



APPENDICES AVAILABLE ON THE HEI WEBSITE

Special Report 23

Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

HEI Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

Chapter 11: Traffic-Related Air Pollution and Mortality

These Appendices were reviewed solely for spelling, grammar, and cross-references to the main text. They have not been formatted or fully edited by HEI. This document was part of the HEI Panel's review process.

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Chapter 11: Traffic-Related Air Pollution and Mortality
Appendices: Additional Figures and Tables

Appendix 11A All-Cause Mortality

Appendix 11B Cause-Specific Mortality

Appendix 11C References for Studies Included in the Systematic Review of Mortality

Appendix 11A All-cause Mortality

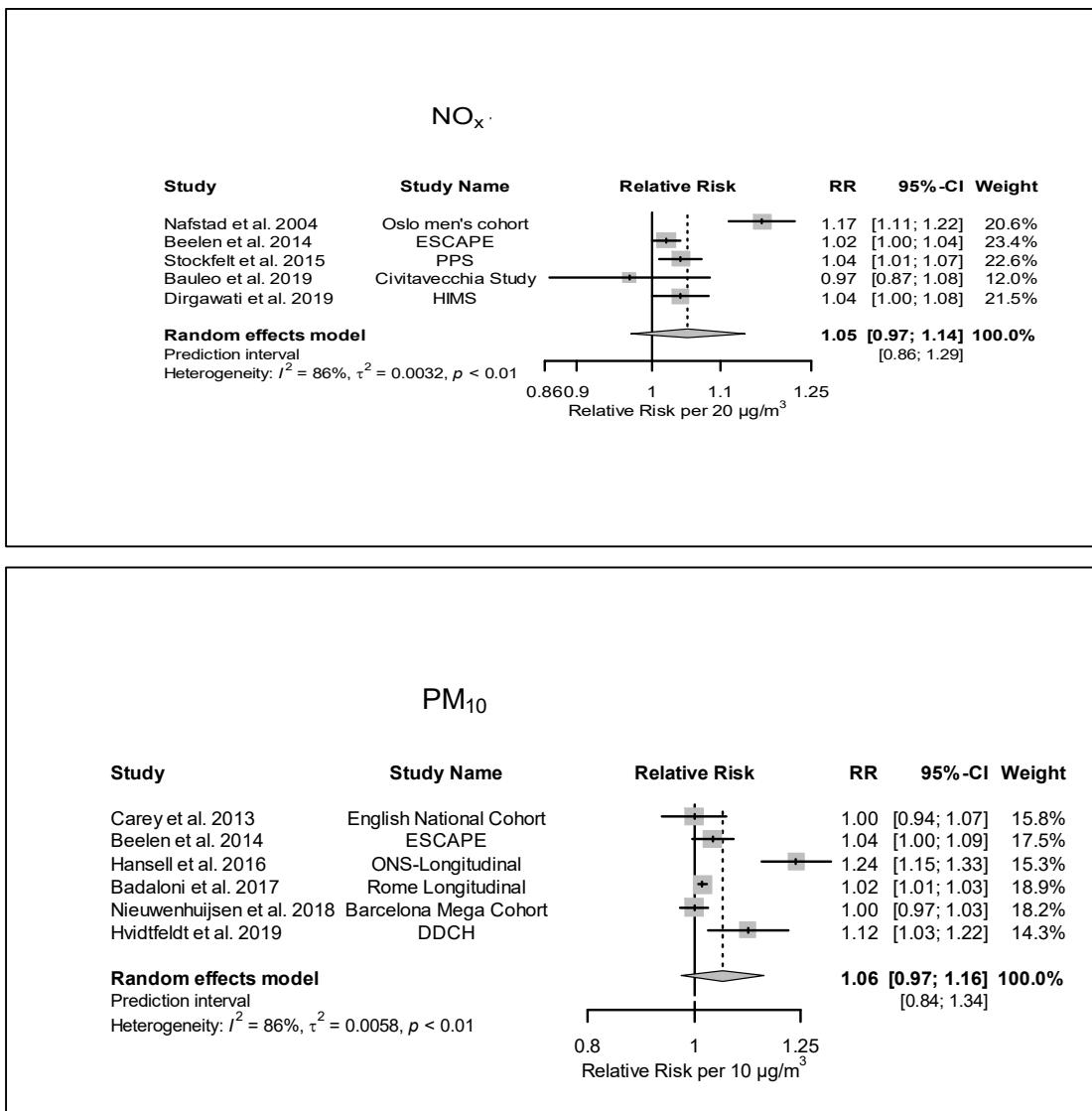


Figure 11A-1. Association between NO_x, PM₁₀, PM_{2.5} Cu, and PM_{2.5} Fe and all-cause mortality: primary meta-analysis. Figure continues next page.

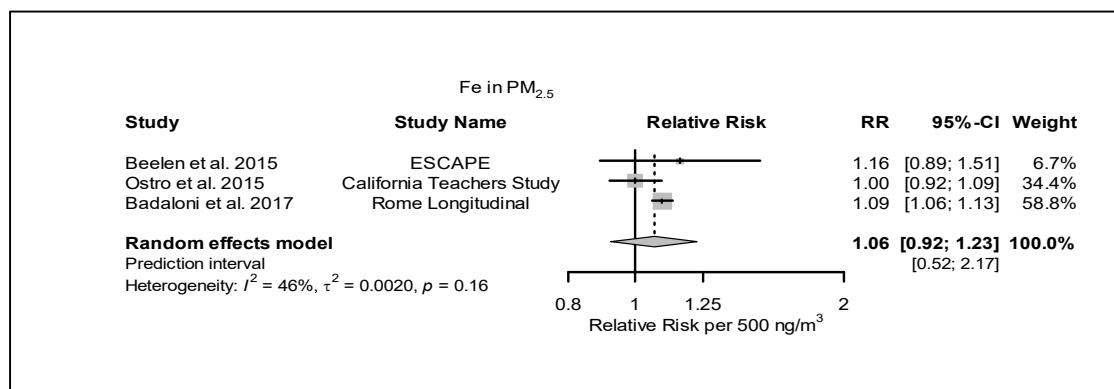
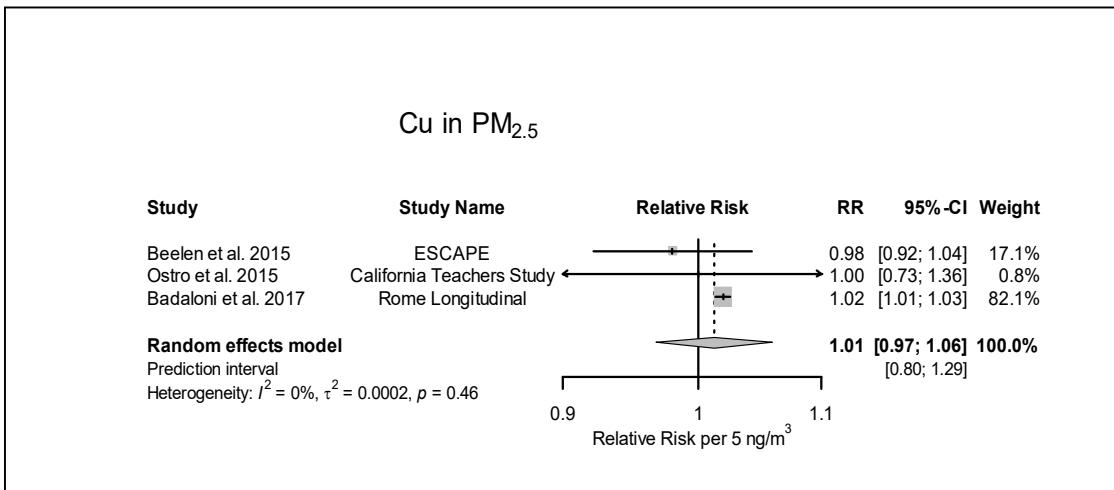


Figure 11A-1. (Continued).

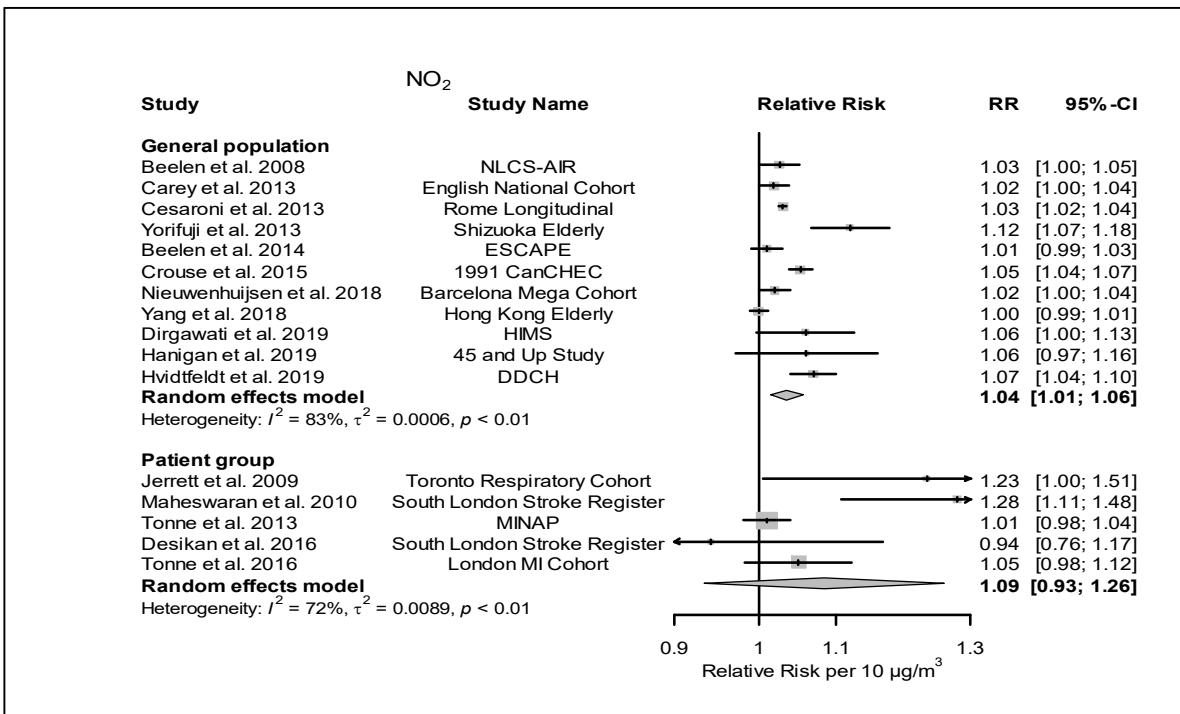
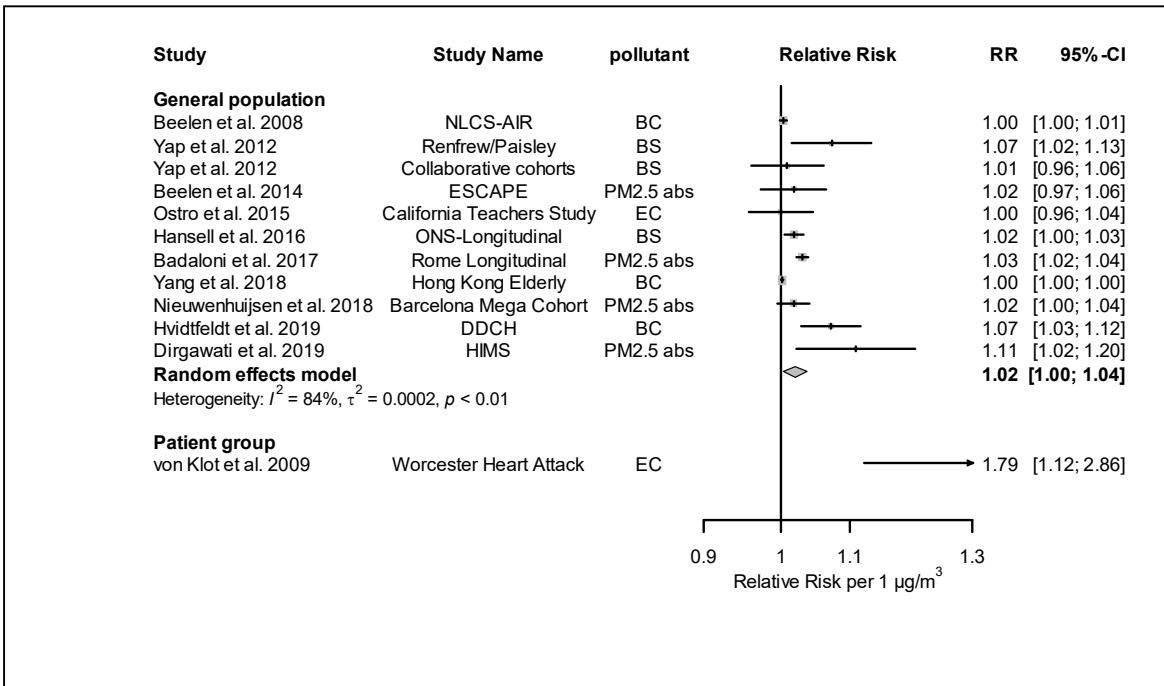
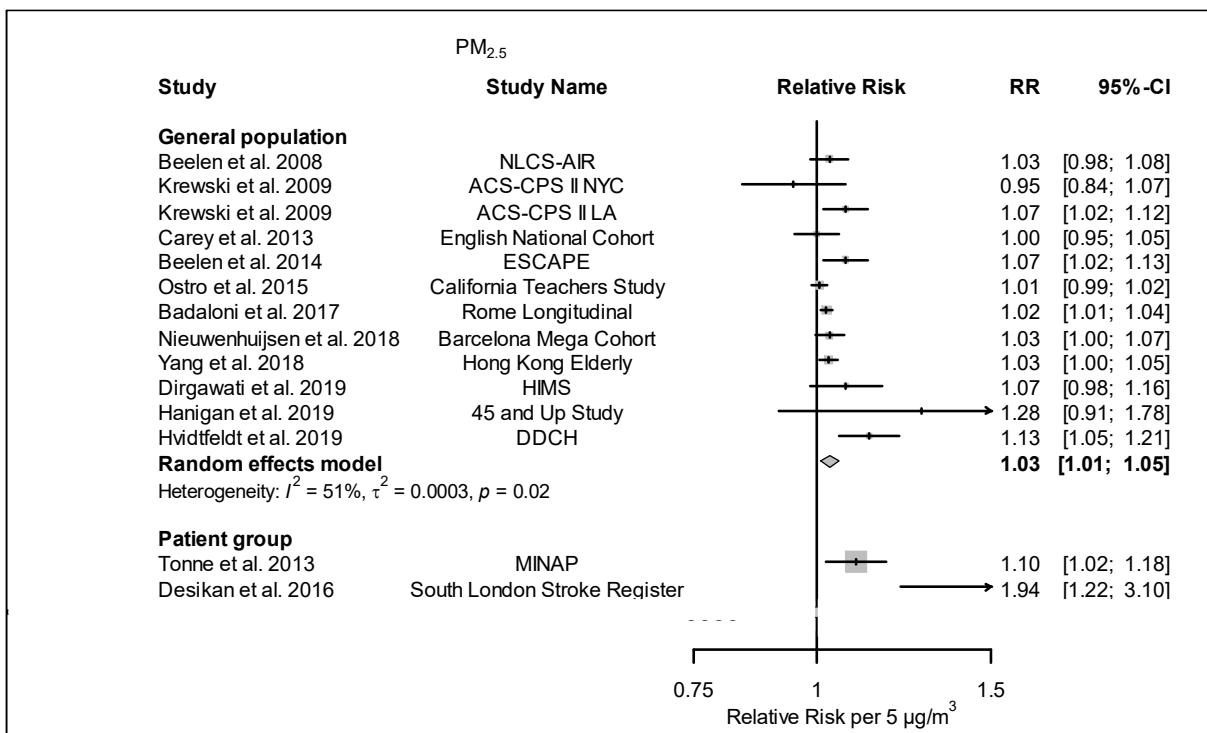
**EC**

Figure 11A-2. Association between NO_2 , EC, and $\text{PM}_{2.5}$ and all-cause mortality: meta-analysis in general population and patient groups. Figure continues next page.

**Figure 11A-2.** (Continued).

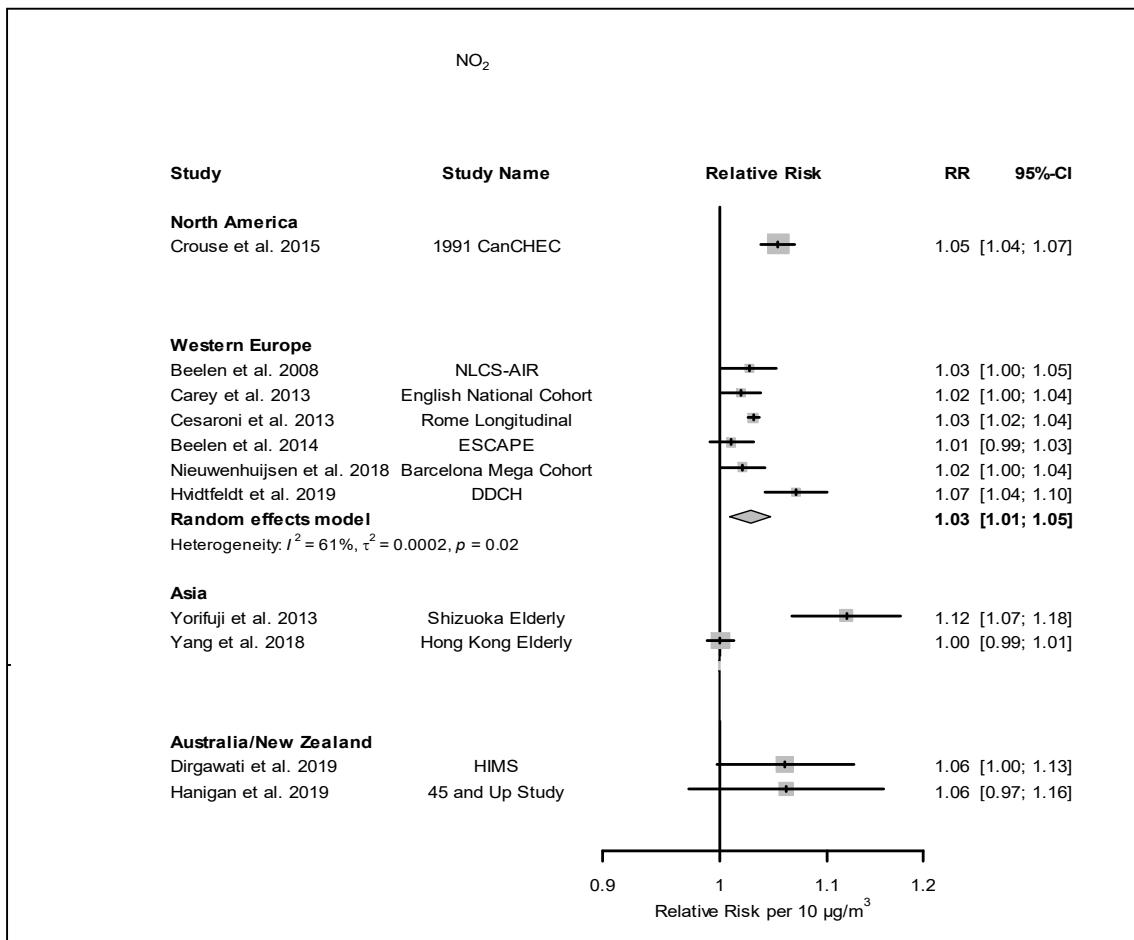
**Figure 11A-3. Association between NO_2 , EC, and $\text{PM}_{2.5}$ and all-cause mortality: meta-analysis by region.**

Figure continues next page.

