for persons >65yrs (as indication of smoking), % PM10 from traffic.	City-specific case-crossover. Meta-regression using restricted maximum likelihood random effects models to estimate overall associations and investigate effect modification. Modifiers other than season examined for warm season only.	Warm (+): COPD % persons >65 in poverty (-): pneumonia Emphysema mortality rate for persons >65 (-): COPD Mean temperature (-): pneumonia Central AC (-): pneumonia
Middleton et al. (2008) [85]	Nicosia, Cyprus (1995-2004)	PM_{10}. Lag 0, 02	Hospital admissions: total, CVD, respiratory, cardio-respiratory	**Individual or daily level:** sex, age (<15, $\geq$15yrs, total, respiratory), dust storm days (binary indicator based on PM_{10} levels and trends, meteorological data, backwards trajectory models), season (warm vs. cold months, total, CVD, respiratory)	Poisson regression. Stratification for effect modification by sex and age. Interaction terms for effect modification by season and temperature.	No statistically significant evidence of effect modification.
Namdeo et al (2011) [86]	Leeds metropolitan area, UK (4/02-12/05)	PM_{10}. Lag 0, 1, 2	Hospital admissions: respiratory	**Individual or daily level:** age (<60, 60-69, 70-74, 75-79, >80yrs)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.

Nuvolone et al. (2011) [87]	Tuscany, Italy (2000-2005)	PM_{10}. Lag 0, 1, 2, 3, 4, 5, 02, 05, 35	Hospital admissions: AMI	**Individual or daily level:** sex, age (<75, >75yrs), season (warm: Apr.-Sep., cool: Oct.-Mar.), secondary diagnosis or hospitalization within previous 3yrs (hypertension, COPD, diabetes, cardiac arrhythmia, heart failure, hospitalization for cardiac disease)	Region-specific case-crossover (5 regions). Interaction terms for effect modification by co-morbidities. Stratification for effect modification by age, sex, season. Random effects meta-analysis to estimate overall associations.	No statistically significant evidence of effect modification.
Oftedal et al. (2003) [88]	Drammen, Norway (1994-2000)	PM_{10}	Hospital admission: respiratory	**Individual or daily level:** time (1994-1997, 1998-2000)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Oudin et al. (2010) [89]	Scania, Sweden (2001-2005)	PM_{10}. Lag 0, 1, 2	Hospital admissions: ischemic stroke, hemorrhagic stroke	**Individual or daily level:** sex, age (< or > 78yrs), season (warm: May-Sep., cold: Oct.-Apr), smoking status (yes, no, unknown), city resident (yes, no)	Time series and case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Peel et al. (2007) [90]	Atlanta, GA, US (1993-2000)	PM_{10}. Lag 02	Emergency department visits: ischemic heart disease, dysrhythmia, peripheral and cerebro-vascular disease, CHF	**Individual or daily level**: secondary diagnosis (hypertension, diabetes, COPD, dysrhythmia)	Case-crossover. Stratification for effect modification.	Hypertension (+): CHF CHF (-): ischemic heart disease
Qorbani et al. (2012) [91]	Tehran, Iran (Apr. 4-Sep. 10, 2007)	PM_{10}. Lag 0 (24hrs before onset)	Emergency hospital admissions: first episode of acute coronary syndrome (n=250)	**Individual or daily level:** age (<60, >60), sex, diabetes, hypertension, smoking (never, current, former)	Case crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.

Ren et al. (2006) [92]	Brisbane, Australia (1996-2001)	PM_{10}. Lag 0, 1, 2	Hospital admissions: CVD, respiratory. Emergency hospital visits: CVD, respiratory. Mortality: total, CVD	**Individual or daily level:** maximum temperature.	Time-series. Bivariate response surface model, nonstratifica-tion parametric model, and stratification parametric model for effect modification.	Temperature (+): respiratory hospital admissions, CVD emergency hospital visits, respiratory emergency, total mortality, CVD mortality
Silverman and Ito (2010) [93]	New York, NY, US (Apr.-Aug. for 1999-2006)	$PM_{2.5}$. Lag 01	Urgent or emergency asthma hospital admissions: ICU, non-ICU	**Individual or daily level**: age (<6, 6-18, 19-49, >50yrs)	Time series. □2 test of heterogeneity on pollution risks across age groups.	Age with highest risk estimate in school-age children (6-18yrs), then generally decreasing with age.
Sousa et al. (2012) [94]	Rio de Janeiro, Brazil (9/00-12/05)	PM_{10}. Lag 0, 1, 2, 3, 4, 5, 6, 7	Emergency hospital admissions: respiratory	**Individual or daily level**: age (<1, 1-5, >65yrs)	Time series. Stratification for effect modification.	No statistically significant evidence of effect modification.
Stieb et al (2000) [95]	Saint John, Canada (1992-1996)	PM_{10}, $PM_{2.5}$. Single day and multiple-day lags up to 10 days previous	Emergency department visits: cardiac (MI/angina, CHF, dysrhythmia/conduction disturbance, total cardiac), respiratory (asthma, COPD, respiratory infection, total respiratory)	**Individual or daily level:** season (all year vs. May-Sep.), presentation of complaint for asthma (yes, no), visit resulted in hospital admission (yes, no), smoking status (yes, no), smoker in household (yes, no), time outdoors in previous week (<2, 2-4, >4 hrs), asthma status (mild, moderate, severe), asthma medication use for asthmatics (yes, no)	Time series. Stratification for effect modification.	Presented complaint of asthma (+)

