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Supplementary appendix

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Global Association of Air Pollution and Heart Failure

A Systematic Review and Meta-analysis

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Supplementary Appendices

Appendix A – Search criteria

Appendix B – Number of studies identified, included and excluded from analysis

Appendix C – Summary of characteristics pertaining to study quality

Appendix D – US state abbreviations

Appendix E – Summary of impact analysis per state

Appendix A

Search Criteria

I. MedLine and EMBASE

1	Exploded - air pollution.mp. or Air Pollution/
2	Exploded - particulate matter.mp. or Particulate Matter/
3	Exploded - nitrogen dioxide.mp. or Nitrogen Dioxide/
4	Exploded - carbon monoxide.mp. or Carbon Monoxide/
5	Exploded - sulphur dioxide.mp. or Sulphur Dioxide/
6	Exploded - ozone.mp. or Ozone/
7	1 or 2 or 3 or 4 or 5 or 6
8	Exploded - heart failure.mp. or Heart failure/
9	Exploded - congestive cardiac failure.mp.
10	Exploded - heart failure, systolic/ or ventricular dysfunction, left/ or systolic dysfunction.mp.
11	Exploded - diastolic dysfunction.mp.
12	Exploded - left ventricular impairment.mp.
13	8 or 9 or 10 or 11 or 12
14	7 and 13

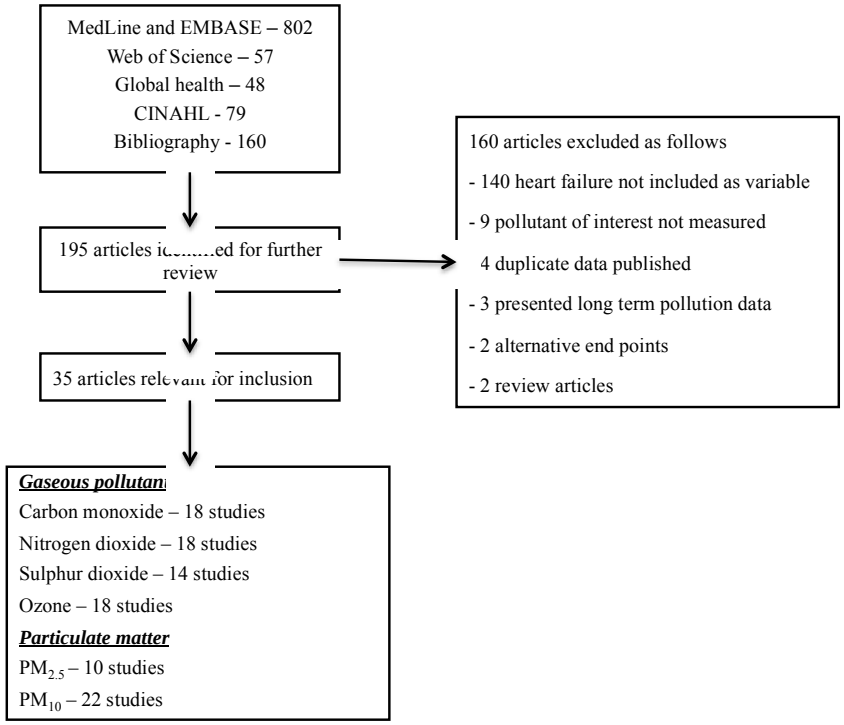
II. Web Of Science, CINAHL AND Global Health

"Cardiac failure" OR "Heart failure" OR "Congestive cardiac failure" OR "Left ventricular failure" OR "Systolic heart failure" OR "Diastolic heart failure"

AND

"Air pollution" OR "Particulate matter" OR "PM_{10}" OR "$PM_{2.5}$" OR "ozone" OR "nitrogen dioxide" OR "sulphur dioxide" OR "carbon monoxide"