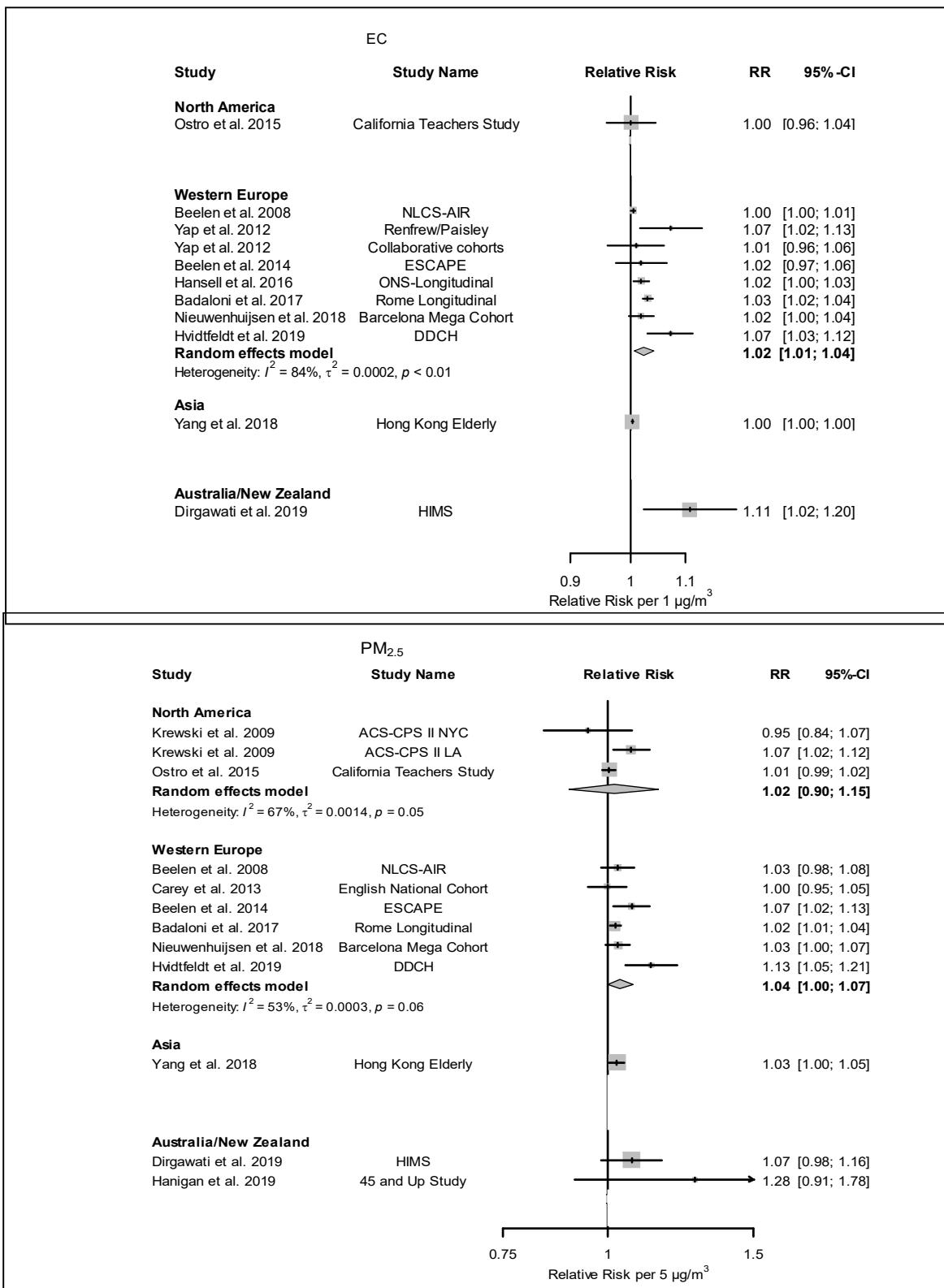


Figure 11A-3. (Continued).

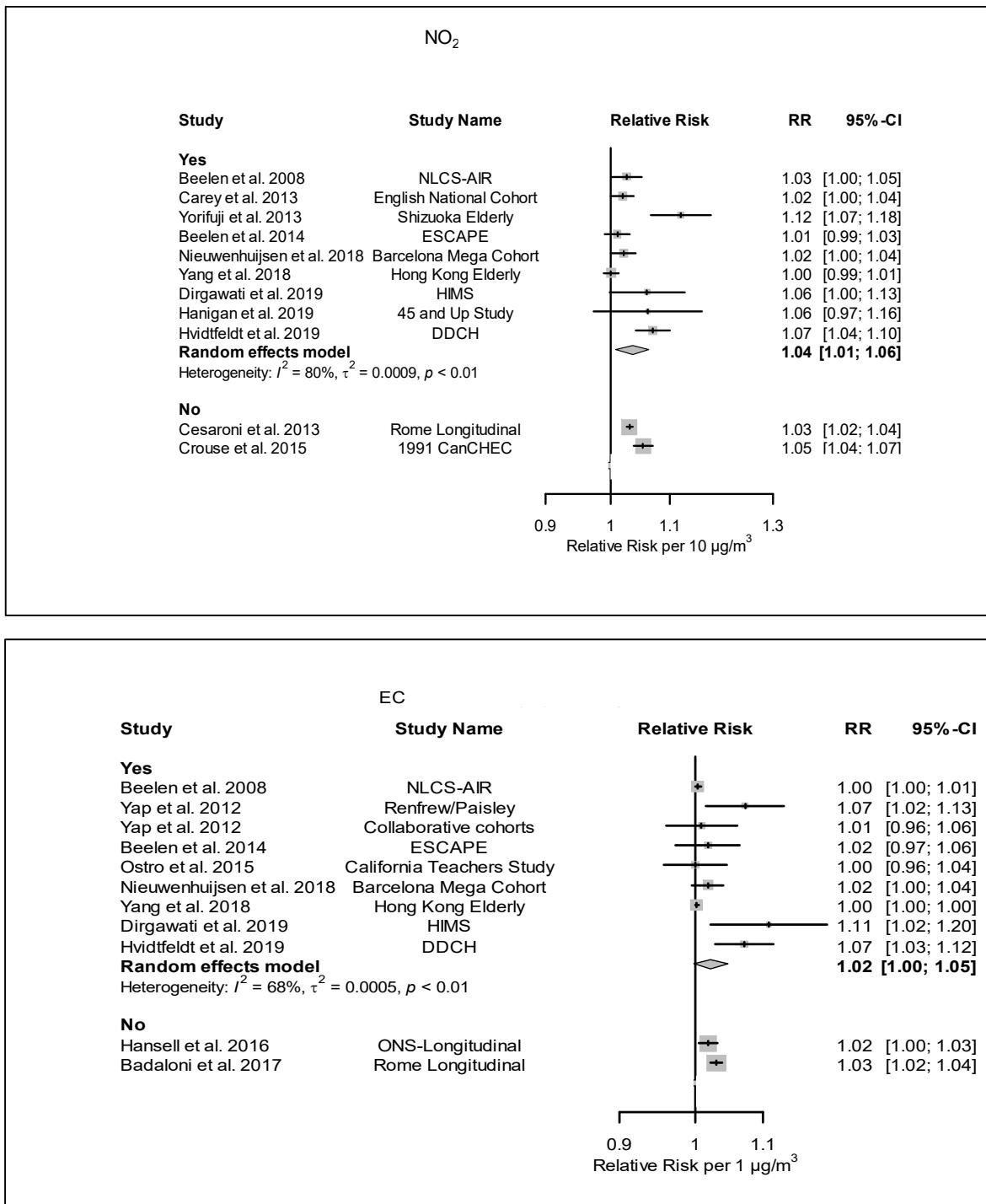


Figure 11A-4. Association between NO_2 , EC, and $\text{PM}_{2.5}$ and all-cause mortality: meta-analysis by individual smoking adjustment. Figure continues next page.

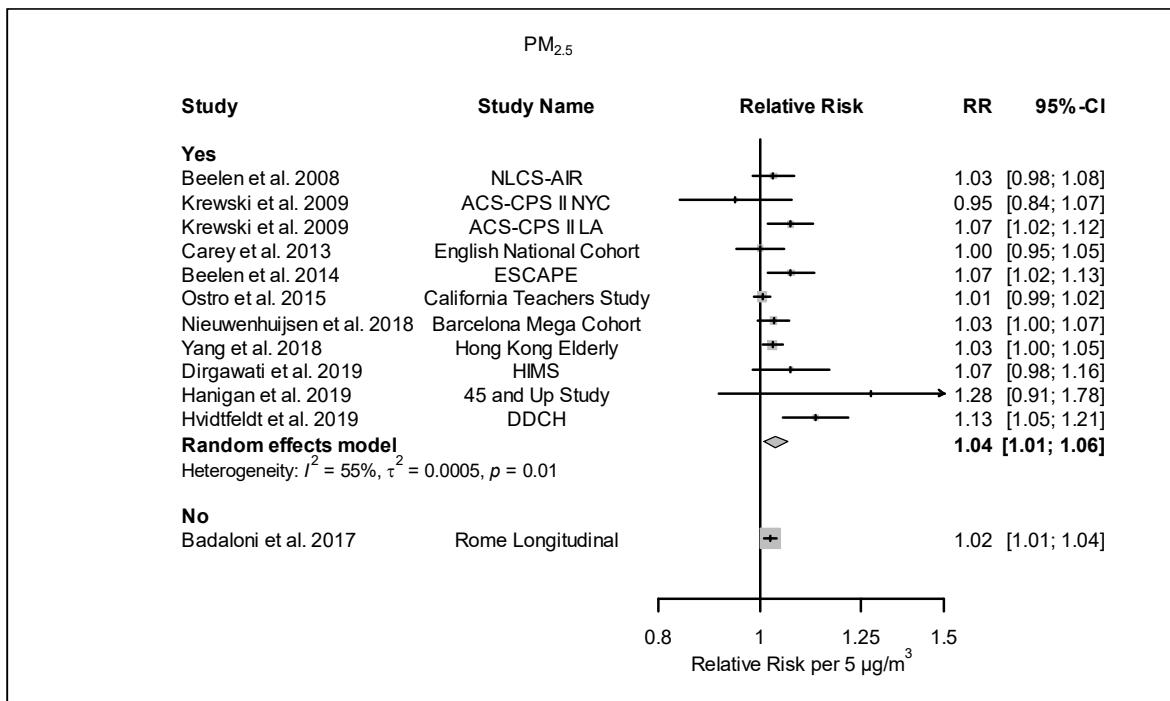
**Figure 11A-4.** (Continued).

Table 11A-1. Noise-adjusted Analyses of All-cause Mortality

Reference	Study Name	Pollutant	Increment	Single Pollutant	Noise-adjusted
Hvidtfeldt 2019	DDCH	NO ₂	10 µg/m ³	1.07 (1.04, 1.10)	1.05 (1.01, 1.09)
		BC	1 µg/m ³	1.09 (1.04, 1.15)	1.04 (0.98, 1.11)
		PM ₁₀ mass	10 µg/m ³	1.12 (1.03, 1.22)	1.03 (0.94, 1.14)
		PM _{2.5} mass	5 µg/m ³	1.13 (1.05, 1.21)	1.06 (0.98, 1.15)
Nieuwenhuijsen 2018	Barcelona Mega Cohort	NO ₂	5 µg/m ³	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)
		PM _{2.5} abs	1 1×10 ⁻⁵ /m	1.02 (1.00, 1.05)	1.03 (1.00, 1.06)
		PM _{2.5} mass	5 µg/m ³	1.03 (0.99, 1.06)	1.03 (0.99, 1.06)
Raaschou-Nielsen 2012	DDCH	NO ₂	1 µg/m ³	1.08 (0.98, 1.18)	1.08 (0.98, 1.18)
		Density	1 vehicle-km/day	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)
		Distance	<50 vs. >50 m	0.94 (0.85, 1.05)	0.94 (0.85, 1.05)
Tonne 2016	London MI Cohort ^a	NO ₂	8 µg/m ³	1.04 (0.99, 1.10)	1.04 (0.97, 1.10)
		NO _x	19.2 µg/m ³	1.03 (0.98, 1.08)	1.02 (0.97, 1.08)
		traffic PM _{2.5}	0.3 µg/m ³	1.02 (0.98, 1.07)	1.02 (0.97, 1.06)
		nontailpipe PM _{2.5}	0.3 µg/m ³	1.04 (1.00, 1.09)	1.04 (0.99, 1.09)

^a Indicates a patient population.

Table 11A-2. Risk of Bias Assessment for Studies Included in Meta-Analysis: All-cause Mortality

Reference	Study Name	Confounding	Selection Bias	Exposure Assessment	Outcome Measurement	Missing Data	Selective Reporting
Badaloni 2017	Rome Longitudinal	High	Low	Mod	Low	Low	Low
Bauleo 2019	Civitavecchia Study	High	Low	Mod	Low	Low	Low
Beelen 2008	NLCS-AIR	Mod	Low	Mod	Low	Low	Low
Beelen 2014a	ESCAPE	Low	Low	Mod	Low	Low	Low
Beelen 2015	ESCAPE	Low	Low	Mod	Low	Low	Low
Carey 2013	English National Cohort	Mod	Mod	Low	Low	Low	Low
Cesaroni 2013	Rome Longitudinal	High	Low	Low	Low	Low	Low
Crouse 2015	1991 CanCHEC	Mod	Low	Mod	Low	Low	Low
Dirgawati 2019	HIMS	Low	Low	Mod	Low	Low	Low
Hanigan 2019	45 and Up Study	Low	Low	Mod	Low	Low	Low
Hansell 2016	ONS-Longitudinal	High	Low	Low	Low	High	Low
Hvidtfeldt 2019	DDCH	Low	Low	Low	Low	Low	Low
Krewski 2009	ACS-CPS II LA	Low	Low	Mod	Low	Low	Low
Krewski 2009	ACS-CPS II NYC	Low	Low	Mod	Low	Low	Low
Nafstad 2004	Oslo men's cohort	Mod	Low	Low	Low	Low	Low
Nieuwenhuijsen 2018	Barcelona Mega Cohort	High	Low	Low	Low	Low	Low
Ostro 2015	California Teachers Study	Low	Low	Low	Low	Low	Low
Stockfelt 2015	PPS	Low	Low	Low	Low	Low	Low
Yang 2018	Hong Kong Elderly	Low	Mod	Mod	Low	Low	Low
Yap 2012	Renfrew/Paisley	Low	Low	High	Low	Low	Low
Yap 2012	Collaborative cohorts	Low	Low	High	Low	Low	Low
Yorifuji 2013	Shizuoka Elderly	Low	High	Low	Low	High	Low

Mod = moderate.

Table 11A-3. Exposure–Response Assessment Used for Upgrading Confidence^a

Reference	Pollutant	All-cause	Circulatory	Respiratory	Lung Cancer	IHD	Stroke	COPD
Badaloni 2017	PM _{2.5} , PM ₁₀ , PM _{2.5} abs, PM _{2.5} Cu, PM _{2.5} Fe, PM _{2.5} Zn	NA	NA	NA	NA	NA	NA	NA
Bauleo 2019	NO _x	NA	NA	NA	NA	NA	NA	NA
Beelen 2008	NO ₂ , BC, PM _{2.5}	NA	NA	NA	NA	NA	NA	NA
Beelen 2009	Distance, density	NA	NA	NA	NA	NA	NA	NA
Beelen 2014a	PM _{2.5} , PM ₁₀ , NO _x	+	NA	NA	NA	NA	NA	NA
Beelen 2014a	PM _{coarse} , PM _{2.5} abs, NO ₂	0	NA	NA	NA	NA	NA	NA
Beelen 2014b	NO ₂ , NO _x , PM _{2.5} abs, PM _{2.5} , PM ₁₀ , PM _{coarse}	NA	0	NA	NA	0	0	NA
Beelen 2015	PM _{2.5} Cu, PM _{2.5} Fe, PM _{2.5} Zn	0	NA	NA	NA	NA	NA	NA
Cakmak 2019	Distance	NA	NA	NA	NA	NA	NA	NA
Carey 2013	NO ₂ , PM _{2.5} , PM ₁₀	NA	NA	NA	NA	NA	NA	NA
Cesaroni 2013	NO ₂	+	+	+	+	+	0	NA
Cesaroni 2013	PM _{2.5}	+	+	+	+	+	+	NA
Chen 2013	NO ₂	NA	+	NA	NA	+	0	NA
Cohen 2019	NO _x	NA	NA	NA	NA	NA	NA	NA
Crouse 2015	NO ₂	+	+	+	NA	+	0	NA
Desikan 2016 ^b	NO ₂ , NO _x , NO, PM _{2.5} , PM ₁₀	NA	NA	NA	NA	NA	NA	NA
Dimakopoulou 2014	NO ₂ , NO _x , PM _{2.5} abs, PM _{2.5} , PM ₁₀ , PM _{coarse} , density	NA	NA	0	NA	NA	NA	NA
Dirgawati 2019	PM _{2.5} , NO ₂ , BC, NO _x	+	NA	NA	NA	NA	NA	NA
Finkelstein 2004 ^b	Distance	NA	NA	NA	NA	NA	NA	NA
Finkelstein 2005 ^b	Distance	NA	NA	NA	NA	NA	NA	NA
Gehring 2006	Distance	NA	NA	NA	NA	NA	NA	NA
Hanigan 2019	PM _{2.5} , NO ₂	0	NA	NA	NA	NA	NA	NA
Hansell 2016	BS	+	+	+	NA	NA	NA	NA
Heinrich 2013	Distance	NA	NA	NA	NA	NA	NA	NA
Huss 2010	PM ₁₀	NA	NA	NA	NA	NA	NA	NA
Hvidtfeldt 2019	PM _{2.5}	+	+	0	NA	NA	NA	NA
Hvidtfeldt 2019	NO ₂	+	+	0	NA	NA	NA	NA
Hvidtfeldt 2019	PM ₁₀	+	+	0	NA	NA	NA	NA

Reference	Pollutant	All-cause	Circulatory	Respiratory	Lung Cancer	IHD	Stroke	COPD
Hvidtfeldt 2019	BC	+	+	0	NA	NA	NA	NA
Jerrett 2009 ^b	NO ₂	NA	NA	NA	NA	NA	NA	NA
Jerrett 2017	PM _{2.5}	NA	+	NA	NA	NA	NA	NA
Kloog 2013	PM _{2.5}	NA	NA	NA	NA	NA	NA	NA
Krewski 2009	PM _{2.5} (LUR)	NA	NA	NA	NA	NA	NA	NA
Maheswaran 2010 ^b	NO ₂ , PM ₁₀	NA	NA	NA	NA	NA	NA	NA
Naess 2007a	NO ₂ , PM _{2.5} , PM ₁₀	NA	+	NA	+	NA	NA	+
Nafstad 2004	NO _x	+	NA	+	+	0	0	NA
Nieuwenhuijsen 2018	NO ₂ , PM _{2.5 abs} , PM _{2.5} , PM ₁₀	NA	NA	NA	NA	NA	NA	NA
Ostro 2015	EC, PM _{2.5} , PM _{2.5} Cu, PM _{2.5} Fe, PM _{0.1-0.01}	NA	NA	NA	NA	NA	NA	NA
Raaschou-Nielsen 2012	NO ₂	+	+	NA	NA	+	0	NA
Schikowski 2007	Distance	NA	NA	NA	NA	NA	NA	NA
Stockfelt 2015	NO _x	+	+	0	NA	+	0	NA
Tonne 2013 ^b	NO ₂ , NO _x , PM _{2.5} , PM ₁₀	NA	NA	NA	NA	NA	NA	NA
Tonne 2016 ^b	NO ₂ , NO _x , PM _{2.5}	NA	NA	NA	NA	NA	NA	NA
Villeneuve 2013	Benzene	+	+	+	+	NA	NA	NA
Von Klot 2009 ^b	EC	NA	NA	NA	NA	NA	NA	NA
Wang 2014	PM _{2.5} Cu, PM _{2.5} Fe, PM _{2.5} Zn	NA	0	NA	NA	0	0	NA
Wilker 2013 ^b	Distance	NA	NA	NA	NA	NA	NA	NA
Yang 2018	PM _{2.5} , BC	NR	+	0	NA	NA	NA	NA
Yang 2018	NO ₂	0	0	0	NA	NA	NA	NA
Yap 2012	BS	NA	NA	NA	NA	NA	NA	NA
Yorifuji 2010	NO ₂	NA	NA	NA	NA	NA	NA	NA
Yorifuji 2013	NO ₂	NA	NA	NA	NA	NA	NA	NA

+ indicates evidence of a monotonic exposure-response function; 0 absence of evidence; NA: not available. NR: not reported (not considered as sufficient evidence).

^a The Panel first assessed evidence from nonparametric spline functions, supplemented with a statistical test of deviation from linearity when available. If splines were not presented, the Panel assessed categorial exposure analyses and required a convincing trend, preferably supported by a trend test to support a judgment of a plausible exposure-response function. Finally, the Panel accepted a statement of no deviation from a linear function in the text obtained with an appropriate nonparametric procedure. To avoid upgrading null findings, the Panel only considered *no deviation from linear* as support if the linear association was at least borderline significant.

^b Indicates a patient population.