Tramuto et al. (2011) [96]	Palermo, Italy (2004-2007)	PM_{10}. Lag 0, 1, 2, 3, 4, 5	Emergency room admissions: respiratory, for persons >16yrs	**Individual or daily level**: season (warm: Apr.-Sep., cool: Oct.-Mar.), sex, age (16-44, 45-54, 55-64, 65-74, 75-84, >85yrs)	Case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Tsai et al. (2012) [97]	Taipei, Taiwan (1999-2009)	PM_{10}. Lag 02	Hospital admissions: MI	**Individual or daily level:** secondary CVD diagnosis (hypertension, diabetes, CHF, arrhythmias), weather (warm vs. cool days)	Case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Villeneuve et al. (2012) [98]	Edmonton, Canada (2003-2009)	$PM_{2.5}$. Lag 0, 1, 02	Hospital visits: stroke, ischemic stroke, hemorrhagic stroke, transient ischemic attack	**Individual or daily level:** season (warm: Apr.-Sep., cool: Oct.-Mar.)	Case-crossover. Stratification for effect modification.	No statistically significant evidence of effect modification.
Wellenius et al. (2005) [99]	Allegheny County, PA, US (1987–1999)	PM_{10}. Lag 0	Hospital admission: CHF, for persons >65yrs	**Individual or daily level**: age (65-79, >80yrs), sex, secondary diagnoses of atrial fibrillation other cardiac arrhythmias, COPD, essential hypertension, type 2 diabetes, AMI within the past 30 days, old MI, angina pectoris, other ischemic heart disease, and acute respiratory infections	Case-crossover. Interaction terms for effect modification.	Recent MI (+)

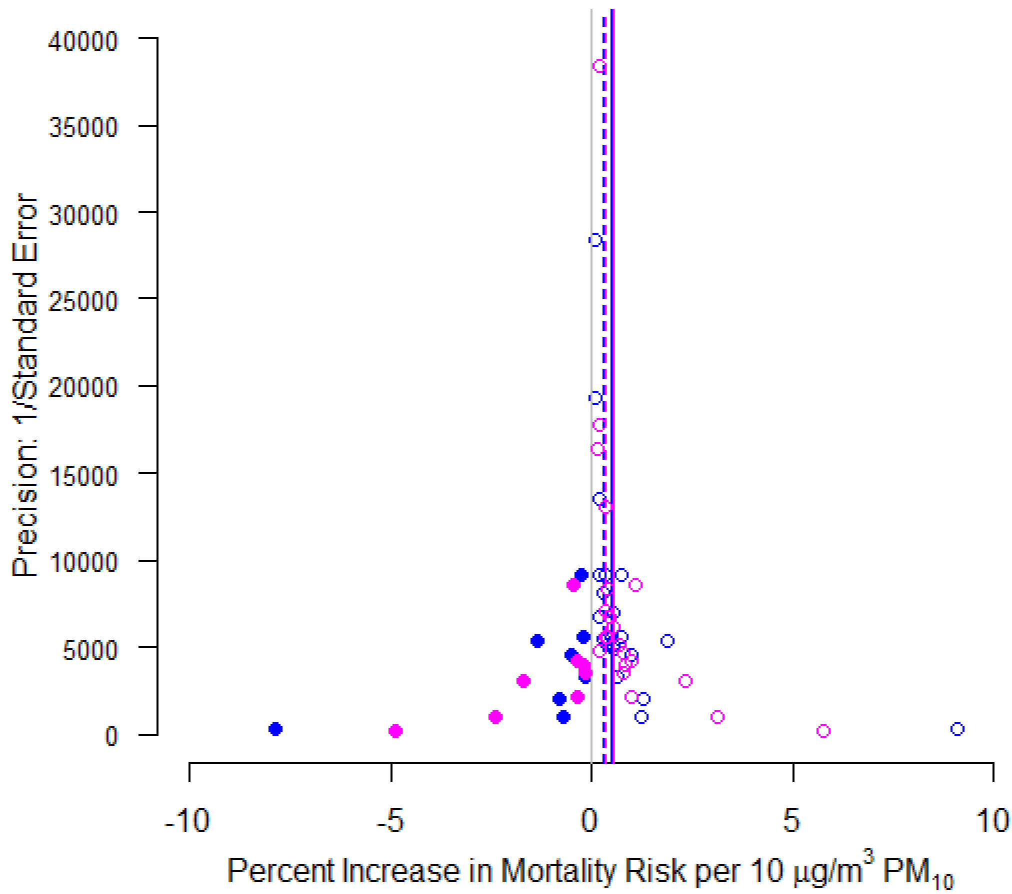
Wellenius et al (2006) [100]	7 US cities (1986–1999)	PM_{10}. Lag 0	Hospital admission: CHF, for persons >65yrs	**Individual or daily level:** age (65-79, >80yrs), sex, race (white, other), secondary diagnoses (type 2 diabetes mellitus, AMI within the past 30 days, acute respiratory infection, COPD, cardiac arrhythmias, essential hypertension)	City-specific case-crossover. Random effects to generate overall estimates.	Hypertension (-)
Wong et al. (2002) [101]	London (1992-1994), Hong Kong (1995-1997)	PM_{10}. Lag 01	Emergency hospital admissions: asthma (15-64yrs), respiratory (>65yrs), cardiac (all ages), ischemic heart disease (all ages)	**Individual or daily level:** season (warm: Apr.-Sep., cool: Oct.-Mar.)	City-specific time series. Interaction terms for effect modification.	Season: Higher in cool period: cardiac Higher in warm period: respiratory for London
Wong et al. (2009) [102]	Hong Kong, (1996–2002)	PM_{10}. Lag 01	Hospital admissions: CVD, respiratory, acute respiratory disease, COPD. Mortality: COPD, CVD, respiratory	**Individual or daily level:** sex **Community level:** influenza intensity based on proportions of specimens positive for influenza	Time series. Interaction terms for effect modification for influenza intensity. Stratification for effect modification by sex.	No statistically significant evidence of effect modification.