Appendix B


MedLine and EMBASE – 802
Web of Science – 57
Global health – 48
CINAHL - 79
Bibliography - 160
195 articles identified for further review
160 articles excluded as follows
- 140 heart failure not included as variable
- 9 pollutant of interest not measured
4 duplicate data published
- 3 presented long term pollution data
- 2 alternative end points
- 2 review articles
35 articles relevant for inclusion
Gaseous pollutant
Carbon monoxide – 18 studies
Nitrogen dioxide – 18 studies
Sulphur dioxide – 14 studies
Ozone – 18 studies
Particulate matter
PM2.5 – 10 studies
PM10 – 22 studies

Appendix C

Author	Year	Generalizability	Mean daily pollutant level	> 10,000 events	Total population ‡	Time-stratified case crossover**	Multiple lags**	Control for repeated events**	Complete evaluation of study area**	Non-linear adjustment for temperature**	Adjusted for temperature	Adjusted for time trends	Adjusted for seasonality	Adjusted for influenza epidemics
Schwartz et al[1]	1995	1	1	1	0	n/a	1	0	1	1	1	1	1	0
Morris et al[2]	1995	1	1	1	0	n/a	1	0	1	0	1	1	1	0
Burnett et al[3]	1997	1	1	1	0	n/a	1	0	0	1	1	1	1	0
Poloniecki et al[4]	1997	1	1	1	1	n/a	0	0	0	0	1	1	1	**1**
Morris et al[5]	1998	1	1	1	0	n/a	1	0	1	1	1	1	1	0
Wong CM et al[6]	1999	1	1	0	0	n/a	1	0	0	0	1	1	1	**1**
Wong TW et al[7]	1999	1	1	0	0	n/a	1	0	1	1	1	1	1	0
Burnett et al[8]	1999	1	0§§	1	1	n/a	1	0	1	1	1	1	1	0
Stieb et al[9]	2000	1	1	0	1	n/a	1	0	1	1	1	1	0	0
Goldberg et al[10-12]	2000	1	0§§	1	0	n/a	1	n/a	1	1	1	0	1	0
Linn et al[13]	2000	1	1	1	1	n/a	1	0	0	1	1	1	1	0
Lippmann et al[12,14]	2000	1	1	1	0	n/a	1	n/a	1	1	1	1	1	**1**
Ye et al[15]	2001	1	1	0	0	n/a	1	0	0	0	1	0	0	0
Kwon et al[16]	2001	1	1	0	1	n/a	0	n/a	1	1	1	1	1	0
Hoek et al[12,17]	2001	1	1	1	1	n/a	1	n/a	1	1	1	1	1	0
McGowan et al[18]	2002	1	1	0	1	n/a	1	0	1	0	1	0	1	0
Koken et al[19]	2003	1	1	0	0	n/a	1	0	1	1	1	0	0	0

Bateson et al[20]	2004	1	1	1	0	1	0	n/a	1	1	1	1	1	0
Metzger et al[21]	2004	1	1	1	1	n/a	1	1	1	1	1	1	1	0
Wellenius et al[22]	2005	1	1	1	0	1	1	1	1	0	1	1	1	0
Wellenius et al[23]	2006	1	1	1	0	1	1	0	1	1	1	1	1	0
Martins et al[24]	2006	1	1	1	1	n/a	1	0	1	1	1	1	1	0
Dominici et al[25]	2006	1	1	1	0	n/a	1	0	1	1	1	1	1	**1**
Barnett et al[26]	2006	1	1	1	1	1	1	0	1	1	1	1	1	0
Lee et al[27]	2007	1	1	1	1	0	1	0	1	0	0	1	1	0
Peel et al[28]	2007	1	1	1	1	1	1	1	1	1	1	1	1	0
Forastiere et al[29]	2008	0†	1	0	0	1	0	n/a	1	0	1	1	1	**1**
Yang et al[30]	2008	1	1	1	1	0	1	0	1	0	0	1	1	0
Bell et al[31]	2009	1	1	1	0	n/a	1	0	1	1	1	1	1	0
Stieb et al[32]	2009	0§	1	1	1	n/a	1	0	0	1	1	1	1	0
Zanobetti et al[33]	2009	1	1	1	0	n/a	0	0	1	1	1	1	1	0
Colais et al[34]	2009	1	1	1	1	1	1	0	1	1	1	1	1	**1**
Haley et al[35]	2009	1	1	1	1	1	1	1	1	1	1	1	1	0
Ueda et al[36]	2009	1	1	1	1	n/a	1	n/a	1	1	1	1	1	0
Belleudi et al[37]	2010	1	1	1	1	1	1	1	1	1	1	1	1	**1**