Appendix 11B Cause-specific Mortality

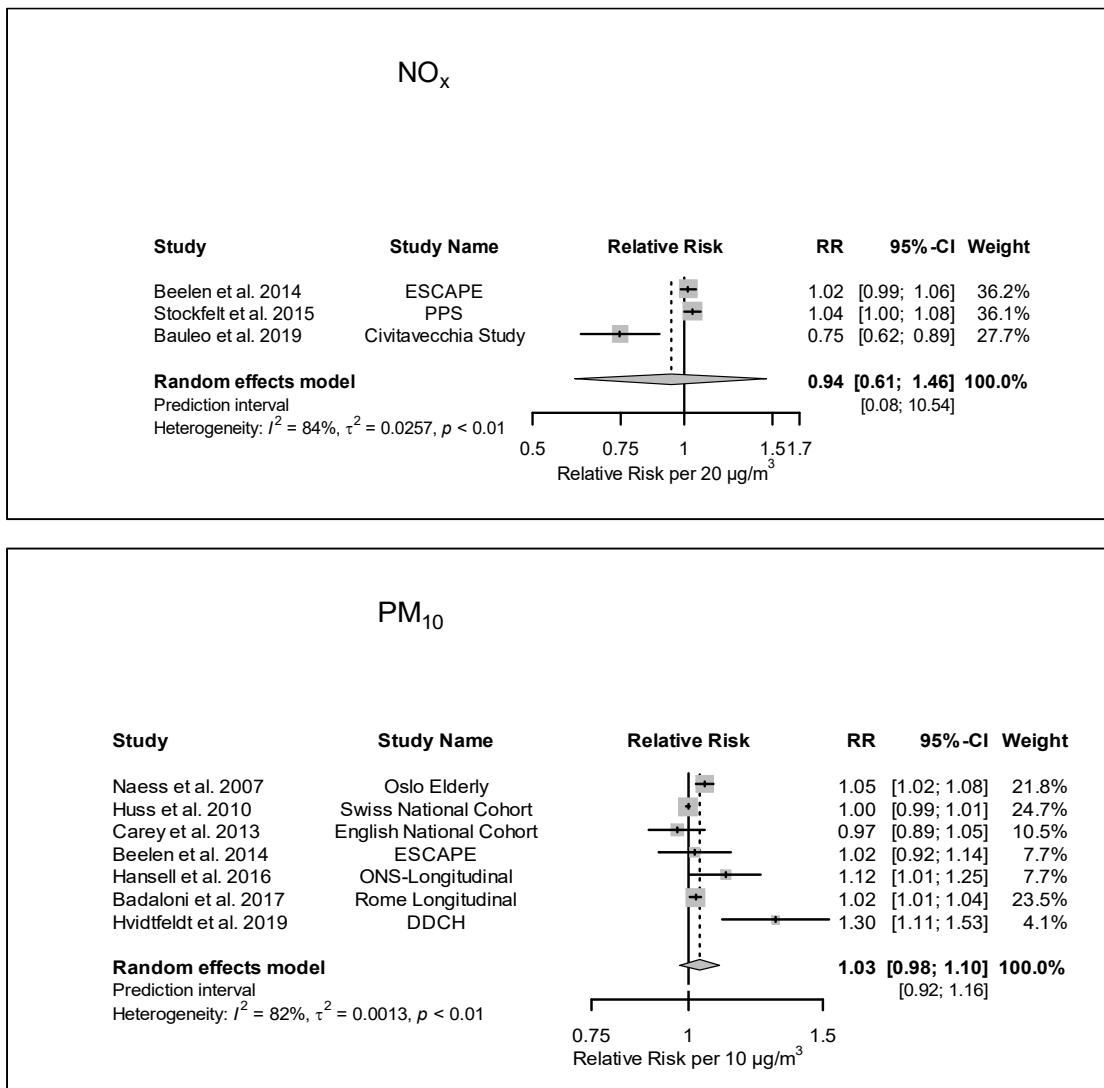


Figure 11B-1. Association between NO_x and PM₁₀ and circulatory mortality: primary meta-analysis.

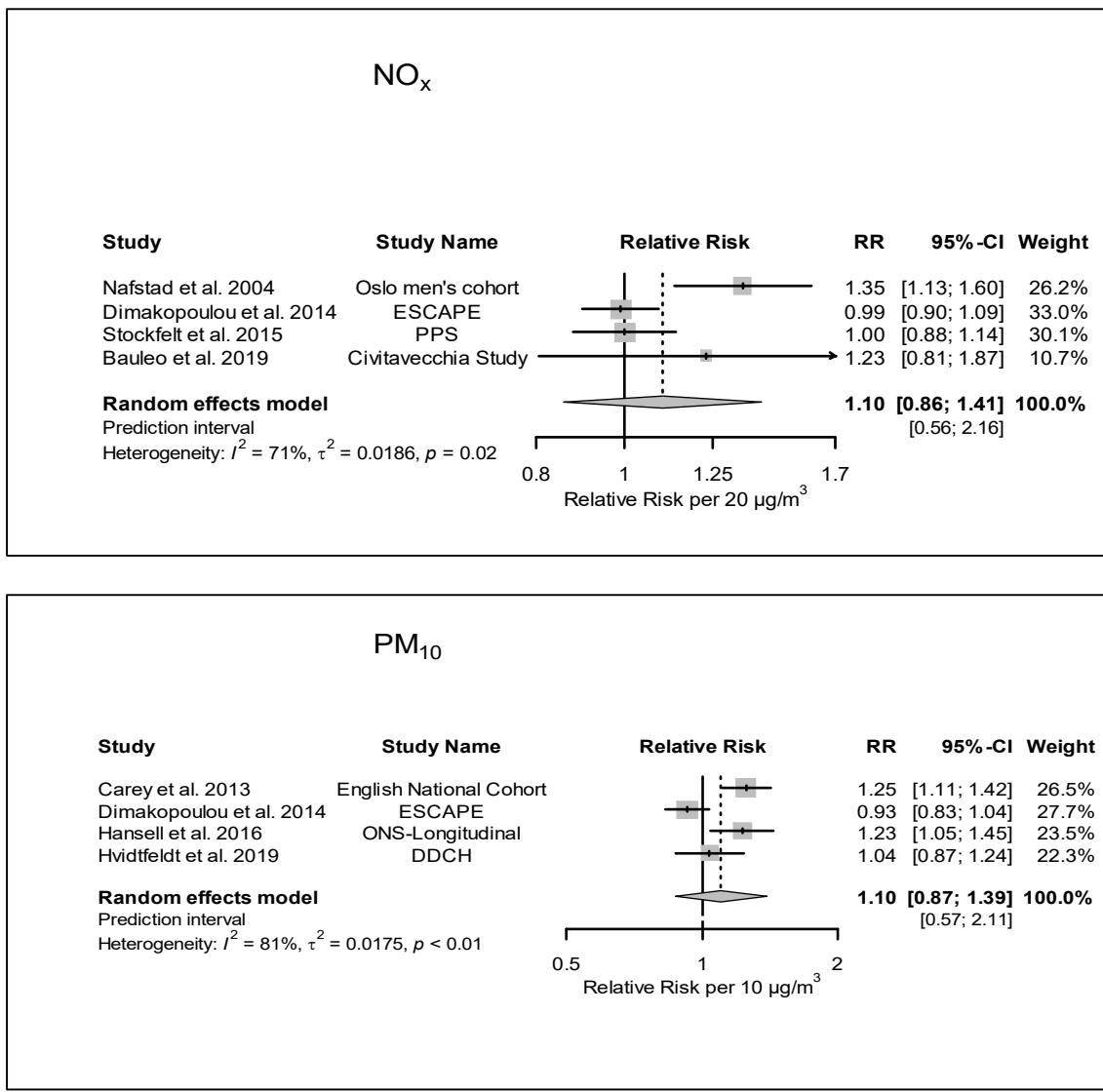


Figure 11B-2. Association between NO_x and PM₁₀ and respiratory mortality: primary meta-analysis.

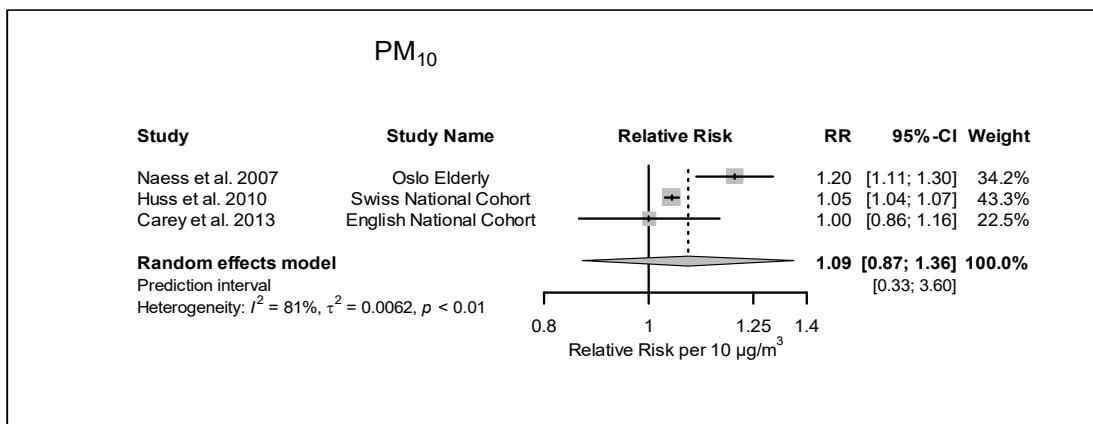


Figure 11B-3. Association between PM₁₀ and lung cancer mortality: primary meta-analysis.

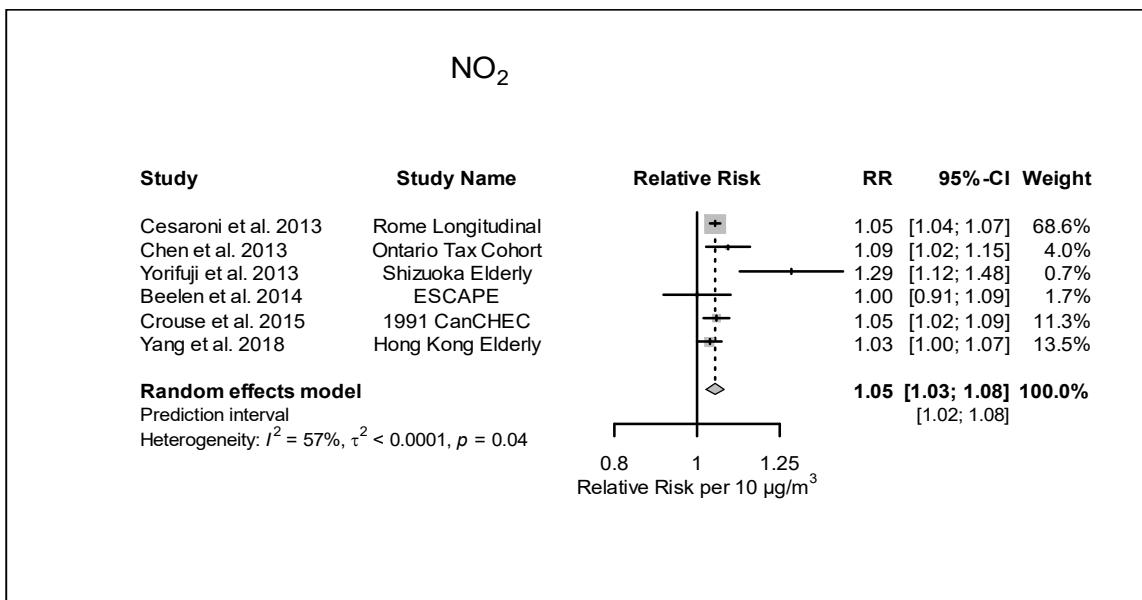
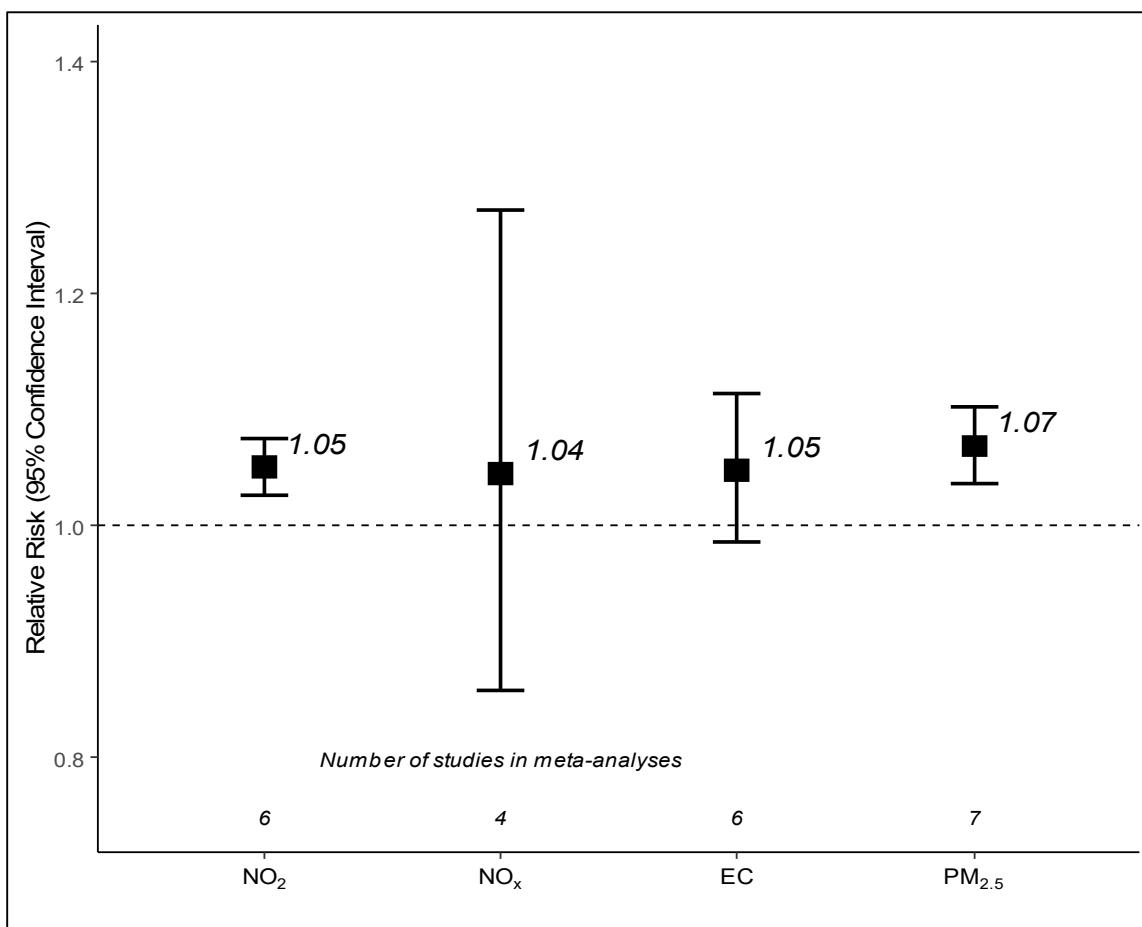


Figure 11B-4. Summary plot and primary meta-analysis for the association between ischemic heart disease mortality and NO_2 , NO_x , EC, and $\text{PM}_{2.5}$. The following increments were used: 10 $\mu\text{g}/\text{m}^3$ for NO_2 , 20 $\mu\text{g}/\text{m}^3$ for NO_x , 1 $\mu\text{g}/\text{m}^3$ for EC, and 5 $\mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$. Effect estimates cannot be directly compared across the different traffic-related pollutants because the selected increments do not necessarily represent the same contrast in exposure. *Figure continues next page.*

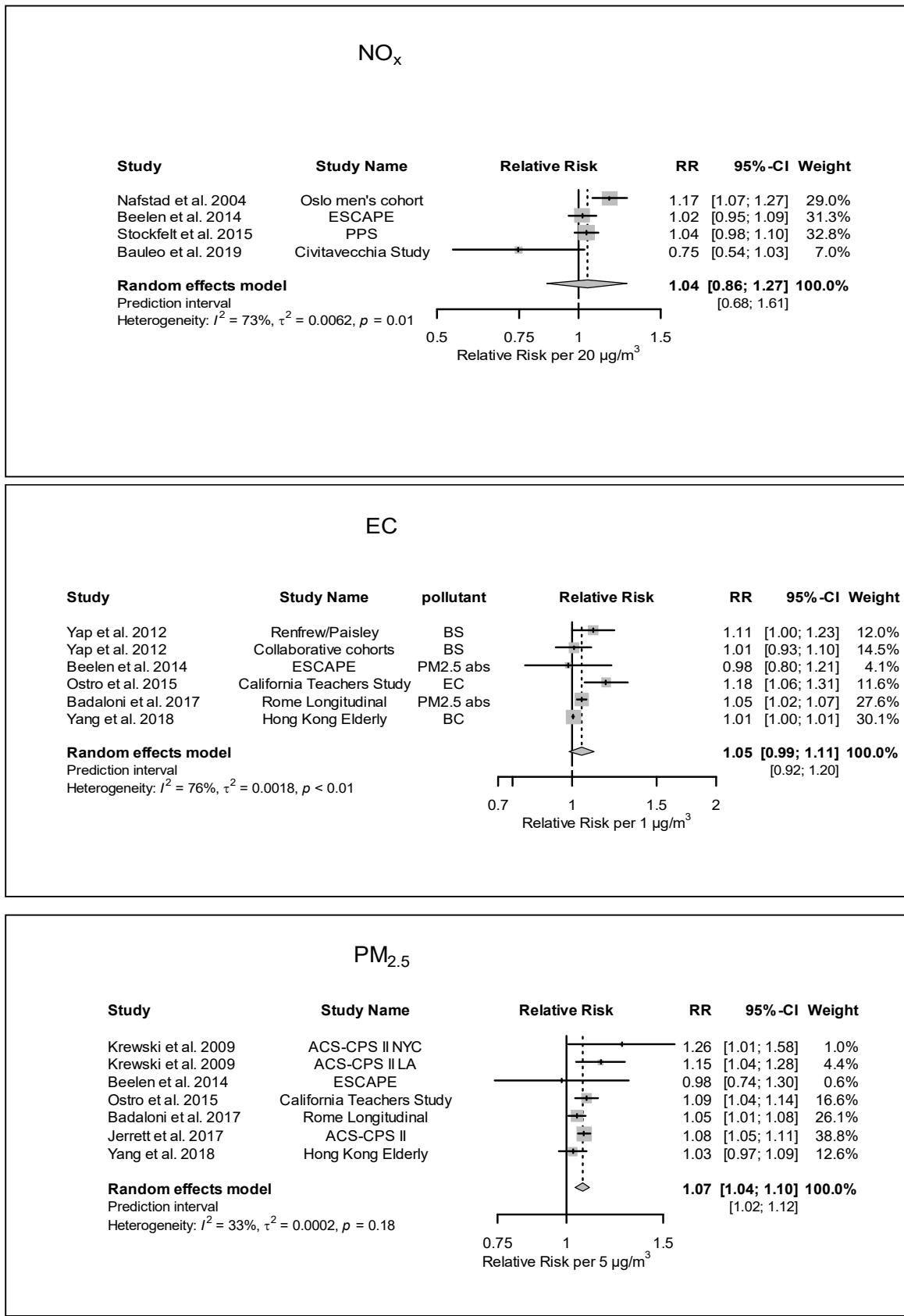


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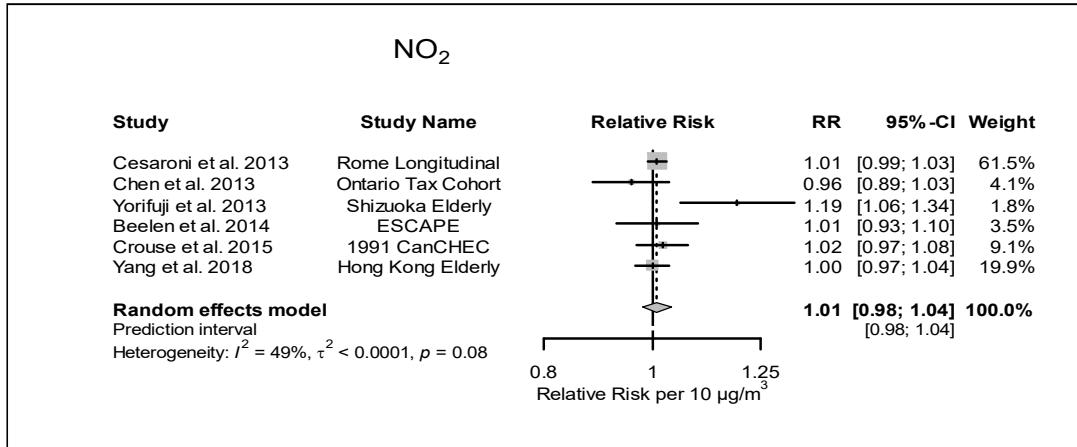
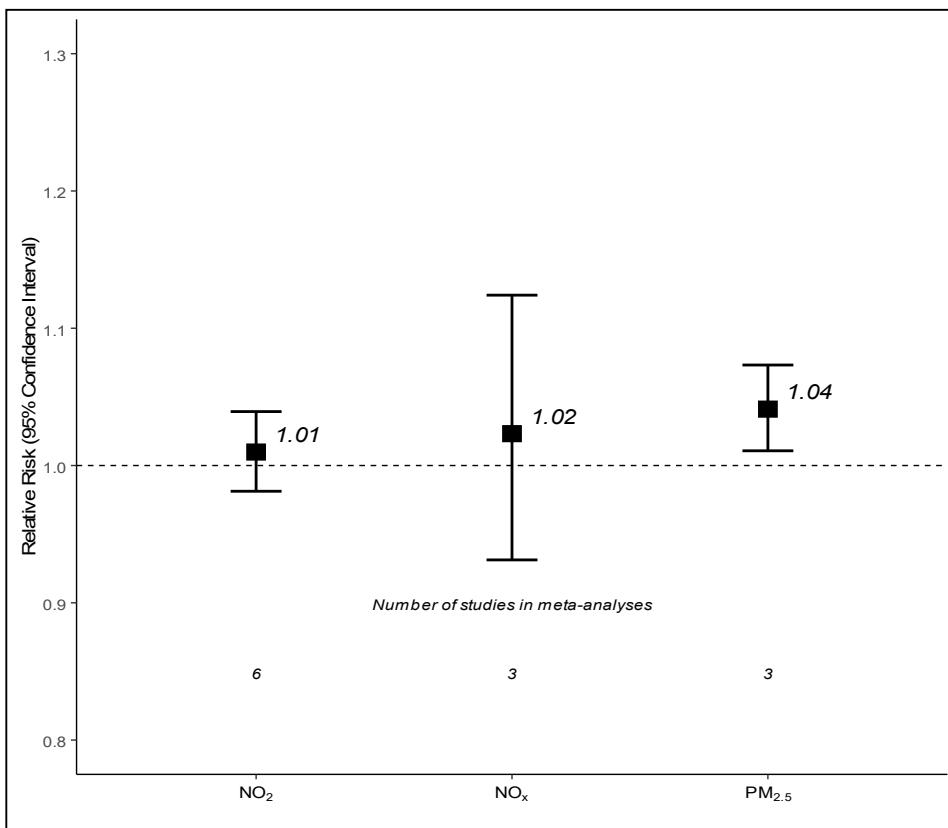
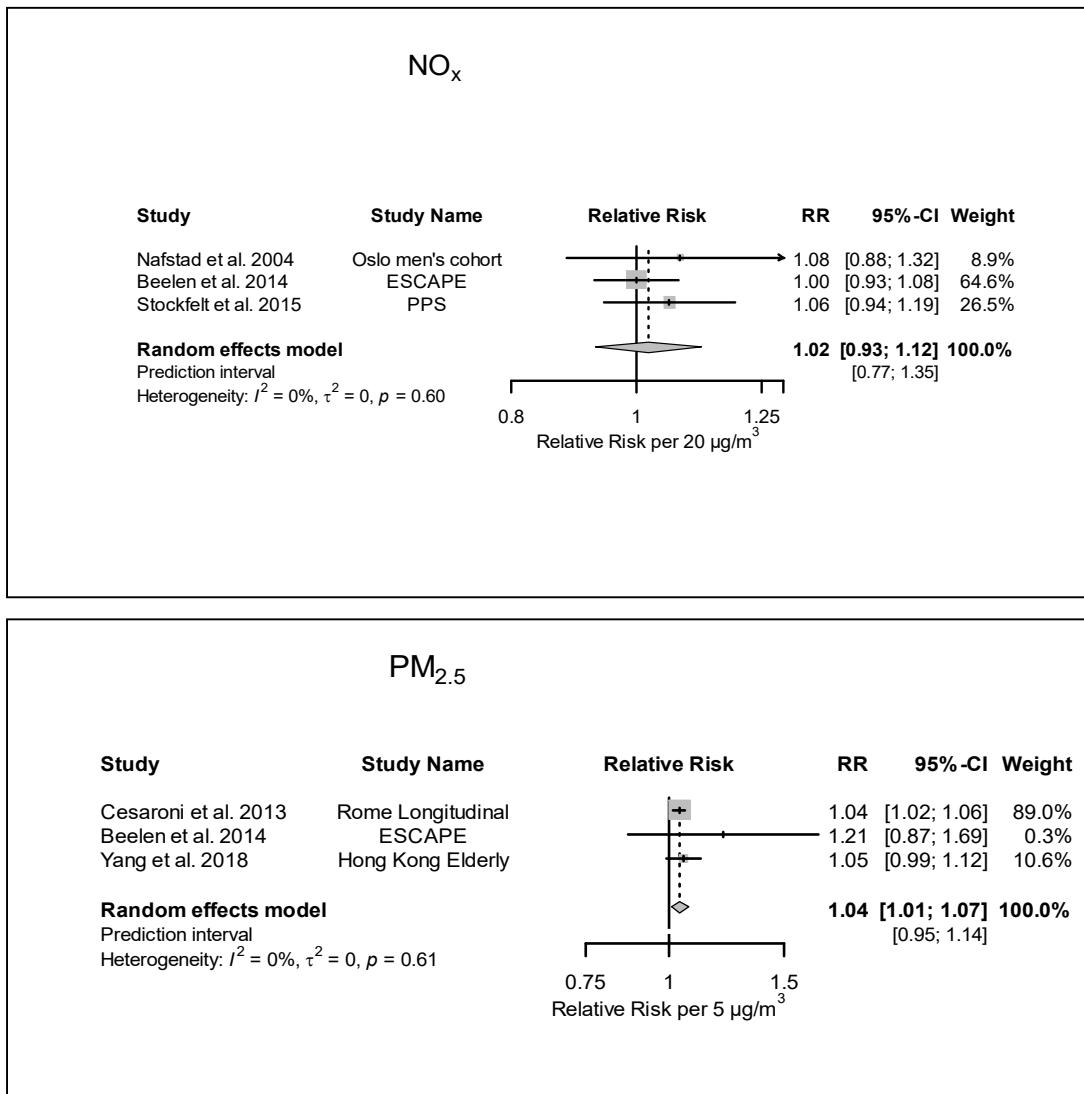