Zanobetti, et al. (2000) [103]	Chicago, IL, US (1985-1994)	PM_{10}. Lag 01	Hospital admissions: CVD, COPD, pneumonia	**Individual or daily level:** age (≤75 vs. >75), sex, race (white, other), previous admission or secondary diagnosis (COPD, asthma, acute bronchitis, acute respiratory illness, pneumonia, MI, CHF, conduction disorders, dyshrethmias)	Time series. Stratification for effect modification.	Acute respiratory illness (+): CVD Conduction disorders (+): CVD, pneumonia Dyshrethmias (+): pneumonia Previous CVD admissions (+): COPD Heart failure (+): COPD
Zanobetti et al. (2000) [104]	10 US cities (1986-1994)	PM_{10}	Hospital admissions: pneumonia, COPD for persons >65yrs	**Community level:** race (white, other), % in poverty, temperature, humidity	City-specific time-series. Inverse-variance weighted meta-regression to estimate overall associations and investigate effect modification.	Humidity (+): COPD
Zanobetti et al. (2001) [105]	Cook County, IL, US (1988-1994)	PM_{10}. Lag 01	Hospital admissions: CVD, pneumonia, COPD	**Individual or daily level:** diabetes, age (<75, >75yrs)	Time series. Stratification for effect modification	Diabetes (+): CVD
Zanobetti et al. (2002) [106]	3 US cities (Chicago, Detroit, Pittsburgh) (1988-1994)	PM_{10}. Lag 01	Hospital admissions: CVD, for persons >65yrs	Individual or daily level: age (75-74, >75yrs), secondary diagnosis of diabetes	City-specific time series. Stratification by age and diabetes status for effect modification in city-specific models. Second stage meta-regression with interaction terms for effect modification.	Diabetes (+): Chicago or overall risk across 4 cities Age (+): overall risk for persons without diabetes.