Abbreviations - N/A = not applicable, 1 = yes, 0 = no

† Forastiere et al only investigated pollutant associated mortality in patients already diagnosed with heart failure.

‡ Studies using Medicare data only included persons ≥ 65 years of age.

§ Refers to emergency department visits rather than hospital admissions per se.

** Time stratified case crossover study defined as one controlling for time varying factors. In most case-crossover studies this consisted of day of the week. Multiple lags defined as studies evaluated pollutant levels in a distributed lag model beyond lag of 1 day. Complete evaluation of study area defined as a study where the unit of analysis for the exposure matched that of the outcome. Non-linear adjustment for temperature defined as either a quadratic, cubic or polynomial. Control for repeated events defined as those studies that have accounted for multiple hospitalisations in their analysis.

§§ Goldberg et al measured particulate matter every six days and Burnett et al estimated $PM_{2.5}$ values from total suspended particles

Appendix D

US state abbreviations used in figure 3

AR=Arkansas, AZ=Arizona, CA=California, CO=Colorado, FL=Florida, IA=Iowa, IL=Illinois, KS=Kansas, KY=Kentucky, MA=Massachusetts, MD=Maryland, ME=Maine, MI=Michigan, MN=Minnesota, NC=North Carolina, NE=Nebraska, NH=New Hampshire, NJ=New Jersey, NM=New Mexico, NV=Nevada, NY=New York, OK=Oklahoma, OR=Oregon, RI=Rhode Island, SC=South Carolina, TN=Tennessee, TX=Texas, UT=Utah, VT=Vermont, WA=Washington, WI=Wisconsin, WV=West Virginia, WY=Wyoming.

Appendix E

State	Annual Hospitalisations	Hospitalisations per 100,000‡	Cost per hospitalisation, $**	Median daily $PM_{2.5}$, $\mu g/m^3$§	$PM_{2.5}$ reduction to 5.8 $\mu g/m^3$ §	PAR (%)	Annual reduction in hospitalisations‡	Savings from reduction in hospitalisations, $
Alabama†	10,362	n/a§§	38,947	12.3	6.5	1.41	146	5,696,564
Arizona*	14,192	298	46,540	10.2	4.4	0.96	136	6,335,475
Arkansas*	11,189	508	24,934	11.7	5.9	1.29	144	3,600,489
California*	80,583	288	64,293	10.0	4.2	0.92	738	47,436,529
Colorado*	7,209	190	39,302	7.7	1.9	0.42	30	1,192,075
Connecticut†	7,671	n/a§§	38,947	9.2	3.4	0.74	57	2,217,698
Delaware†	1,701	n/a§§	38,947	11.2	5.4	1.17	20	772,502
District of Columbia†	1,141	n/a§§	38,947	12.1	6.3	1.37	16	610,134
Florida*	70,682	478	44,079	8.0	2.2	0.49	344	15,146,138
Georgia†	15,451	n/a§§	38,947	11.6	5.825	1.27	196	7,641,612
Idaho†	1,634	n/a§§	38,947	6.8	1.025	0.22	4	142,211
Illinois*	42,045	433	35,357	10.3	4.525	0.99	415	14,664,418
Indiana†	1,634	n/a§§	38,947	11.9	6.055	1.32	176	6,863,296
Iowa*	8,651	373	20,872	9.1	3.3	0.72	62	1,298,975
Kansas*	7,077	333	25,864	8.5	2.735	0.60	42	1,091,337
Kentucky*	18,526	559	25,786	12.6	6.76	1.47	273	7,039,938
Louisiana†	11,551	n/a§§	38,947	11.2	5.39	1.18	136	5,286,206
Maine*	4,070	386	19,582	8.5	2.74	0.60	24	476,057
Maryland*	18,627	421	13,382	11.0	5.22	1.14	212	2,836,553
Massachusetts*	22,439	438	23,764	9.4	3.625	0.79	177	4,213,932
Michigan*	34,372	456	26,594	9.4	3.58	0.78	268	7,133,916
Minnesota*	10,550	262	27,904	9.2	3.42	0.75	79	2,194,833
Mississippi*	21,368	966	32,016	13.4	7.565	1.65	352	11,282,267
Missouri†	12,879	n/a§§	38,947	9.2	3.39	0.74	95	3,706,838