Figure 11B-5. Summary plot and primary meta-analysis for the association between stroke mortality and NO_2 , NO_x , and $\text{PM}_{2.5}$. The following increments were used: $10 \mu\text{g}/\text{m}^3$ for NO_2 , $20 \mu\text{g}/\text{m}^3$ for NO_x and $5 \mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$. Effect estimates cannot be directly compared across the different traffic-related pollutants because the selected increments do not necessarily represent the same contrast in exposure. *Figure continues next page.*

**Figure 11B-5. (Continued).**

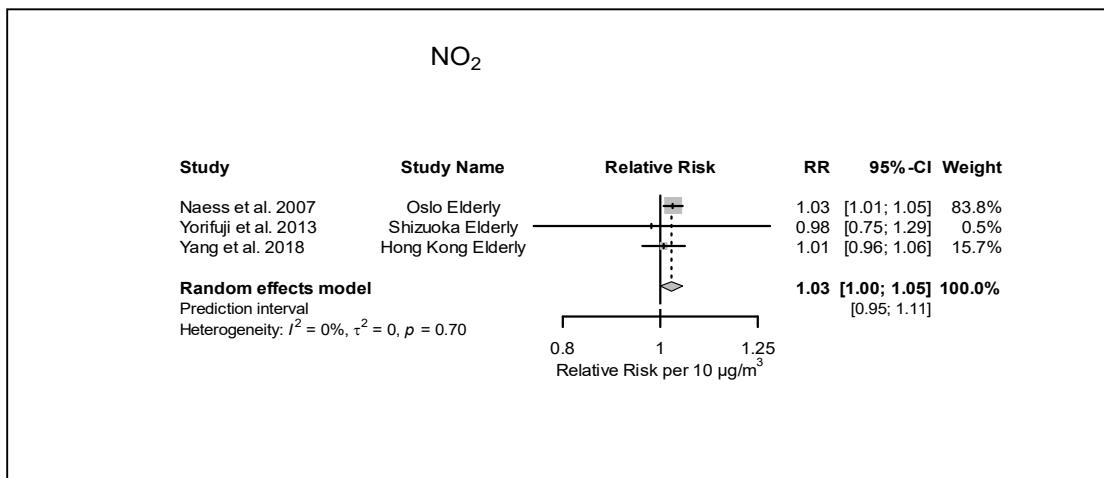


Figure 11B-6. Primary meta-analysis for the association between COPD mortality and NO_2 .

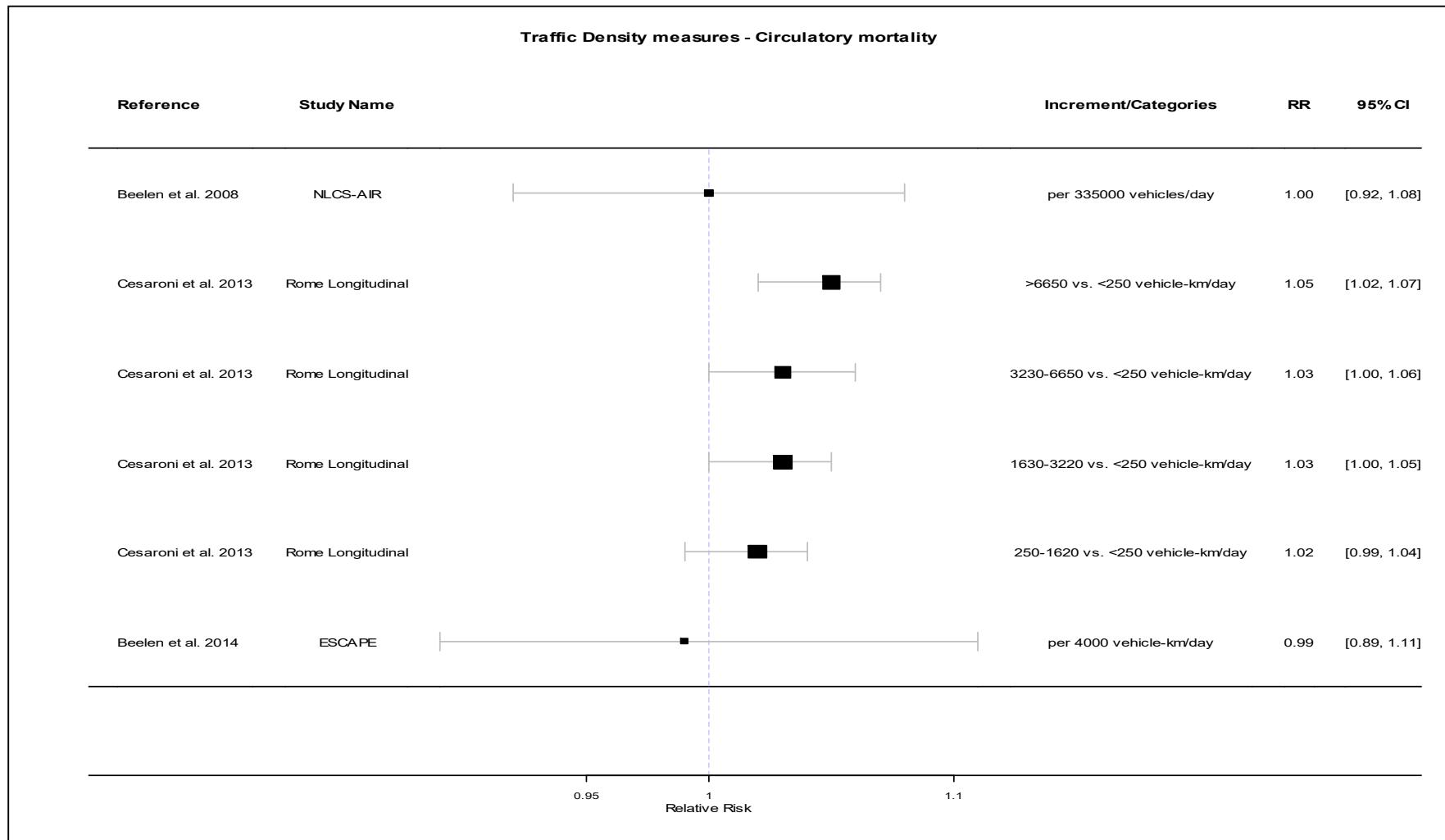
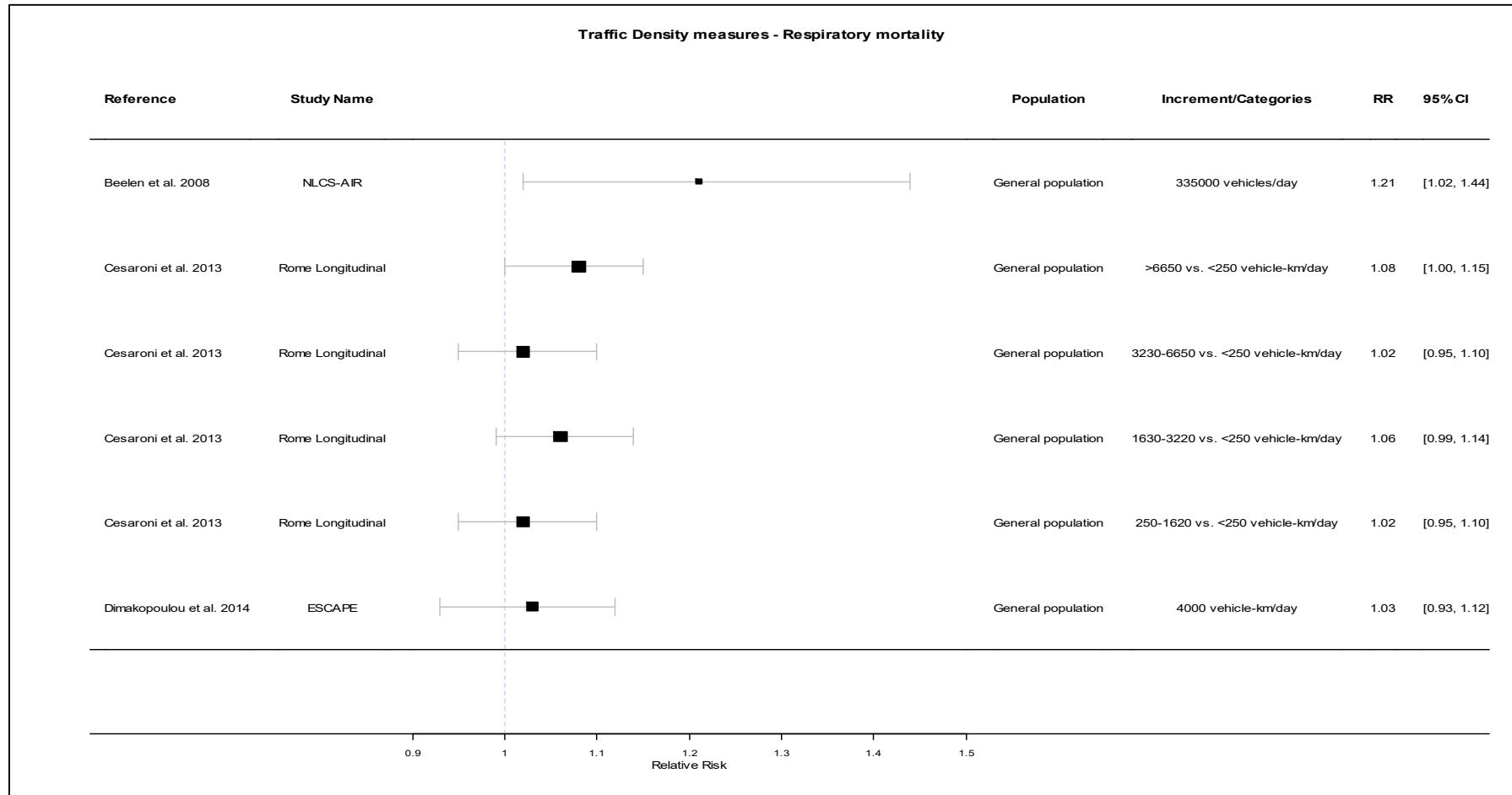
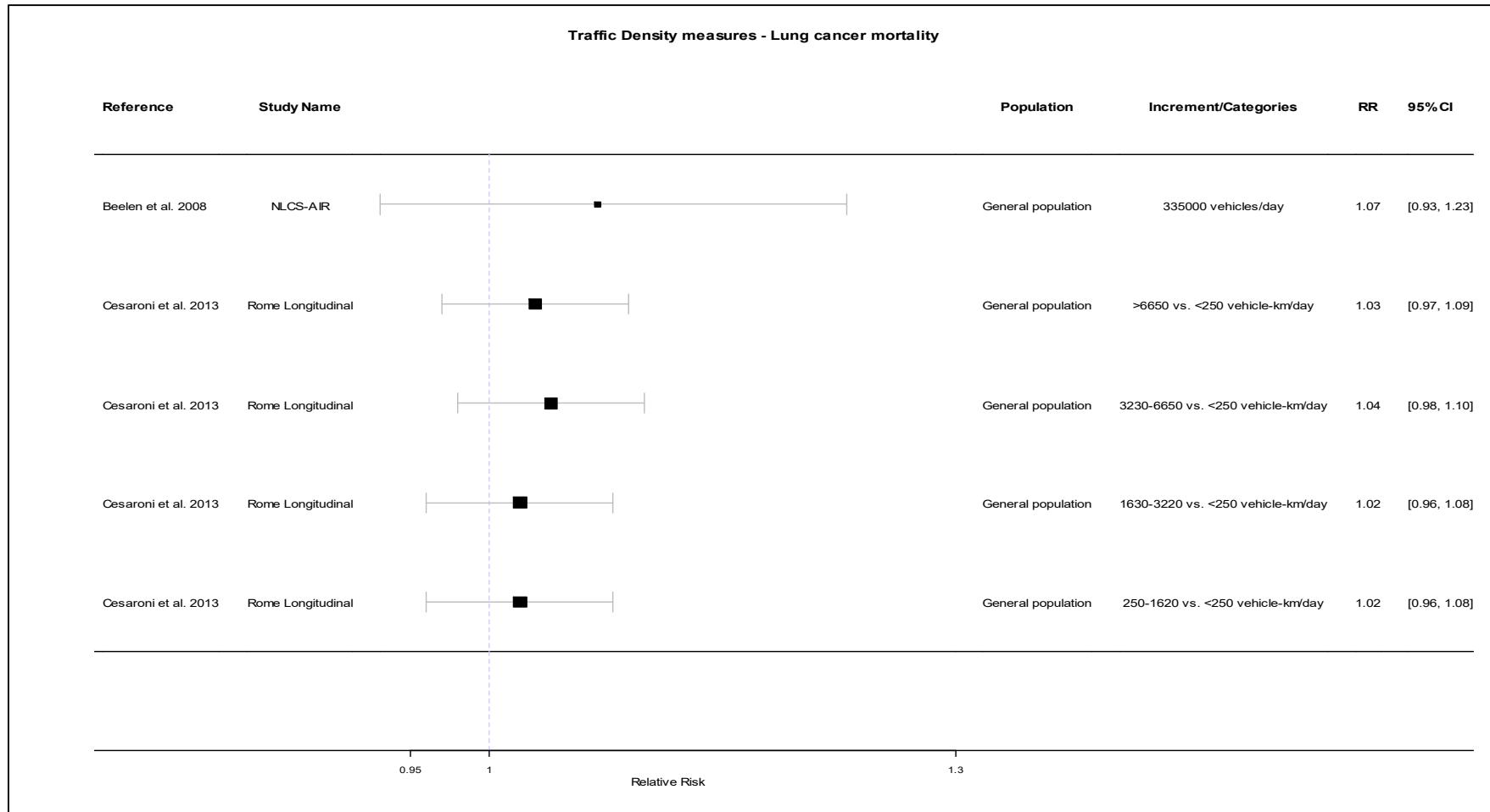


Figure 11B-7. Associations of traffic density with circulatory, respiratory, and lung cancer mortality. Figure continues next page.

**Figure 11B-7. (Continued).**

**Figure 11B-7. (Continued).**

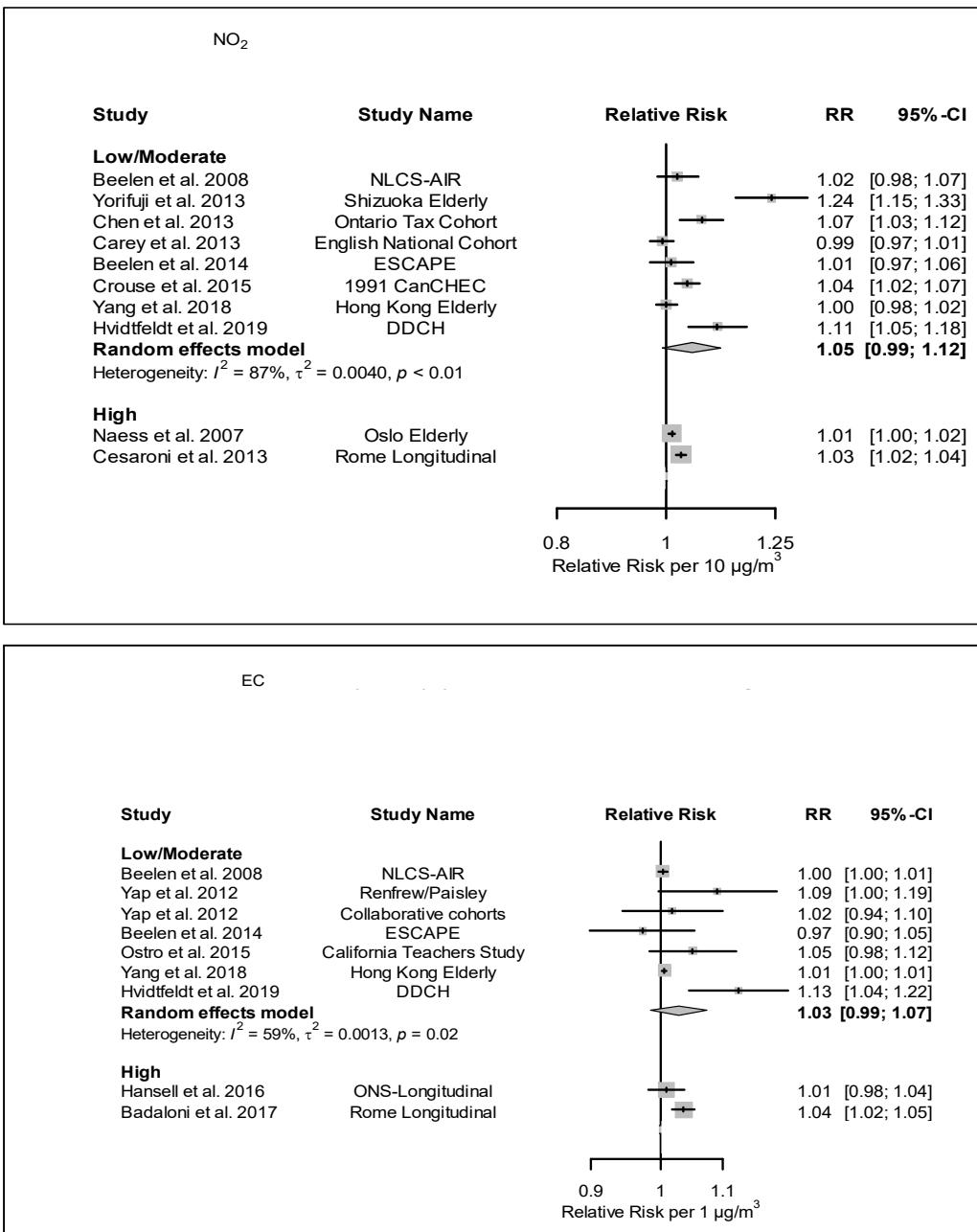


Figure 11B-8. Association between NO₂, EC, PM₁₀, and PM_{2.5} and circulatory mortality – stratified by risk of bias assessment on confounding. Figure continues next page.