Zanobetti et al. (2005) [107]	21 US cities (1985–1999)	PM_{10}. Lag 0	Hospital admissions: MI, for persons >65yrs	**Individual or daily level:** sex, age (< 75, >75yrs), previous admission (atrial fibrillation, COPD, diabetes, CHF), secondary diagnosis of pneumonia	City-specific case-crossover. Stratification for effect modification. Meta-regression to estimate overall sasociations.	No statistically significant evidence of effect modification.
Zanobetti et al. (2009) [108]	26 US cities (2000-2003)	$PM_{2.5}$. Lag 01	Emergency hospital admissions: CVD, MI, CHF, respiratory disease, diabetes	**Individual or daily level:** season Community level: income, poverty, education (<high school, >high school), poverty (% >65yrs in poverty), prevalence of central AC, fraction of PM2.5 that is: As, Al, Br, Cr, Fe, Pb, Mn, Ni, K, Si, V, Zn, nitrate, sulfate, ammonium, sodium ion, EC, organic carbon	City-specific time-series. Random effects meta-analysis to estimate overall associations.	Season: higher in spring than summer for CVD, higher in spring than summer or autumn for CHF. Br (+): CVD V (+): CVD Al (+): CVD, CHF Ni (+): CVD, MI, CHF, respiratory Organic carbon (+): MI, diabetes As (+): MI Cr (+): MI Na+ (+): CVD, MI, respiratory Mn (+): MI K(+): MI EC (+): diabetes As (+): diabetes sulfate (+): diabetes

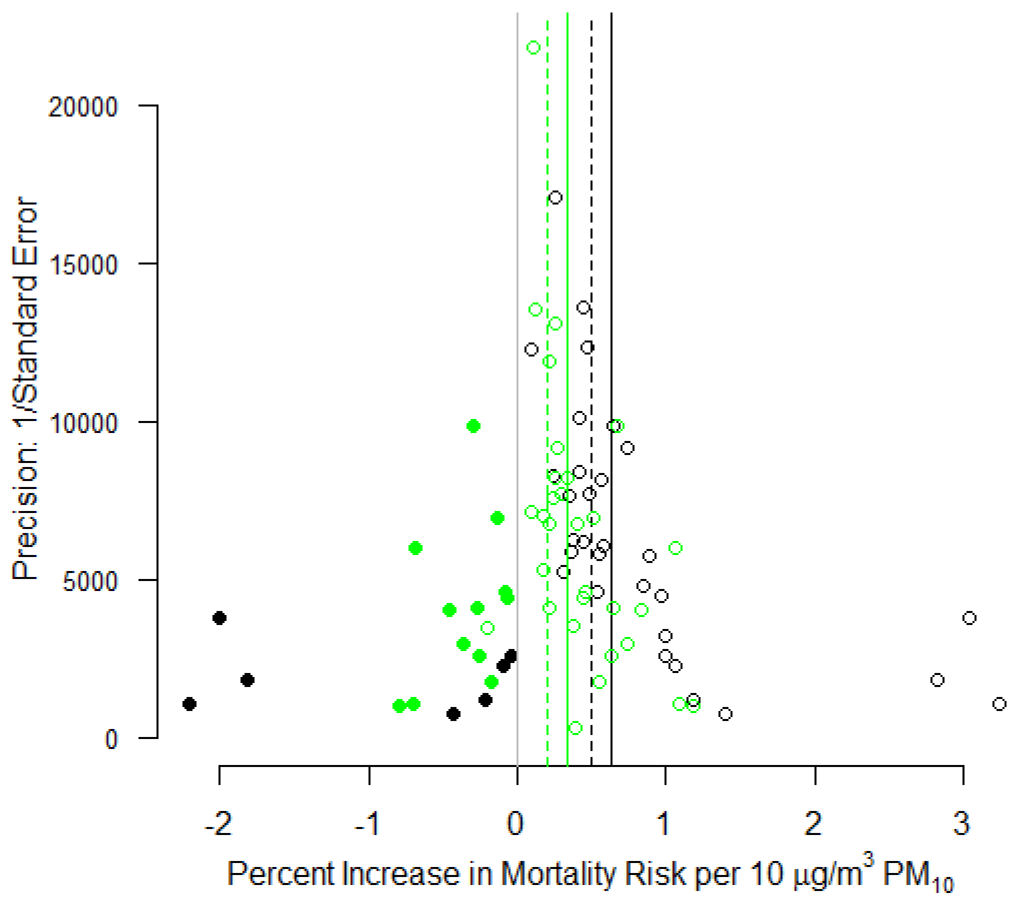
Web Figure 1. Funnel plot of effect modification by sex

Note: Blue lines and points reflect results for men; pink lines and points reflect results for women. Open circles reflect observed estimates from the studies; closed circles reflect "filled" studies from the "trim and fill" method. Solid blue and pink vertical lines represent the overall risk estimates for men and women, respectively; dashed vertical lines represent the overall risk estimates adjusted for publication bias. The gray vertical line represents the null (i.e., no association).



Web Figure 2. Funnel plot of effect modification by age

Note: Black lines and points reflect results for older populations; green lines and points reflect results for younger populations. Open circles reflect observed estimates from the studies; closed circles reflect "filled" studies from the "trim and fill" method. Solid black and green vertical lines represent the overall risk estimates for older and younger populations, respectively; dashed vertical lines represent the overall risk estimates adjusted for publication bias. The gray vertical line represents the null (i.e., no association).



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