Montana†	1,455	n/a§§	38,947	7.8	2.025	0.44	6	250,177
Nebraska*	4,565	334	30,500	8.2	2.37	0.52	24	719,359
Nevada*	5,778	284	57,549	9.9	4.055	0.88	51	2,939,427
New Hampshire*	3,267	317	21,887	8.3	2.495	0.54	18	388,922
New Jersey*	31,506	468	71,588	11.1	5.275	1.15	362	25,936,565
New Mexico*	3,358	218	25,962	8.8	2.99	0.65	22	568,259
New York*	61,320	407	38,213	9.8	4.035	0.88	539	20,611,676
North Carolina*	30,682	423	24,528	11.1	5.3	1.16	354	8,695,172
North Dakota†	1,287	n/a§§	38,947	6.3	0.48	0.10	1	52,459
Ohio†	31,478	n/a§§	38,947	12.2	6.38	1.39	438	17,051,540
Oklahoma*	11,842	420	33,925	8.6	2.845	0.62	73	2,491,631
Oregon*	8,051	272	25,805	8.8	2.955	0.64	52	1,338,344
Pennsylvania†	35,514	n/a§§	38,947	12.2	6.365	1.39	493	19,192,219
Rhode Island*	3,791	458	28,848	8.7	2.87	0.63	24	684,239
South Carolina*	15,052	425	33,290	11.3	5.495	1.20	180	6,002,500
South Dakota†	1,303	n/a§§	38,947	7.5	1.71	0.37	5	189,125
Tennessee*	22,694	468	30,256	12.4	6.61	1.44	327	9,894,196
Texas*	63,155	345	45,107	8.6	2.79	0.61	384	17,326,561
Utah*	2,836	150	34,570	6.6	0.77	0.17	5	164,571
Vermont*	1,238	249	15,691	8.0	2.225	0.49	6	94,223
Virginia†	13,375	n/a	38,947	11.0	5.21	1.14	152	5,916,376
Washington*	13,174	256	30,625	9.6	3.82	0.83	110	3,359,801
West Virginia*	7,923	541	17,850	12.2	6.375	1.39	110	1,965,462
Wisconsin*	14,626	336	24,791	8.8	3.03	0.66	97	2,395,073
Wyoming*	1,006	235	20,279	6.6	0.82	0.18	2	36,468
Total							**7,978**	**307,144,339**

*Data derived from the Health Care Utilization Project for 2010, except for New Hampshire for which only 2009 data was available.
† Data derived from Chronic Condition Data Warehouse (CCDW) database for 2010
‡ To calculate annual reduction in heart failure hospitalizations population data was derived from the US Census 2010
§ Daily median $PM_{2.5}$ levels were acquired by state from 2008 Centre of Disease Control WONDER database and reduction in $PM_{2.5}$ per state was calculated by using a target threshold of 5.8 $\mu g/m^3$ as described by Evans et al[38]
§§ Heart failure hospitalizations were only available for patients over the age of 65 from the CCDW database therefore we were unable to calculate hospitalisations per 100,000 for these states
** Amount the hospital charged for the entire hospital stay by state excluding professional fees in dollars. Derived from the Healthcare Cost and Utilization Project (HCUP) - State Inpatient Database (SID) in the USA
Abbreviations: PAR = Population attributable risk

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