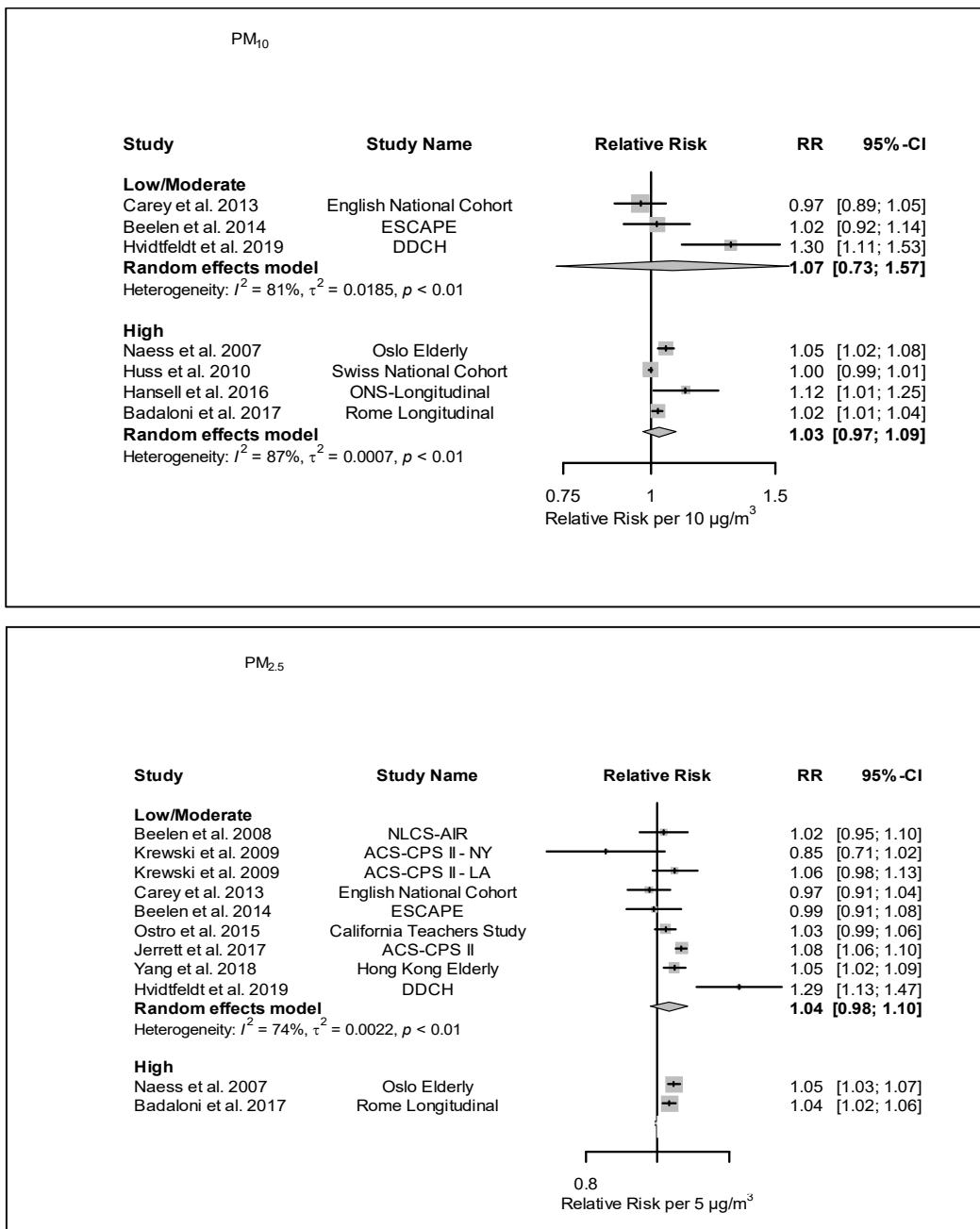


Figure 11B-8. (Continued).

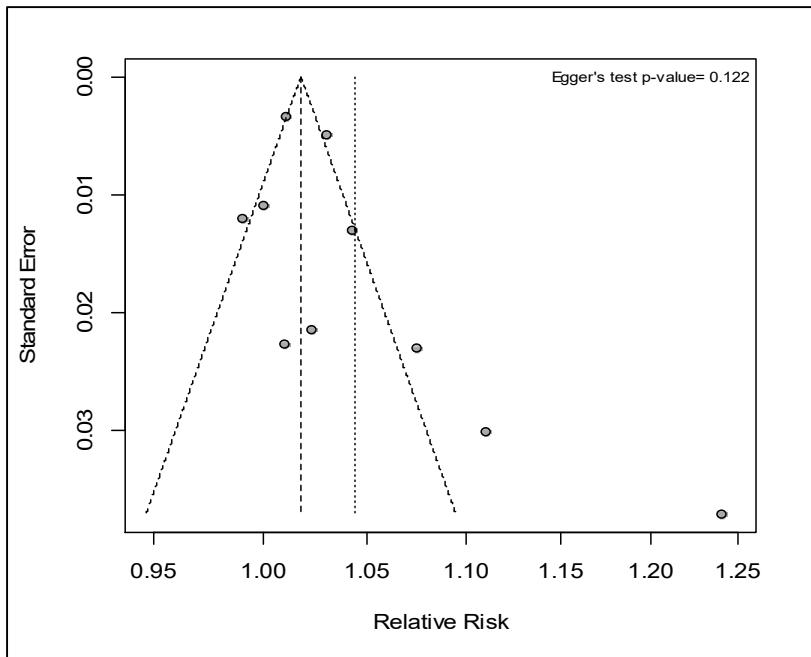
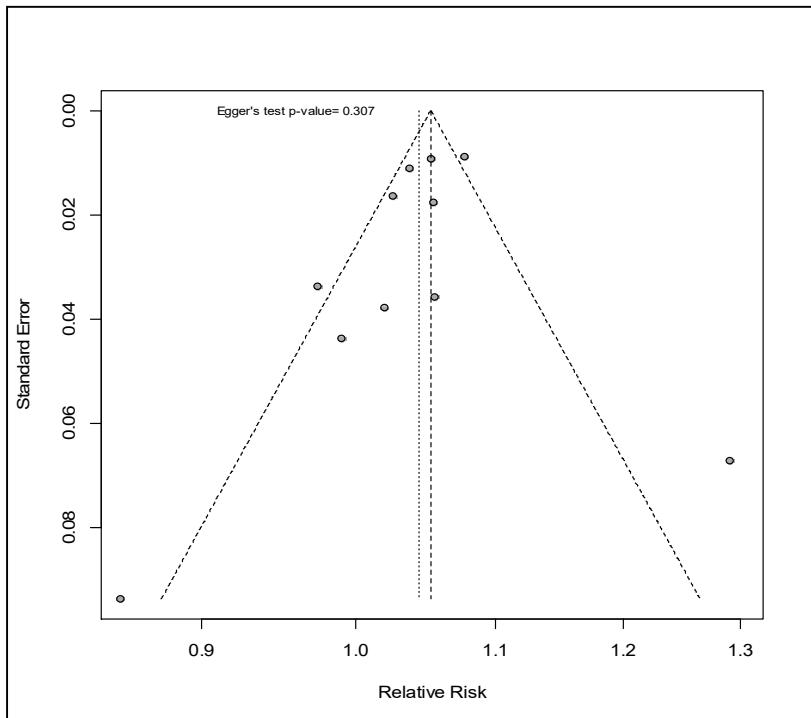
NO_2  $\text{PM}_{2.5}$ 

Figure 11B-9. Funnel plot NO_2 and $\text{PM}_{2.5}$ and circulatory mortality. The vertical lines in the funnel plots represent the pooled fixed and random effect estimates. The vertical dashed line in the middle of the funnel shows the fixed effect estimate. As the Panel applied a random-effects model, the funnel plot also presents the random-effects estimate with the dotted line.

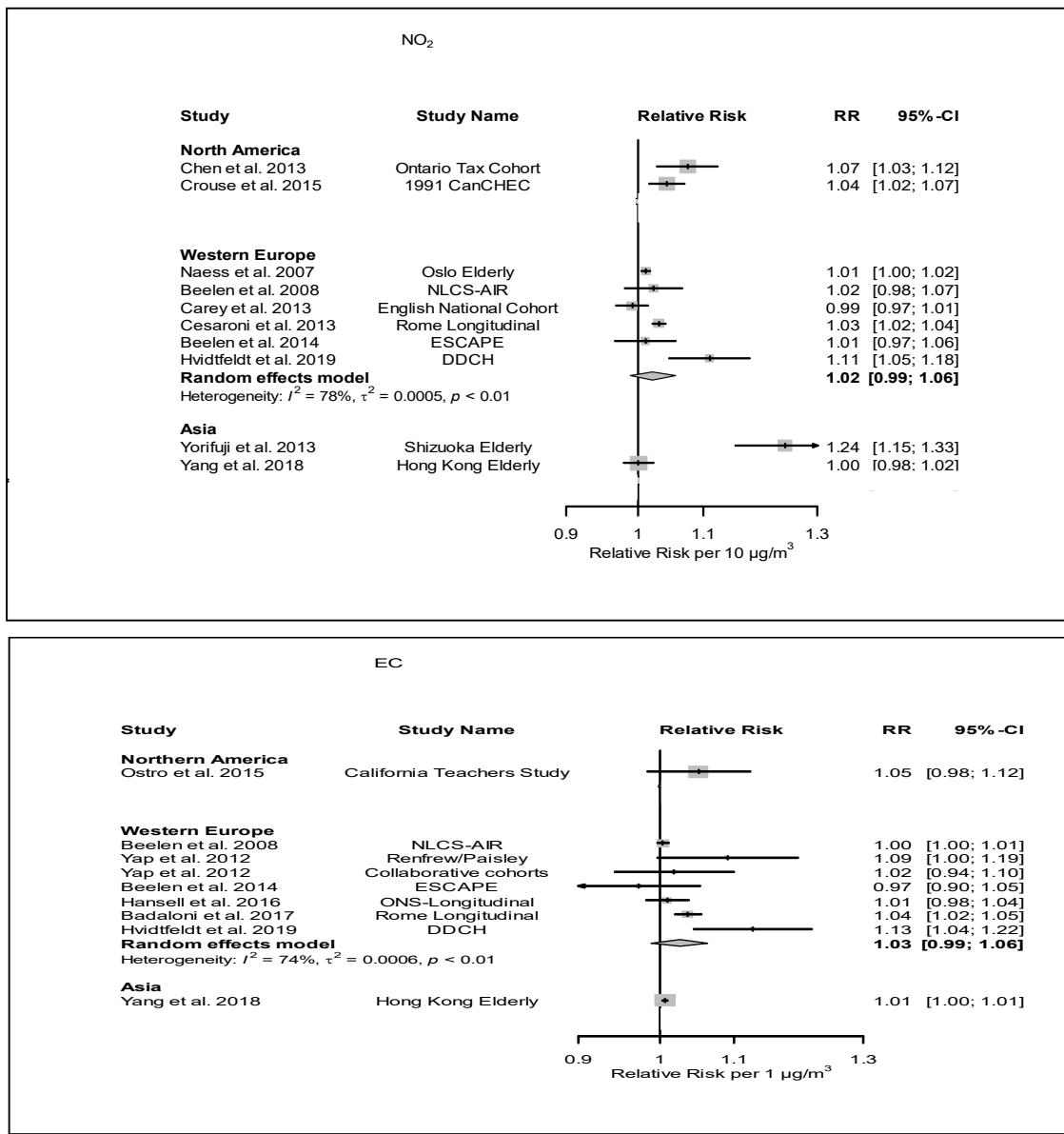
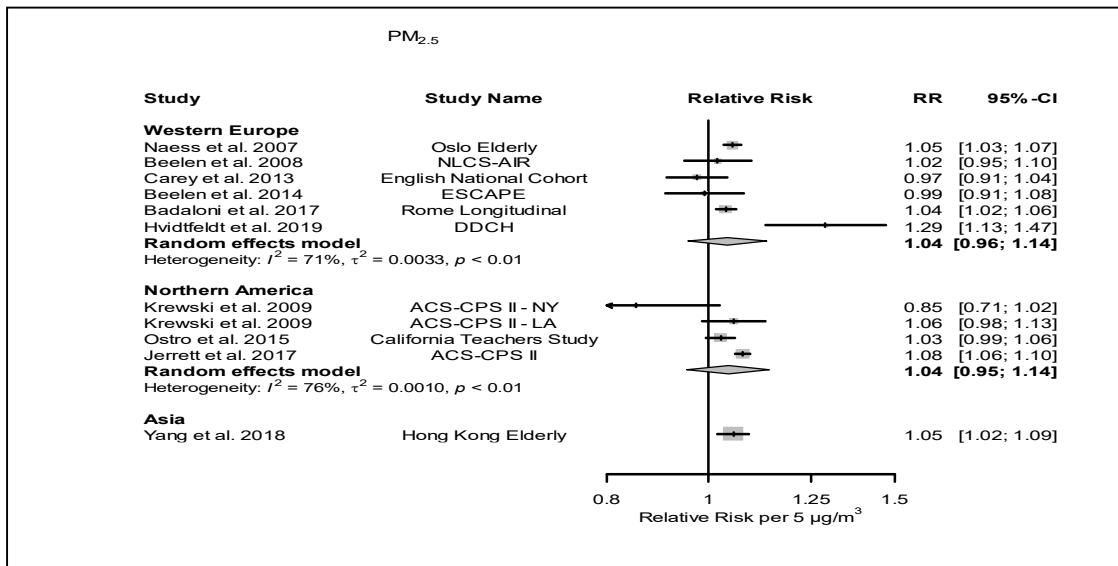


Figure 11B-10. Association between NO_2 , EC, and $\text{PM}_{2.5}$ and circulatory mortality – stratified by geographical area. Figure continues next page.

**Figure 11B-10. (Continued).**

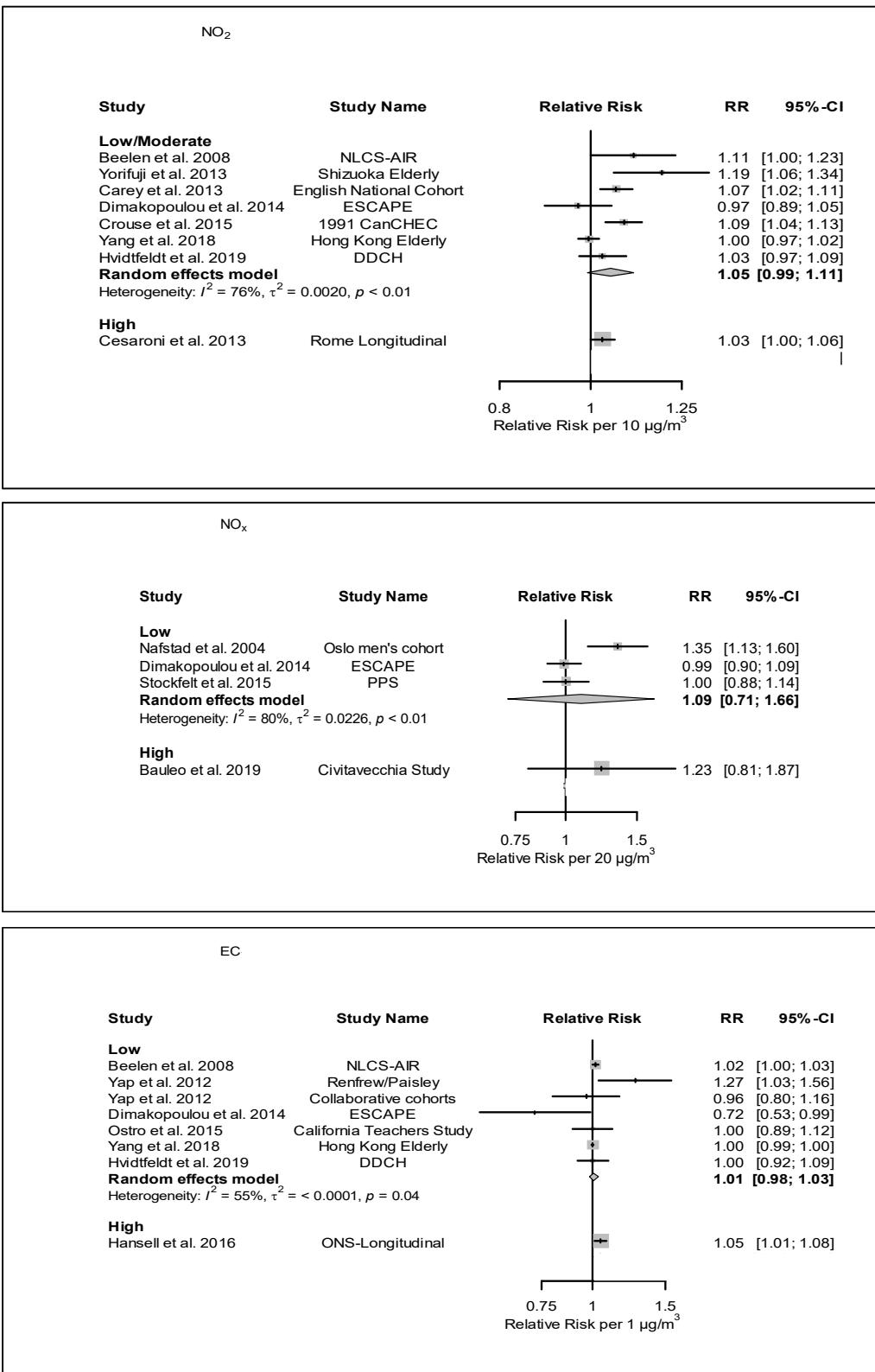
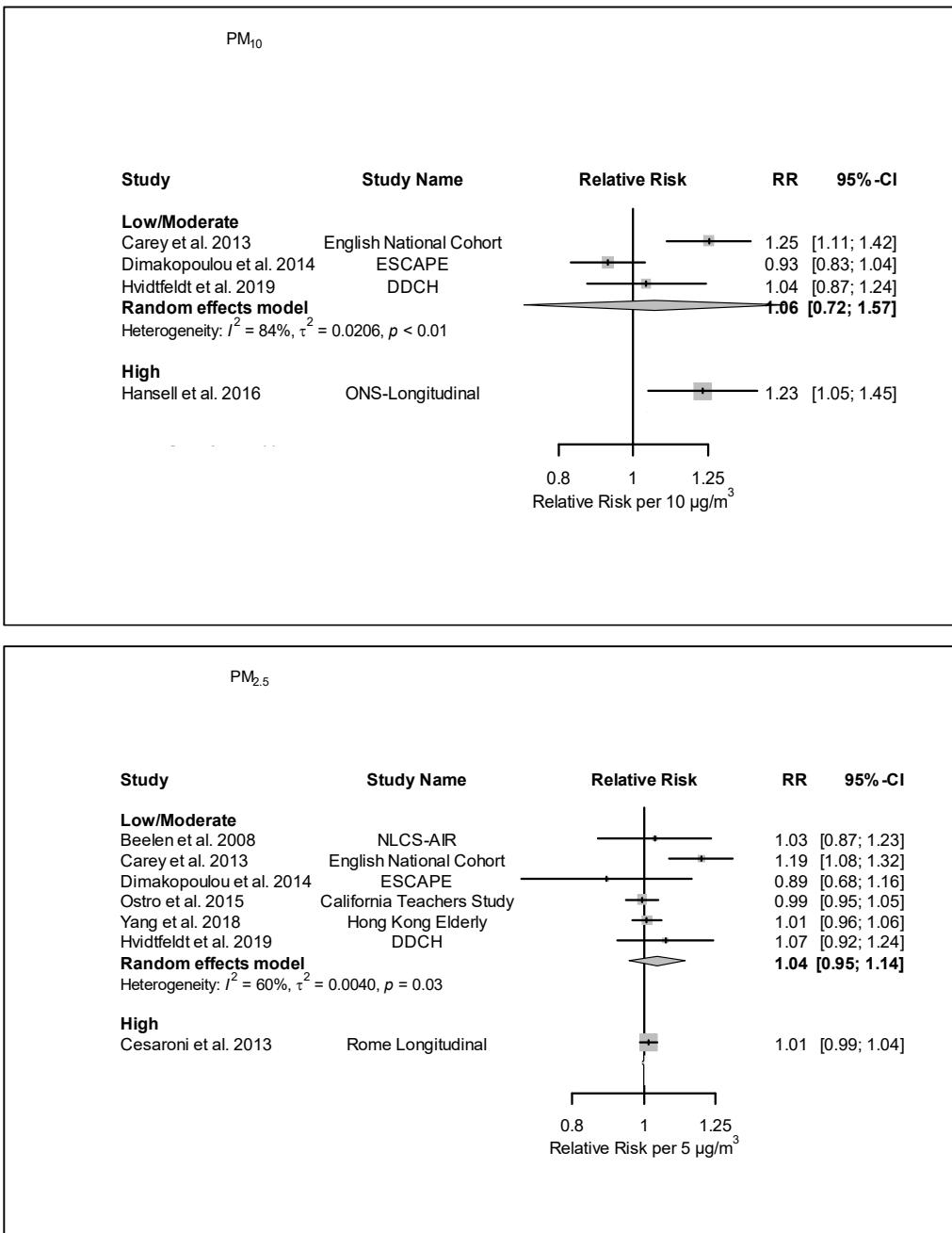


Figure 11B-11. Association between NO₂, NO_x, EC, PM₁₀, and PM_{2.5} and respiratory mortality – stratified by risk of bias assessment on confounding. Figure continues next page.

**Figure 11B-11. (Continued).**

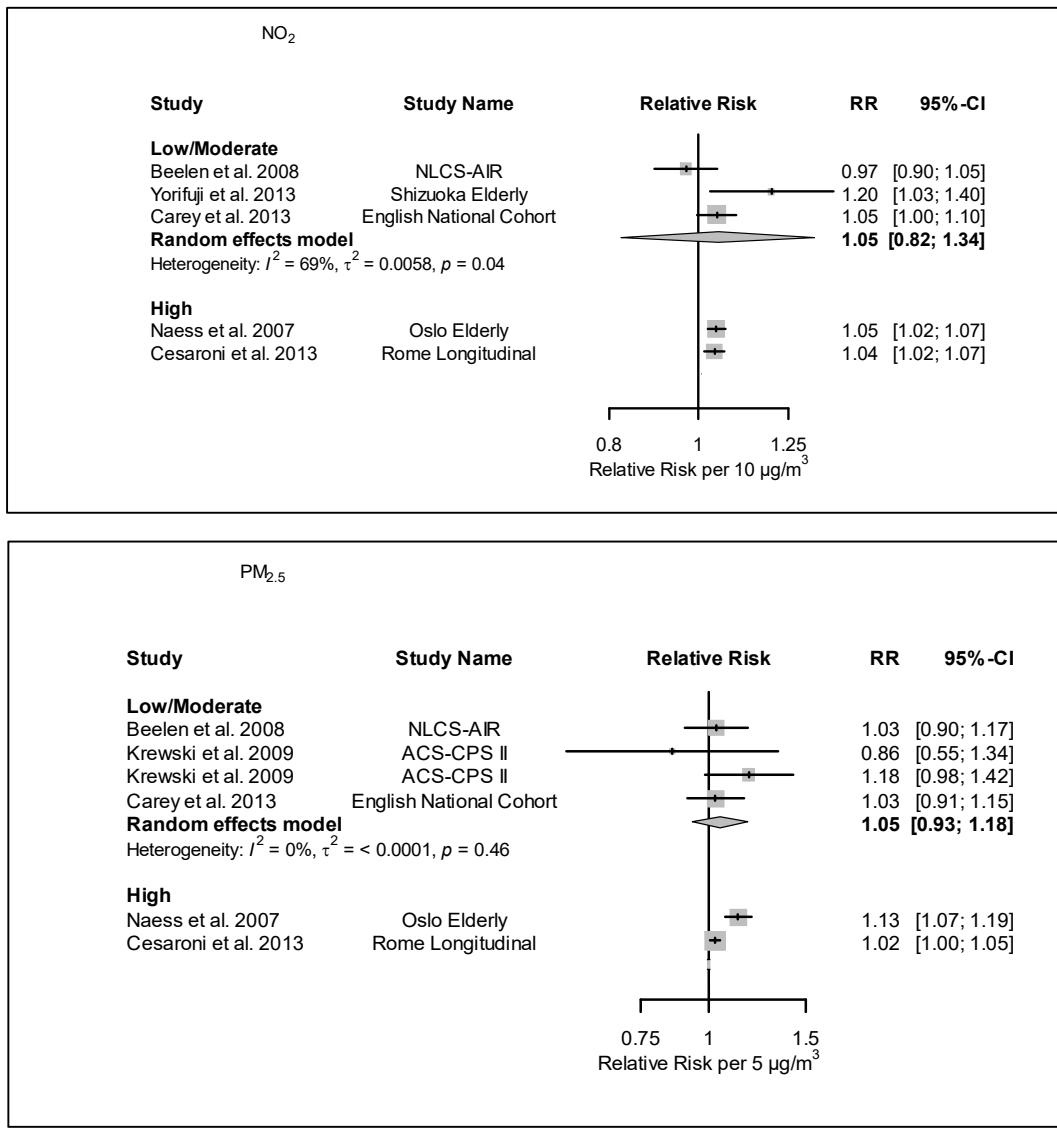


Figure 11B-12. Association between NO₂ and PM_{2.5} and lung cancer mortality – stratified by risk of bias assessment on confounding.

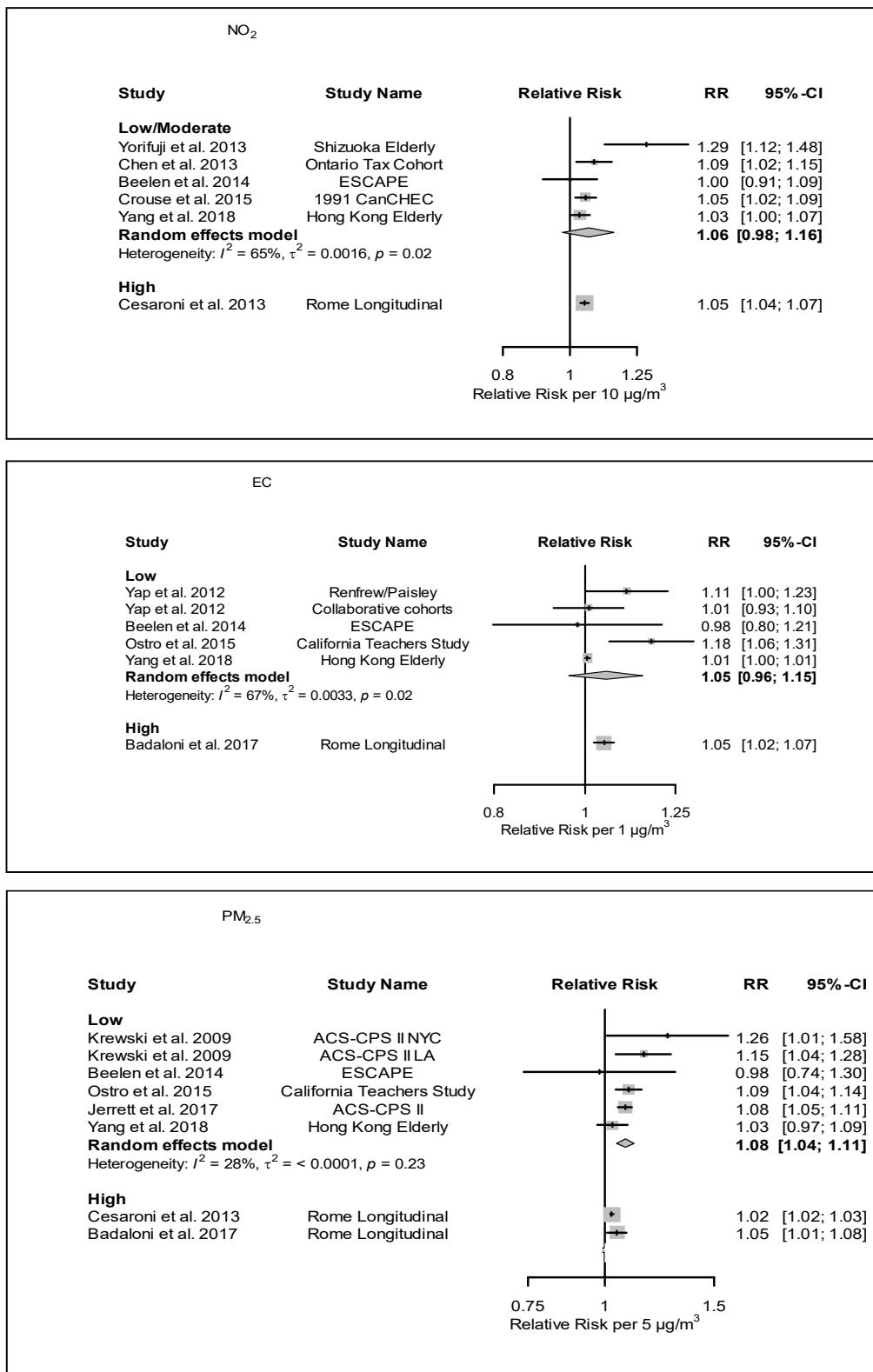


Figure 11B-13. Association between NO₂, EC, and PM_{2.5} and IHD mortality – stratified by risk of bias assessment on confounding.

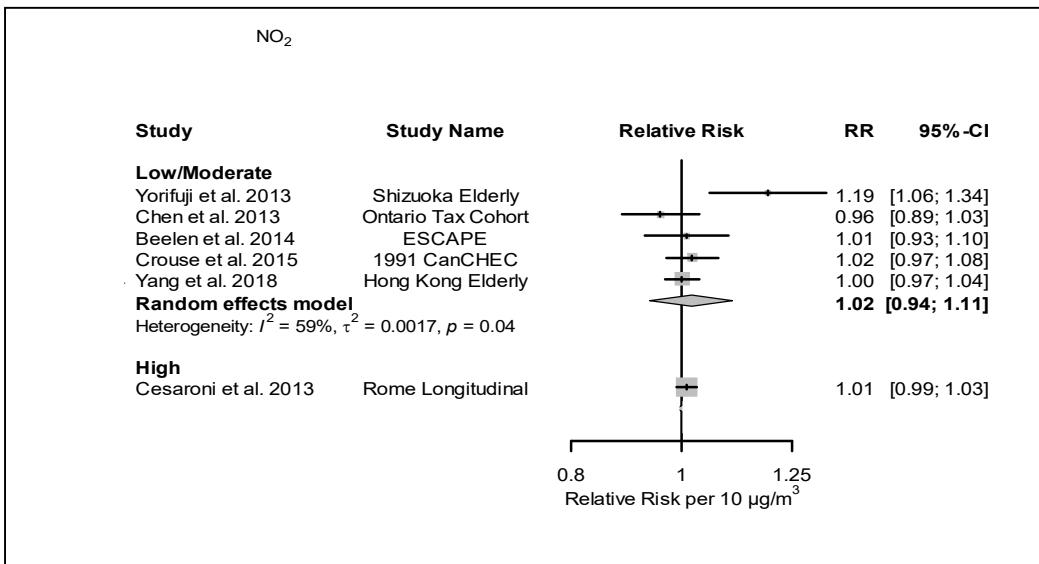


Figure 11B-14. Association between NO_2 and stroke mortality – stratified by risk of bias assessment on confounding.

Table 11B-1. Key Study Characteristics of Articles Included in the Systematic Review for Circulatory, IHD, and Stroke Mortality

Reference	Study Name	Location	Study Period	Sample Size	Age	Sex	Exposure Assessment	Pollutant	Mean Median Exp
Circulatory Mortality									
Badaloni 2017	Rome Longitudinal	Rome, Italy	2001-2010	1,249,108	Adults (18+)	Both	LUR	PM _{2.5} abs	3
								PM ₁₀ mass	37
								PM _{2.5} mass	20
								PM _{2.5} Cu	15
								PM _{2.5} Fe	260
								PM _{2.5} Zn	24
Bauleo 2019	Civitavecchia Study	Civitavecchia, Italy	1996-2013	71,362	Adults (18+)	Both	Disp / CTM	NO _x	5.8
Beelen 2008	NLCS-AIR	The Netherlands	1987-1996	117,528	Adults (18+)	Both	LUR	NO ₂	36.9
								BC	16.5
								PM _{2.5} mass	28.3
Beelen 2014b	ESCAPE	Multiple cities, multiple countries	1985-2008	367,383	Adults (18+)	Both	LUR	NO ₂	5.2-
								NO _x	7-97
								PM _{2.5} abs	0.6-
								PM ₁₀ mass	11-42
								PM _{coarse} mass	6-21
								PM _{2.5} mass	6.6-
Carey 2013	English National Cohort	England	2003-2007	830,842	Adults (18+)	Both	Disp / CTM	NO ₂	22.5
								PM ₁₀ mass	19.7
								PM _{2.5} mass	12.9

Chapter 11 Appendices

Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001- 2010	1,265,058	Adults (18+)	Both	LUR	NO ₂	43.6	1.03 (1.02, 1.04)	10 µg/m ³
							Disp / CTM	PM _{2.5} mass	23.0	1.03 (1.02, 1.04)	10 µg/m ³
Chen 2013	Ontario Tax Cohort	Multiple cities, Ontario, Canada	1982- 2004	205,440	Adults (18+)	Both	LUR	NO ₂	12.1-21.7	1.07 (1.02, 1.11)	5 ppb
Crouse 2015	1991 CanCHEC	Multiple cities, Canada	1991- 2006	735,590	Adults (18+)	Both	LUR	NO ₂	25.2	1.04 (1.02, 1.07)	5 ppb
Hansell 2016	ONS- Longitudinal	England and Wales, United Kingdom	1971- 2009	367,658	Adults (18- 64)	Both	LUR	BS	42.7	1.01 (0.98, 1.04)^c	10 µg/m ³
								PM ₁₀ mass	20.7	1.12 (1.01, 1.25)^c	10 µg/m ³
Huss 2010	Swiss National Cohort	Switzerland	2000- 2005	4,580,311	Adults (18+)	Both	Disp / CTM	PM ₁₀ mass	18.8	1.00 (0.99, 1.00)	10 µg/m ³
								NO ₂	25.0	1.11 (1.04, 1.17)	10 µg/m ³
								BC	0.92	1.16 (1.05, 1.27)	1 µg/m ³
								PM ₁₀ mass	25.1	1.30 (1.11, 1.53)	10 µg/m ³
								PM _{2.5} mass	18.0	1.29 (1.13, 1.47)	5 µg/m ³
Jerrett 2009	Toronto Respiratory Cohort ^d	Toronto, Canada	1992- 2002	2,360	Adults (18+)	Both	LUR	NO ₂	22.9	1.45 (1.10, 1.92)	4 ppb
Jerrett 2017	ACS-CPS II	United States	1982- 2004	668,629	Adults (18- 64)	Both	LUR	PM _{2.5} mass	12	1.16 (1.12, 1.20)	10 µg/m ³
Kloog 2013	Massachusetts Mortality Study	Boston, Massachusetts, United States	2000- 2008	468,570	Adults (18- 64)	Both	LUR	PM _{2.5} mass	9.9	1.4 (1.3, 1.5) (cardio- respiratory)	10 µg/m ³
Krewski 2009	ACS-CPS II LA	Los Angeles, California, United States	1982- 2000	22,905	Adults (18+)	Both	LUR	PM _{2.5} mass	20	1.11 (0.97, 1.28)	10 µg/m ³
	ACS-CPS II NYC	New York City, New York, United States	1982- 2000	44,056	Adults (18+)	Both	LUR	PM _{2.5} mass	14.3	0.95 (0.90, 1.01)	1.5 µg/m ³

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Naess 2007a	Oslo Elderly	Oslo, Norway	1992- 1998	143,842	Adults (51- 70)	Male	Disp / CTM	NO ₂	39	1.08 (1.04, 1.13)^f	25.4 µg/m ³
					Older Adults (71-90)					1.02 (0.99, 1.05)^f	
					Adults (51- 70)	Female				1.07 (1.00, 1.14)^f	
					Older Adults (71-90)					1.01 (0.99, 1.04)^f	
					Adults (51- 70)	Male		PM ₁₀ mass	19	1.09 (1.04, 1.15)^f	6.8 µg/m ³
					Older Adults (71-90)					1.04 (1.01, 1.08)^f	
					Adults (51- 70)	Female				1.11 (1.04, 1.19)^f	
					Older Adults (71-90)					1.01 (0.99, 1.04)^f	
					Adults (51- 70)	Male		PM _{2.5} mass	15	1.10 (1.05, 1.16)^f	4.9 µg/m ³
					Older Adults (71-90)					1.05 (1.01, 1.08)^f	
					Adults (51- 70)	Female				1.14 (1.06, 1.21)^f	
					Older Adults (71-90)					1.03 (1.00, 1.05)^f	
Naess 2007b	Oslo Elderly	Oslo, Norway	1992- 1998	86,828	Adults (18+)	Both	Disp / CTM	PM _{2.5} mass	14.2	1.11 (1.07, 1.15)	6.0 µg/m ³
Ostro 2015	California Teachers Study	California, United States	1995- 2007	101,884	Adults (18+)	Female	Disp / CTM	EC	1.1	1.04 (0.98, 1.09)	0.8 µg/m ³
								PM _{2.5} mass	17.9	1.05 (0.99, 1.12)	9.6 µg/m ³
								PM _{2.5} Cu	0.5	1.02 (0.98, 1.06)	0.4 ng/m ³
								PM _{2.5} Fe	0.4	1.00 (0.95, 1.06)	0.2 µg/m ³
								on-road diesel	0.4	1.02 (0.96, 1.09)	0.4 µg/m ³
								on-road gasoline	0.3	1.01 (0.96, 1.07)	0.3 µg/m ³
								PM _{0.1-0.01}	1293	1.03 (0.97, 1.08)	969 ng/m ³
Raaschou- Nielsen 2012	DDCH	Copenhagen and Aarhus, Denmark	1993- 2009	52,061	Adults (18- 64)	Both	Disp / CTM	NO ₂	16.9	1.27 (1.06, 1.51)^e	1 µg/m ³

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Stockfelt 2015	PPS	Gothenburg, Sweden	1970- 2007	6,557	Adults (18- 64)	Male	Disp / CTM	NO _x	42	1.02 (1.00, 1.04)	10 µg/m ³
Villeneuve 2013	Ontario Tax Cohort	Toronto, Canada	1982- 2004	58,760	Adults (18+)	Both	LUR	benzene	0.64	1.03 (0.99, 1.07)	0.1 µg/m ³
Wang 2014	ESCAPE	Multiple cities, multiple countries	1985- 2008	322,291	Adults (18+)	Both	LUR	PM _{2.5} Cu	1-12	0.90 (0.77, 1.07)	5 ng/m ³
								PM _{2.5} Fe	15-240	0.99 (0.87, 1.11)	100 ng/m ³
								PM _{2.5} Zn	8-41	1.04 (0.88, 1.24)	10 ng/m ³
Yang 2018	Hong Kong Elderly	Hong Kong, China	1998- 2011	61,386	Older Adults (65+)	Both	LUR	NO ₂	104	1.00 (0.95, 1.06)	25.6 µg/m ³
								NO	147	0.96 (0.91, 1.00)	167 µg/m ³
								BC	12.1	1.07 (1.02, 1.11)	9.6 µg/m ³
								PM _{2.5} mass	42.2	1.06 (1.02, 1.10)	5.5 µg/m ³
Yap 2012	Renfrew/Paisley	Glasgow, Scotland	1972- 1998	15,188	Adults (18+)	Both	LUR	BS	19.3	1.10 (1.00, 1.22)	10 µg/m ³
	Collaborative cohorts	Glasgow, Scotland	1972- 1998	6,255	Adults (18+)	Both	LUR	BS	23.2	1.02 (0.93, 1.10)	10 µg/m ³
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999- 2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	1.15 (1.03, 1.28)	10 µg/m ³
Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999- 2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	1.24 (1.15, 1.33)	10 µg/m ³
IHD Mortality											
Badaloni 2017	Rome Longitudinal	Rome, Italy	2001- 2010	1,249,108	Adults (18+)	Both	LUR	PM _{2.5} abs	3	1.08 (1.03, 1.12)	1.5 1×10 ⁻⁵ /m
								PM ₁₀ mass	37	1.05 (1.00, 1.09)	17.2 µg/m ³
								PM _{2.5} mass	20	1.06 (1.01, 1.11)	6.6 µg/m ³
								PM _{2.5} Cu	15	1.11 (1.06, 1.17)	15.4 ng/m ³
								PM _{2.5} Fe	260	1.07 (1.02, 1.12)	275.5 ng/m ³
								PM _{2.5} Zn	24	1.11 (1.06, 1.16)	16.3 ng/m ³
Bauleo 2019	Civitavecchia Study	Civitavecchia, Italy	1996- 2013	71,362	Adults (18+)	Both	Disp / CTM	NO _x	5.8	0.83 (0.67, 1.01)	12.8 µg/m ³

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Beelen 2014b	ESCAPE	Multiple cities, multiple countries	1985-2008	367,383	Adults (18+)	Both	LUR	NO ₂	5.2-59.8	1.00 (0.91, 1.09)	10 µg/m ³
								NO _x	7-97	1.02 (0.95, 1.09)	20 µg/m ³
								PM _{2.5 abs}	0.6-3.2	0.98 (0.78, 1.23)	1 1×10 ⁻⁵ /m
								PM _{10 mass}	11-49	0.93 (0.77, 1.13)	10 µg/m ³
								PM _{coarse mass}	6-21	0.92 (0.77, 1.11)	5 µg/m ³
								PM _{2.5 mass}	6.6-31.0	0.98 (0.74, 1.30)	5 µg/m ³
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Adults (18+)	Both	LUR	NO ₂	43.6	1.05 (1.03, 1.06)	10 µg/m ³
							Disp / CTM	PM _{2.5 mass}	23.0	1.05 (1.03, 1.06)	10 µg/m ³
Chen 2013	Ontario Tax Cohort	Multiple cities, Ontario, Canada	1982-2004	205,440	Adults (18+)	Both	LUR	NO ₂	12.1-21.7	1.08 (1.02, 1.14)	5 ppb
Crouse 2015	1991 CanCHEC	Multiple cities, Canada	1991-2006	735,590	Adults (18+)	Both	LUR	NO ₂	25.2	1.05 (1.02, 1.09)	5 ppb
Jerrett 2017	ACS-CPS II	United States	1982-2004	668,629	Adults (18-64)	Both	LUR	PM _{2.5 mass}	12	1.16 (1.10, 1.22)	10 µg/m ³
Krewski 2009	ACS-CPS II LA	Los Angeles, California, United States	1982-2000	22,905	Adults (18+)	Both	LUR	PM _{2.5 mass}	20	1.33 (1.08, 1.63)	10 µg/m ³
	ACS-CPS II NYC	New York City, New York, United States	1982-2000	44,056	Adults (18+)	Both	LUR	PM _{2.5 mass}	14.3	1.07 (1.00, 1.15)	1.5 µg/m ³
Nafstad 2004	Oslo men's cohort	Oslo, Norway	1972-1998	16,209	Adults (18-64)	Male	Disp / CTM	NO _x	10.7	1.08 (1.03, 1.12)	10 µg/m ³
Ostro 2015	California Teachers Study	California, United States	1995-2007	101,884	Adults (18+)	Female	Disp / CTM	EC	1.1	1.14 (1.05, 1.24)	0.8 µg/m ³
								PM _{2.5 mass}	17.9	1.18 (1.08, 1.30)	9.6 µg/m ³
								PM _{2.5 Cu}	0.5	1.09 (1.04, 1.15)	0.4 ng/m ³
								PM _{2.5 Fe}	0.4	1.06 (0.97, 1.16)	0.2 µg/m ³
								on-road diesel	0.4	1.13 (1.03, 1.23)	0.4 µg/m ³
								on-road gasoline	0.3	1.12 (1.04, 1.22)	0.3 µg/m ³
								PM _{0.1-0.01}	1293	1.10 (1.02, 1.18)	969 ng/m ³
Raaschou-Nielsen 2012	DDCH	Copenhagen and Aarhus, Denmark	1993-2009	52,061	Adults (18-64)	Both	Disp / CTM	NO ₂	16.9	1.12 (0.85, 1.47) ^e	1 µg/m ³

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Stockfelt 2015	PPS	Gothenburg, Sweden	1970- 2007	6,557	Adults (18- 64)	Male	Disp / CTM	NO _x	42	1.02 (0.99, 1.05)	10 µg/m ³
Yang 2018	Hong Kong Elderly	Hong Kong, China	1998- 2011	61,386	Older Adults (65+)	Both	LUR	NO ₂	104	1.09 (1.00, 1.18)	25.6 µg/m ³
								NO	147	0.98 (0.91, 1.05)	167 µg/m ³
								BC	12.1	1.08 (1.01, 1.15)	9.6 µg/m ³
								PM _{2.5} mass	42.2	1.03 (0.97, 1.10)	5.5 µg/m ³
Yap 2012	Renfrew/Paisley	Glasgow, Scotland	1972- 1998	15,188	Adults (18+)	Both	LUR	BS	19.3	1.12 (1.00, 1.25)	10 µg/m ³
	Collaborative cohorts	Glasgow, Scotland	1972- 1998	6,255	Adults (18+)	Both	LUR	BS	23.2	1.01 (0.92, 1.11)	10 µg/m ³
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999- 2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	1.27 (1.02, 1.58)	10 µg/m ³
Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999- 2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	1.29 (1.12, 1.48)	10 µg/m ³
Stroke Mortality											
Beelen 2014b	ESCAPE	Multiple cities, multiple countries	1985- 2008	367,383	Adults (18+)	Both	LUR	NO ₂	5.2-59.8	1.01 (0.93, 1.10)	10 µg/m ³
								NO _x	7-97	1.00 (0.93, 1.08)	20 µg/m ³
								PM _{2.5} abs	0.6-3.2	1.01 (0.82, 1.24)	1 1×10 ⁻⁵ /m
								PM ₁₀ mass	11-49	1.22 (0.91, 1.63)	10 µg/m ³
								PM _{coarse} mass	6-21	1.17 (0.90, 1.52)	5 µg/m ³
								PM _{2.5} mass	6.6-31.0	1.21 (0.87, 1.69)	5 µg/m ³
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001- 2010	1,265,058	Adults (18+)	Both	LUR	NO ₂	43.6	1.01 (0.99, 1.03)	10 µg/m ³
							Disp / CTM	PM _{2.5} mass	23.0	1.08 (1.04, 1.13)	10 µg/m ³
Chen 2013	Ontario Tax Cohort	Multiple cities, Ontario, Canada	1982- 2004	205,440	Adults (18+)	Both	LUR	NO ₂	12.1-21.7	0.96 (0.89, 1.03)	5 ppb
Crouse 2015	1991 CanCHEC	Multiple cities, Canada	1991- 2006	735,590	Adults (18+)	Both	LUR	NO ₂	25.2	1.02 (0.97, 1.07)	5 ppb
Huss 2010	Swiss National Cohort	Switzerland	2000- 2005	4,580,311	Adults (18+)	Both	Disp / CTM	PM ₁₀ mass	18.8	0.99 (0.98, 1.00)	10 µg/m ³
Nafstad 2004	Oslo men's cohort	Oslo, Norway	1972- 1998	16,209	Adults (18- 64)	Male	Disp / CTM	NO _x	10.7	1.04 (0.94, 1.15)	10 µg/m ³

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Raaschou-Nielsen 2012	DDCH	Copenhagen and Aarhus, Denmark	1993-2009	52,061	Adults (18-64)	Both	Disp / CTM	NO ₂	16.9	1.11 (0.76, 1.63) ^e	1 µg/m ³
Stockfelt 2015	PPS	Gothenburg, Sweden	1970-2007	6,557	Adults (18-64)	Male	Disp / CTM	NO _x	42	1.03 (0.97, 1.09)	10 µg/m ³
Yang 2018	Hong Kong Elderly	Hong Kong, China	1998-2011	61,386	Older Adults (65+)	Both	LUR	NO ₂	104	1.00 (0.91, 1.09)	25.6 µg/m ³
								NO	147	0.96 (0.89, 1.04)	167 µg/m ³
								BC	12.1	1.05 (0.98, 1.13)	9.6 µg/m ³
								PM _{2.5} mass	42.2	1.06 (0.99, 1.13)	5.5 µg/m ³
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999-2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	1.09 (0.94, 1.27)	10 µg/m ³
Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999-2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	1.19 (1.06, 1.34)	10 µg/m ³

^a Units are in the increment column.

^b Effect estimates are expressed as relative risk or hazard ratio. **Bold** indicates the effect estimate was included in the meta-analysis.

^c Odds ratio.

^d Indicates a patient population.

^e Log transformed.

^f Estimates were combined by a fixed effect meta-analysis before entering the random-effects model.

Table 11B-2. Key Study Characteristics of Articles Included in the Systematic Review for Circulatory, IHD, and Stroke Mortality Analysis — Indirect Traffic Measures

Reference	Study Name	Location	Study Period	Sample Size	Traffic Measure	Age	Sex	Effect Estimate (95% CI) ^a	Increment
Circulatory Mortality									
Beelen 2008	NLCS-AIR	The Netherlands	1987-1996	117,528	Density	Adults (18+)	Both	1.00 (0.92, 1.08)	335,000 vehicles/day
					Distance			1.05 (0.93, 1.18)	<100 m to highway or <50 m to major road vs. higher
Beelen 2014b	ESCAPE	Multiple cities, multiple countries	1985-2008	357,512	Density	Adults (18+)	Both	0.99 (0.89, 1.11)	4,000 vehicle-km/day
Cakmak 2019	1991 CanCHEC	Canada	1991-2011	2,644,370	Distance	Adults (18+)	Both	1.70 (1.44, 2.01)	<475 vs. >1583 m
								1.18 (1.12, 1.24)	475-1,152 vs. >1583 m
								1.07 (1.05, 1.09)	1,152-1,583 vs. >1583 m
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Density	Adults (18+)	Both	1.05 (1.02, 1.07)	>6,650 vs. <250 vehicle-km/day
								1.03 (1.00, 1.06)	3,230-6,650 vs. <250 vehicle-km/day
								1.03 (1.00, 1.05)	1,630-3,220 vs. <250 vehicle-km/day
								1.02 (0.99, 1.04)	250-1,620 vs. <250 vehicle-km/day
					Distance			1.03 (1.01, 1.05)	<50 vs. >250 m
								0.99 (0.97, 1.02)	50-100 vs. >250 m
								1.00 (0.97, 1.02)	100-150 vs. >250 m
								0.99 (0.97, 1.02)	150-250 vs. >250 m
Chen 2013	Ontario Tax Cohort	Multiple cities, Ontario, Canada	1982-2004	205,440	Distance	Adults (18+)	Both	1.04 (1.00, 1.08)	<50 m to major road or <100 m to highway vs. higher
Finkelstein 2005	Hamilton Pulmonary Cohort ^b	Hamilton, Ontario, Canada	1985-2001	5,228	Distance	Adults (18-64)	Both	1.35 (1.03, 1.75)	<150 to highway or <50 m to major road vs. higher
Gehring 2006	SALIA	North Rhine-Westphalia, Germany	1985-2003	4,230	Distance	Adults (18-64)	Female	1.70 (1.02, 2.81)	<50 vs. >50 m
Heinrich 2013	SALIA	North Rhine-Westphalia, Germany	1985-2008	4,615	Distance	Adults (18-64)	Female	1.95 (1.37, 2.77)	<50 vs. >50 m

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Huss 2010	Swiss National Cohort	Switzerland	2000-2005	4,580,311	Distance	Adults (18+)	Both	1.04 (1.03, 1.06)	<50 vs. >200 m
								1.04 (1.02, 1.05)	50-99 vs. >200 m
								1.02 (1.00, 1.03)	100-199 vs. >200 m
Jerrett 2009	Toronto Respiratory Cohort ^b	Toronto, Canada	1992-2002	2,360	Distance	Adults (18+)	Both	1.48 (0.91, 2.42)	<50 m from major road or <100 m from highway vs. higher
Raaschou-Nielsen 2012	DDCH	Copenhagen and Aarhus, Denmark	1993-2009	52,061	Distance	Adults (18- 64)	Both	0.98 (0.79, 1.21)	<50 vs. >50 m
					Density	Adults (18- 64)	Both	1.02 (0.98, 1.06) ^c	1 vehicle-km/day
Schikowski 2007	SALIA	North Rhine- Westphalia, Germany	1985-2003	4,457	Distance	Adults (18- 64)	Female	1.67 (0.98, 2.83)	<50 vs. >50 m
IHD Mortality									
Beelen 2009	NLCS-AIR	The Netherlands	1987-1996	117,528	Density	Adults (18+)	Both	1.05 (0.95, 1.16)	335,000 vehicles/day
					Distance			1.15 (0.99, 1.34)	<100 m to highway or <50 m to major road vs. higher
Beelen 2014b	ESCAPE	Multiple cities, multiple countries	1985-2008	357,512	Density	Adults (18+)	Both	1.02 (0.88, 1.18)	4,000 vehicle-km/day
Cakmak 2019	1991 CanCHEC	Canada	1991-2011	2,644,370	Distance	Adults (18+)	Both	1.08 (0.87, 1.34)	<475 vs. >1583 m
								1.10 (1.04, 1.17)	475-1152 vs. >1583 m
								1.05 (1.03, 1.07)	1,152-1,583 vs. >1,583 m
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Density	Adults (18+)	Both	1.04 (1.00, 1.09)	>6,650 vs. <250 vehicle- km/day
								1.04 (1.00, 1.09)	3,230-6,650 vs. <250 vehicle-km/day
								1.01 (0.97, 1.04)	1,630-3,220 vs. <250 vehicle-km/day
								1.00 (0.95, 1.04)	250-1620 vs. <250 vehicle-km/day
					Distance			1.05 (1.01, 1.09)	<50 vs. >250 m
								1.02 (0.98, 1.06)	50-100 vs. >250 m
								0.99 (0.95, 1.04)	100-150 vs. >250 m
								1.01 (0.97, 1.05)	150-250 vs. >250 m

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Chen 2013	Ontario Tax Cohort	multiple cities, Ontario, Canada	1982-2004	205,440	Distance	Adults (18+)	Both	1.07 (1.01, 1.13)	<50 m to major road or <100 m to highway vs. higher
Raaschou-Nielsen 2012	DDCH	Copenhagen and Aarhus, Denmark	1993-2009	52,061	Distance	Adults (18-64)	Both	1.04 (0.76, 1.44)	<50 vs. >50 m
					Density			1.01 (0.95, 1.07) ^c	1 vehicle-km/day
Stroke mortality									
Beelen 2009	NLCS-AIR	The Netherlands	1987-1996	117,528	Density	Adults (18+)	Both	0.81 (0.67, 0.99)	335,000 vehicles/day
					Distance			0.70 (0.51, 0.96)	<100 m to highway or <50 m to major road vs. higher
Beelen 2014b	ESCAPE	Multiple cities, multiple countries	1985-2008	357,512	Density	Adults (18+)	Both	1.04 (0.90, 1.19)	4,000 vehicle-km/day
Cakmak 2019	1991 CanCHEC	Canada	1991-2011	2,644,370	Distance	Adults (18+)	Both	2.94 (2.05, 4.23)	<475 vs. >1583 m
								1.27 (1.14, 1.41)	475-1,152 vs. >1583 m
								1.10 (1.06, 1.14)	1,152-1,583 vs. >1,583 m
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Density	Adults (18+)	Both	1.02 (0.97, 1.08)	>6,650 vs. <250 vehicle-km/day
								1.02 (0.96, 1.08)	3,230-6,650 vs. 250 vehicle-km/day
								1.00 (0.94, 1.05)	1,630-3,220 vs. <250 vehicle-km/day
								1.02 (0.97, 1.09)	250-1620 vs. <250 vehicle-km/day
					Distance			1.03 (0.98, 1.08)	<50 vs. >250 m
								1.01 (0.95, 1.06)	50-100 vs. >250 m
								1.00 (0.94, 1.05)	100-150 vs. >250 m
								1.00 (0.96, 1.05)	150-250 vs. >250 m
Chen 2013	Ontario Tax Cohort	Multiple cities, Ontario, Canada	1982-2004	205,440	Distance	Adults (18+)	Both	1.01 (0.92, 1.10)	<50 to major road or <100 m to highway vs. higher
Finkelstein 2005	Hamilton Pulmonary Cohort ^b	Hamilton, Ontario, Canada	1985-2001	5,228	Distance	Adults (18-64)	Both	1.80 (1.07, 3.03)	<150 m to highway or <50 m to major road vs. higher

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Huss 2010	Swiss National Cohort	Switzerland	2000-2005	4,580,311	Distance	Adults (18+)	Both	1.01 (0.98, 1.05)	<50 vs. >200 m
								0.99 (0.95, 1.03)	50-99 vs. >200 m
								1.02 (0.98, 1.06)	100-199 vs. >200 m
Raaschou-Nielsen 2012	DDCH	Copenhagen and Aarhus, Denmark	1993-2009	52,061	Distance	Adults (18- 64)	Both	0.87 (0.54, 1.39)	<50 vs. >50 m
					Density			1.02 (0.94, 1.11) ^c	1 vehicle-km/day

^a Effect estimates are expressed as relative risk or hazard ratio.

^b Indicates a patient population.

^c Log transformed.

Table 11B-3. Key Study Characteristics of Articles Included in the Systematic Review for Respiratory, COPD, and ALRI Mortality Analysis – Pollutants

Reference	Study Name	Location	Study Period	Sample Size	Age	Sex	Exposure Assessment	Pollutant	Mean or Median Exposure ^a	Effect Estimate (95% CI) ^b	Increment
Respiratory Mortality											
Bauleo 2019	Civitavecchia Study	Civitavecchia, Italy	1996-2013	71,362	Adults (18+)	Both	Dispersion / CTM	NO _x	5.8	1.14 (0.87, 1.49)	12.8 µg/m ³
Beelen 2008	NLCS-AIR	The Netherlands	1987-1996	117,528	Adults (18+)	Both	LUR	NO ₂	36.9	1.37 (1.00, 1.87)	30 µg/m ³
								BC	16.5	1.22 (0.99, 1.50)	10 µg/m ³
								PM _{2.5} mass	28.3	1.07 (0.75, 1.52)	10 µg/m ³
Carey 2013	English National Cohort	England	2003-2007	830,842	Adults (18+)	Both	Dispersion / CTM	NO ₂	22.5	1.07 (1.03, 1.12)	10.7 µg/m ³
								PM ₁₀ mass	19.7	1.07 (1.03, 1.11)	3.0 µg/m ³
								PM _{2.5} mass	12.9	1.07 (1.03, 1.11)	1.9 µg/m ³
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Adults (18+)	Both	LUR	NO ₂	43.6	1.03 (1.00, 1.06)	10 µg/m ³
							Dispersion / CTM	PM _{2.5} mass	23.0	1.03 (0.97, 1.08)	10 µg/m ³
Crouse 2015	1991 CanCHEC	Multiple cities, Canada	1991-2006	735,590	Adults (18+)	Both	LUR	NO ₂	25.2	1.08 (1.03, 1.12)	5 ppb
Dimakopoulou 2014	ESCAPE	Multiple cities, multiple countries	1985-2008	307,553	Adults (18+)	Both	LUR	NO ₂	5.2-53.1	0.97 (0.89, 1.05)	10 µg/m ³
								NO _x	8.7-96.1	0.99 (0.90, 1.09)	20 µg/m ³
								PM _{2.5} abs	0.6-3.1	0.70 (0.47, 0.93)	1.1×10 ⁻⁵ /m
								PM ₁₀ mass	13.5-46.4	0.86 (0.67, 1.04)	10 µg/m ³
								PM _{coarse} mass	4.0-20.7	0.95 (0.76, 1.14)	5 µg/m ³
								PM _{2.5} mass	7.1-30.1	0.89 (0.66, 1.12)	5 µg/m ³
Hansell 2016	ONS-Longitudinal	England and Wales, United Kingdom	1971-2009	367,658	Adults (18-64)	Both	LUR	BS	42.7	1.05 (1.01, 1.09)^c	10 µg/m ³
								PM ₁₀ mass	20.7	1.23 (1.05, 1.45)^c	10 µg/m ³

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Hvidtfeldt 2019	DDCH	Copenhagen and Aarhus, Denmark	1993-2015	49,564	Adults (18-64)	Both	Dispersion / CTM	NO ₂	25.0	1.03 (0.97, 1.09)	10 µg/m ³
								BC	0.92	1.00 (0.90, 1.12)	1 µg/m ³
								PM ₁₀ mass	25.1	1.04 (0.87, 1.24)	10 µg/m ³
								PM _{2.5} mass	18.0	1.07 (0.92, 1.24)	5 µg/m ³
Jerrett 2009	Toronto Respiratory Cohort ^d	Toronto, Canada	1992-2002	2,360	Adults (18+)	Both	LUR	NO ₂	22.9	1.06 (0.67, 1.49)	4 ppb
Nafstad 2004	Oslo men's cohort	Oslo, Norway	1972-1998	16,209	Adults (18-64)	Male	Dispersion / CTM	NO _x	10.7	1.16 (1.06, 1.26)	10 µg/m ³
Ostro 2015	California Teachers Study	California, United States	1995-2007	101,884	Adults (18+)	Female	Dispersion / CTM	EC	1.1	1.00 (0.91, 1.09)	0.8 µg/m ³
								PM _{2.5} mass	17.9	0.99 (0.90, 1.09)	9.6 µg/m ³
								PM _{2.5} Cu	0.5	1.00 (0.94, 1.08)	0.4 ng/m ³
								PM _{2.5} Fe	0.4	0.99 (0.90, 1.09)	0.2 µg/m ³
								on-road diesel	0.4	0.98 (0.88, 1.08)	0.4 µg/m ³
								on-road gasoline	0.3	0.94 (0.86, 1.03)	0.3 µg/m ³
								PM _{0.1-0.01}	1293	1.01 (0.93, 1.10)	969 ng/m ³
Stockfelt 2015	PPS	Gothenburg, Sweden	1970-2007	6,557	Adults (18-64)	Male	Dispersion / CTM	NO _x	42	1.00 (0.94, 1.07)	10 µg/m ³
Villeneuve 2013	Ontario Tax Cohort	Toronto, Canada	1982-2004	58,760	Adults (18+)	Both	LUR	benzene	0.64	1.07 (0.98, 1.16)	0.1 µg/m ³
Yang 2018	Hong Kong Elderly	Hong Kong, China	1998-2011	61,386	Older Adults (65+)	Both	LUR	NO ₂	104	0.99 (0.93, 1.06)	25.6 µg/m ³
								NO	147	1.00 (0.94, 1.05)	167 µg/m ³
								BC	12.1	0.99 (0.94, 1.04)	9.6 µg/m ³
								PM _{2.5} mass	42.2	1.01 (0.96, 1.06)	5.5 µg/m ³
Yap 2012	Renfrew/Paisley	Glasgow, Scotland	1972-1998	15,331	Adults (18+)	Both	LUR	BS	19.3	1.30 (1.04, 1.63)	10 µg/m ³
	Collaborative cohorts	Glasgow, Scotland	1972-1998	6,297	Adults (18+)	Both	LUR	BS	23.2	0.96 (0.78, 1.18)	10 µg/m ³
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999-2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	1.19 (1.02, 1.38)	10 µg/m ³

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Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999-2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	1.19 (1.06, 1.34)	10 µg/m ³
COPD Mortality											
Bauleo 2019	Civitavecchia Study	Civitavecchia, Italy	1996-2013	71,362	Adults (18+)	Both	Dispersion / CTM	NO _x	5.8	1.34 (0.90, 1.99)	12.8 µg/m ³
Naess 2007a	Oslo Elderly	Oslo, Norway	1992-1998	143,842	Adults (51-70)	Male	Dispersion / CTM	NO ₂	39	1.21 (1.05, 1.39)^e	25.4 µg/m ³
					Older Adults (71-90)					1.04 (0.95, 1.14)^e	
					Adults (51-70)	Female				1.06 (0.92, 1.21)^e	
					Older Adults (71-90)					1.07 (0.97, 1.17)^e	
					Adults (51-70)	Male		PM ₁₀ mass	19	1.29 (1.12, 1.48)	6.8 µg/m ³
					Older Adults (71-90)					1.08 (0.98, 1.18)	
					Adults (51-70)	Female				1.06 (0.92, 1.22)	
					Older Adults (71-90)					1.08 (0.98, 1.19)	
					Adults (51-70)	Male		PM _{2.5} mass	15	1.27 (1.11, 1.47)	4.9 µg/m ³
					Older Adults (71-90)					1.10 (1.00, 1.21)	
					Adults (51-70)	Female				1.09 (0.94, 1.25)	
					Older Adults (71-90)					1.05 (0.96, 1.16)	
Naess 2007b	Oslo Elderly	Oslo, Norway	1992-1998	86,828	Adults (18+)	Both	Dispersion / CTM		14.2	1.17 (1.09, 1.25)	6.0 µg/m ³
Yang 2018	Hong Kong Elderly	Hong Kong, China	1998-2011	61,386	Older Adults (65+)	Both	LUR	NO ₂	104	1.02 (0.90, 1.16)	25.6 µg/m ³
								NO	147	1.04 (0.94, 1.15)	167 µg/m ³
								BC	12.1	0.98 (0.9, 1.08)	9.6 µg/m ³
								PM _{2.5} mass	42.2	1.06 (0.97, 1.15)	5.5 µg/m ³
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999-2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	1.11 (0.78, 1.56)	10 µg/m ³
Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999-2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	0.98 (0.75, 1.29)	10 µg/m ³

ALRI Mortality										
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999-2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	1.18 (0.96, 1.45) 10 µg/m ³
Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999-2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	1.15 (0.99, 1.35) 10 µg/m ³

^a Units are in the increment column.

^b Effect estimates expressed as relative risk or hazard ratio. **Bold** indicates the effect estimate was included in the meta-analysis.

^c Odds ratio.

^d Indicates a patient population.

^e Estimates were combined by a fixed effect meta-analysis before entering the random-effects model.

Table 11B-4. Key Study Characteristics of Articles Included in the Systematic Review for Respiratory, COPD, and ALRI Mortality Analysis — Indirect Traffic Measures

Reference	Study Name	Location	Study Period	Sample Size	Age	Sex	Traffic Measure	Effect Estimate (95% CI) ^a	Increment
Respiratory Mortality									
Beelen 2008	NLCS-AIR	The Netherlands	1987-1996	117,528	Adults (18+)	Both	Density	1.21 (1.02, 1.44)	335,000 vehicles/day
							Distance	1.19 (0.91, 1.56)	<100 m to highway or <50 m to major road vs. higher
Cakmak 2019	1991 CanCHEC	Canada	1991-2011	2,644,370	Adults (18+)	Both	Distance	1.03 (0.76, 1.40)	<475 vs. >1583 m
								1.07 (0.98, 1.16)	475-1,152 vs. >1,583 m
								1.06 (1.03, 1.09)	1,152-1,583 vs. >1,583 m
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Adults (18+)	Both	Density	1.08 (1.00, 1.15)	>6650 vs. <250 vehicle-km/day
								1.02 (0.95, 1.10)	3,230-6,650 vs. <250 vehicle-km/day
								1.06 (0.99, 1.14)	1,630-3,220 vs. <250 vehicle-km/day
								1.02 (0.95, 1.10)	250-1620 vs. <250 vehicle-km/day
							Distance	1.01 (0.95, 1.08)	<50 vs. >250 m
								1.02 (0.96, 1.09)	50-100 vs. 250 m
								0.96 (0.90, 1.03)	100-150 vs. >250 m
								0.97 (0.91, 1.03)	150-250 vs. >250 m
Dimakopoulou 2014	ESCAPE	Multiple cities, multiple countries	1985-2008	307,553	Adults (18+)	Both	Density	1.03 (0.93, 1.12)	4,000 vehicle-km/day
Finkelstein 2005	Hamilton Pulmonary Cohort ^b	Hamilton, Ontario, Canada	1985-2001	5,228	Adults (18-64)	Both	Distance	0.95 (0.71, 1.27)	<150 to highway or <50 m to major road vs. higher
Heinrich 2013	SALIA	North Rhine-Westphalia, Germany	1985-2008	4,615	Adults (18-64)	Female	Distance	3.54 (1.49, 8.40)	<50 vs. >50 m

COPD Mortality								
Cakmak 2019	1991 CanCHEC	Canada	1991-2011	2,644,370	Adults (18+)	Both	Distance	1.99 (1.32, 2.99) <475 vs. >1583 m
								475-1,152 vs. >1,583 m
								1,152-1,583 vs. >1,583 m

^aEffect estimates are expressed as relative risk or hazard ratio.

^bIndicates a patient population. No studies with ALRI.

Table 11B-5. Key Study Characteristics of Articles Included in the Systematic Review for Lung Cancer Mortality Analysis – Pollutants

Reference	Study Name	Location	Study Period	Sample Size	Age	Sex	Exposure Assessment	Pollutant	Mean or Median Exposure ^a	Effect Estimate (95% CI) ^b	Increment
Bauleo 2019	Civitavecchia Study	Civitavecchia, Italy	1996-2013	71,362	Adults (18+)	Both	Dispersion / CTM	NO _x	5.8	1.19 (0.95, 1.49)	12.77 µg/m ³
Beelen 2008	NLCS-AIR	The Netherlands	1987-1996	117,528	Adults (18+)	Both	LUR	NO ₂	36.9	0.91 (0.72, 1.15)	30 µg/m ³
								BC	16.5	1.03 (0.88, 1.20)	10 µg/m ³
								PM _{2.5} mass	28.3	1.06 (0.82, 1.38)	10 µg/m ³
Carey 2013	English National Cohort	England	2003-2007	830,842	Adults (18+)	Both	Dispersion / CTM	NO ₂	22.5	1.05 (1.00, 1.11)	10.7 µg/m ³
								PM ₁₀ mass	19.7	1.00 (0.96, 1.05)	3.0 µg/m ³
								PM _{2.5} mass	12.9	1.01 (0.96, 1.05)	1.9 µg/m ³
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Adults (18+)	Both	LUR	NO ₂	43.6	1.04 (1.02, 1.07)	10 µg/m ³
							Dispersion / CTM	PM _{2.5} mass	23.0	1.05 (1.01, 1.10)	10 µg/m ³
Huss 2010	Swiss National Cohort	Switzerland	2000-2005	4,580,311	Adults (18+)	Both	Dispersion / CTM	PM ₁₀ mass	18.8	1.05 (1.04, 1.07)	10 µg/m ³
Krewski 2009	ACS-CPS II LA	Los Angeles, California, United States	1982-2000	22,905	Adults (18+)	Both	LUR	PM _{2.5} mass	20	1.39 (0.96, 2.01)	10 µg/m ³
	ACS-CPS II NYC	New York City, New York, United States	1982-2000	44,056	Adults (18+)	Both	LUR	PM _{2.5} mass	14.3	0.95 (0.84, 1.09)	1.5 µg/m ³
Nafstad 2004	Oslo men's cohort	Oslo, Norway	1972-1998	16,209	Adults (18-64)	Male	Dispersion / CTM	NO _x	10.7	1.11 (1.03, 1.19)	10 µg/m ³
Naess 2007a	Oslo Elderly	Oslo, Norway	1992-1998	143,842	Adults (51-70)	Male	Dispersion / CTM	NO ₂	39	1.07 (0.97, 1.18)^c	25.38 µg/m ³
					Older Adults (71-90)					1.09 (0.98, 1.20)^c	
					Adults (51-70)	Female				1.23 (1.10, 1.38)^c	
					Older Adults (71-90)					1.12 (0.98, 1.27)^c	
					Adults (51-70)	Male		PM ₁₀ mass	19	1.07 (0.97, 1.18)^c	6.76 µg/m ³

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				Older Adults (71-90)			PM ₁₀ mass		1.08 (0.98, 1.20)^c		
				Adults (51-70)	Female		PM ₁₀ mass		1.27 (1.13, 1.43)^c		
				Older Adults (71-90)			PM ₁₀ mass		1.17 (1.03, 1.33)^c		
				Adults (51-70)	Male		PM _{2.5} mass	15	1.07 (0.97, 1.18)^c	4.89 µg/m ³	
				Older Adults (71-90)			PM _{2.5} mass		1.07 (0.97, 1.18)^c		
				Adults (51-70)	Female		PM _{2.5} mass		1.27 (1.13, 1.43)^c		
				Older Adults (71-90)			PM _{2.5} mass		1.16 (1.02, 1.32)^c		
Naess 2007b	Oslo Elderly	Oslo, Norway	1992-1998	86,828	Adults (18+)	Both	Dispersion / CTM	PM _{2.5} mass	14.2	1.12 (1.05, 1.19)	6.0 µg/m ³
Villeneuve 2013	Ontario Tax Cohort	Toronto, Canada	1982-2004	58,760	Adults (18+)	Both	LUR	benzene	0.64	1.06 (0.97, 1.14)	0.13 µg/m ³
Yap 2012	Renfrew/Paisley	Glasgow, Scotland	1972-1998	15,331	Adults (18+)	Both	LUR	BS	19.3	0.99 (0.81, 1.21)	10 µg/m ³
	Collaborative cohorts	Glasgow, Scotland	1972-1998	6,297	Adults (18+)	Both	LUR	BS	23.2	1.15 (0.98, 1.34)	10 µg/m ³
Yorifuji 2010	Shizuoka Elderly	Shizuoka, Japan	1999-2006	12,029	Older Adults (65+)	Both	LUR	NO ₂	25	0.95 (0.78, 1.17)	10 µg/m ³
Yorifuji 2013	Shizuoka Elderly	Shizuoka, Japan	1999-2009	13,412	Older Adults (65+)	Both	LUR	NO ₂	22	1.20 (1.03, 1.40)	10 µg/m ³

^a Units are in the increment column.

^b Effect estimates are expressed as relative risk or hazard ratio. **Bold** indicates the effect estimate was included in the meta-analysis.

^c Estimates were combined by a fixed effect meta-analysis before entering the random-effects model.

Table 11B-6. Key Study Characteristics of Articles Included in the Systematic Review for Lung Cancer Mortality Analysis — Indirect Traffic Measures

Reference	Study Name	Location	Study Period	Sample Size	Age	Sex	Traffic measure	Effect Estimate (95% CI) ^a	Increment
Beelen 2008	NLCS-AIR	The Netherlands	1987-1996	117,528	Adults (18+)	Both	Density	1.07 (0.93, 1.23)	335,000 vehicles/day
							Distance	1.20 (0.98, 1.47)	<100 m to highway or <50 m to major road vs. higher
Cakmak 2019	1991 CanCHEC	Canada	1991-2011	2,644,370	Adults (18+)	Both	Distance	2.30 (1.74, 3.03)	<475 vs. >1,583 m
								1.11 (1.03, 1.21)	475-1,152 vs. >1583 m
								1.02 (0.99, 1.05)	1,152-1,583 vs. >1,583 m
Cesaroni 2013	Rome Longitudinal	Rome, Italy	2001-2010	1,265,058	Adults (18+)	Both	Density	1.03 (0.97, 1.09)	>6,650 vs. <250 vehicle-km/day
								1.04 (0.98, 1.10)	3,230-6,650 vs. <250 vehicle-km/day
								1.02 (0.96, 1.08)	1,630-3,220 vs. <250 vehicle-km/day
								1.02 (0.96, 1.08)	250-1,620 vs. <250 vehicle-km/day
							Distance	0.99 (0.94, 1.05)	<50 vs. >250 m
								1.01 (0.95, 1.07)	50-100 vs. >250 m
								1.01 (0.96, 1.07)	100-150 vs. >250 m
								0.98 (0.93, 1.03)	150-250 vs. >250 m
Heinrich 2013	SALIA	North Rhine-Westphalia, Germany	1985-2008	4615	Adults (18-64)	Female	Distance	0.62 (0.15, 2.60)	<50 vs. >50 m
Huss 2010	Swiss National Cohort	Switzerland	2000-2005	4,580,311	Adults (18+)	Both	Distance	1.22 (1.16, 1.28)	<50 vs. >200 m
								1.16 (1.09, 1.22)	50-99 vs. >200 m
								1.10 (1.04, 1.17)	100-199 vs. >200 m

^a Effect estimates are expressed as relative risk or hazard ratio.

Table 11B-7. Summary of Risk of Bias Rating for Studies on Circulatory Mortality

Domain	Subdomain	Per Study			Per Pollutant-Study Pair		
		Low-risk	Moderate-risk	High-risk	Low-risk	Moderate-risk	High-risk
1. Confounding	Were all important potential confounders adjusted for in the design or analysis?	12	1	6	26	3	11
	Validity of measuring of confounding factors	17	2	0	36	4	0
	Control in analysis	17	2	0	38	2	0
	Overall	9	4	6	21	8	11
2. Selection Bias	Selection of participants into the study	16	2	1	33	6	1
3. Exposure assessment	Methods used for exposure assessment	19	0	0	40	0	0
	Exposure measurement methods comparable across the range of exposure	19	0	0	40	0	0
	Change in exposure status	10	8	1	19	19	2
	Overall	10	8	1	19	19	2
4. Outcome measurements	Blinding of outcome measurements	19	0	0	40	0	0
	Validity of outcome measurements	19	0	0	40	0	0
	Outcome measurements	19	0	0	40	0	0
	Overall	19	0	0	40	0	0
5. Missing data	Missing data on outcome measures	18	0	1	39	0	1
	Missing data on exposures	17	1	1	37	1	2
	Overall	16	1	2	36	1	3
6. Selective reporting	Authors reported a priori primary and secondary study aims	19	0	0	40	0	0

Mod = moderate.

Table 11B-8. Summary of Risk of Bias Rating for Studies on Respiratory Mortality

Domain	Subdomain	Per Study			Per Pollutant-Study Pair		
		Low-risk	Moderate-risk	High-risk	Low-risk	Moderate-risk	High-risk
1. Confounding	Were all important potential confounders adjusted for in the design or analysis?	11	0	3	26	0	5
	Validity of measuring of confounding factors	13	1	0	28	3	0
	Control in analysis	13	1	0	30	1	0
	Overall	9	2	3	22	4	5
2. Selection Bias	Selection of participants into the study	11	2	1	24	6	1
3. Exposure assessment	Methods used for exposure assessment	14	0	0	31	0	0
	Exposure measurement methods comparable across the range of exposure	14	0	0	31	0	0
	Change in exposure status	8	5	1	16	13	2
	Overall	8	5	1	16	13	2
4. Outcome measurements	Blinding of outcome measurements	14	0	0	31	0	0
	Validity of outcome measurements	14	0	0	31	0	0
	Outcome measurements	14	0	0	31	0	0
	Overall	14	0	0	31	0	0
5. Missing data	Missing data on outcome measures	13	0	1	30	0	1
	Missing data on exposures	13	0	1	29	0	2
	Overall	12	0	2	28	0	3
6. Selective reporting	Authors reported a priori primary and secondary study aims	14	0	0	31	0	0

Mod = moderate.

Table 11B-9. Summary of Risk of Bias Rating for Studies on Lung Cancer Mortality

Domain	Subdomain	Per Study			Per Pollutant-Study Pair		
		Low-risk	Moderate-risk	High-risk	Low-risk	Moderate-risk	High-risk
1. Confounding	Were all important potential confounders adjusted for in the design or analysis?	5	0	3	11	0	6
	Validity of measuring of confounding factors	7	1	0	14	3	0
	Control in analysis	7	1	0	16	1	0
	Overall	3	2	3	7	4	6
2. Selection Bias	Selection of participants into the study	6	1	1	13	3	1
3. Exposure assessment	Methods used for exposure assessment	8	0	0	17	0	0
	Exposure measurement methods comparable across the range of exposure	8	0	0	17	0	0
	Change in exposure status	5	2	1	10	5	2
	Overall	5	2	1	10	5	2
4. Outcome measurements	Blinding of outcome measurements	8	0	0	17	0	0
	Validity of outcome measurements	8	0	0	17	0	0
	Outcome measurements	8	0	0	17	0	0
	Overall	8	0	0	17	0	0
5. Missing data	Missing data on outcome measures	7	0	1	16	0	1
	Missing data on exposures	8	0	0	17	0	0
	Overall	7	0	1	16	0	1
6. Selective reporting	Authors reported a priori primary and secondary study aims	8	0	0	17	0	0

Mod = moderate.

Table 11B-10. Risk of Bias Assessment for Studies Included in Meta-analysis for Circulatory Mortality

Reference	Study Name	Confounding	Selection Bias	Exposure Assessment	Outcome Measurement
Badaloni 2017	Rome Longitudinal	High	Low	Mod	Low
Bauleo 2019	Civitavecchia Study	High	Low	Mod	Low
Beelen 2008	NLCS-AIR	Mod	Low	Mod	Low
Beelen 2014b	ESCAPE	Low	Low	Mod	Low
Carey 2013	English National Cohort	Mod	Mod	Low	Low
Cesaroni 2013	Rome Longitudinal	High	Low	Low	Low
Chen 2013	Ontario Tax Cohort	Mod	Low	Low	Low
Crouse 2015	1991 CanCHEC	Mod	Low	Mod	Low
Hansell 2016	ONS-Longitudinal	High	Low	Low	Low
Huss 2010	Swiss National Cohort	High	Low	Low	Low
Hvidtfeldt 2019	DDCH	Low	Low	Low	Low
Jerrett 2017	ACS-CPS II	Low	Low	Mod	Low
Krewski 2009	ACS-CPS II LA	Low	Low	Mod	Low
Krewski 2009	ACS-CPS II NYC	Low	Low	Mod	Low
Naess 2007a	Oslo Elderly	High	Low	Low	Low
Ostro 2015	California Teachers Study	Low	Low	Low	Low
Stockfelt 2015	PPS	Low	Low	Low	Low
Yang 2018	Hong Kong Elderly	Low	Mod	Mod	Low
Yap 2012	Renfrew/Paisley	Low	Low	High	Low
Yap 2012	Collaborative cohorts	Low	Low	High	Low
Yorifuji 2013	Shizuoka Elderly	Low	High	Low	Low

Mod = moderate.

Table 11B-11. Risk of Bias Assessment for Studies Included in Meta-analysis for Respiratory Mortality

Reference	Study Name	Confounding	Selection Bias	Exposure Assessment	Outcome Measurement	Missing Data	Selective Reporting
Bauleo 2019	Civitavecchia Study	High	Low	Mod	Low	Low	Low
Beelen 2008	NLCS-AIR	Low	Low	Mod	Low	Low	Low
Carey 2013	English National Cohort	Mod	Mod	Low	Low	Low	Low
Cesaroni 2013	Rome Longitudinal	High	Low	Low	Low	Low	Low
Crouse 2015	1991 CanCHEC	Mod	Low	Mod	Low	Low	Low
Dimakopoulou 2014	ESCAPE	Low	Low	Mod	Low	Low	Low
Hansell 2016	ONS-Longitudinal	High	Low	Low	Low	High	Low
Hvidtfeldt 2019	DDCH	Low	Low	Low	Low	Low	Low
Nafstad 2004	Oslo men's cohort	Low	Low	Low	Low	Low	Low
Ostro 2015	California Teachers Study	Low	Low	Low	Low	Low	Low
Stockfelt 2015	PPS	Low	Low	Low	Low	Low	Low
Yang 2018	Hong Kong Elderly	Low	Mod	Mod	Low	Low	Low
Yap 2012	Renfrew/Paisley	Low	Low	High	Low	Low	Low
Yap 2012	Collaborative cohorts	Low	Low	High	Low	Low	Low
Yorifuji 2013	Shizuoka Elderly	Low	High	Low	Low	High	Low

Mod = moderate.

Table 11B-12. Risk of Bias Assessment for Studies Included in Meta-analysis for Lung Cancer Mortality

Reference	Study Name	Confounding	Selection Bias	Exposure Assessment	Outcome Measurement	Missing Data	Selective Reporting
Beelen 2008	NLCS-AIR	Low	Low	Mod	Low	Low	Low
Carey 2013	English National Cohort	Mod	Mod	Low	Low	Low	Low
Cesaroni 2013	Rome Longitudinal	High	Low	Low	Low	Low	Low
Huss 2010	Swiss National Cohort	High	Low	Low	Low	Low	Low
Krewski 2009	ACS-CPS II LA	Low	Low	Mod	Low	Low	Low
Krewski 2009	ACS-CPS II NYC	Low	Low	Mod	Low	Low	Low
Naess 2007a	Oslo Elderly	High	Low	Low	Low	Low	Low
Yap 2012	Renfrew/Paisley	Low	Low	High	Low	Low	Low
Yap 2012	Collaborative cohorts	Low	Low	High	Low	Low	Low
Yorifuji 2013	Shizuoka Elderly	Mod	High	Low	Low	High	Low

Mod = moderate.

Appendix 11C References for Studies Included in the Systematic Review of Mortality

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