

**Temperature-mortality associations by age and cause: a multi-country  
multi-city study**

**Supporting Information**

**Supplementary Table 1. Data sources for each country.**

Country	Notes
Argentina	Mortality data was obtained from the National Ministry of Health. Daily temperature data was obtained from the National Weather Service.
Brazil	Mortality data was collected from the Ministry of Health, Brazil. Temperature data was obtained from the Weather Meteorological Service of Brazil.
Canada	Mortality data was obtained from Statistics Canada through access to the Canadian Mortality Database. Temperature data was obtained from Environment Canada using the airport monitoring station located closest to the CMA centre.
China	Mortality data was obtained from the Municipal Center for Disease Control and Prevention in each city. Temperature data was obtained from the China Meteorological Data Sharing Service System ( <a href="http://data.cma.cn/">http://data.cma.cn/</a> ).
Colombia	Mortality data was provided by the National Administrative Department of Statistics DANE. Temperature data was obtained from Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia (IDEAM)
Costa Rica	Mortality data was provided by the Instituto Nacional de Estadística y Censo. Temperature data was obtained from WMO-NOAA (Surface Data Hourly Global, DS3505).
Czech Republic	Mortality data was provided by the Czech Statistical Office and the Institute of Health Information and Statistics. Temperature data was obtained from stations operated by the Czech Hydrometeorological Institute.
Ecuador	Mortality data was provided by the Instituto Nacional de Estadística y Censos. Temperature data were obtained from WMO-NOAA (Surface Data Hourly Global, DS3505).
Estonia	Mortality data was provided by <i>Estonian Causes of Death Registry</i> . Temperature data was collected from <i>the Estonian Environment Agency</i> .
Finland	Mortality was obtained from Statistics Finland. Temperature data was obtained from the Finnish Meteorological Institute.
France	Mortality data was obtained from the French National Institute of Health and Medical Research. Temperature data were obtained from the Meteo France.
Greece	Mortality data was provided by the Hellenic Statistical Authority. Temperature data was collected from the National observatory of Athens ( <a href="http://www.noa.gr/">http://www.noa.gr/</a> ) from site "Thisio" located in the city of Athens.
Ireland	Mortality data was collected from the Irish Central Statistics Office and the Northern Ireland Social Research Agency. Temperature data was obtained from the Met Eireann and the United Kingdom Meteorological Office.
Iran	Mortality data was provided by the Ferdows organization of Mashhad Municipality. Temperature data was collected from the IRAN Meteorological Organization (IRIMO) ( <a href="http://www.irimo.ir">http://www.irimo.ir</a> ).

Italy	Mortality data was collected from local mortality registries and from the rapid mortality surveillance system. Temperature data was obtained from the Meteorological Service of the Italian Air Force.
Japan	Mortality data was provided by Ministry of Health, Labour and Welfare. Temperature data were from the Japan Meteorological Agency.
South Korea	Mortality data was collected from the Korea Bureau of Statistics. Temperature data were obtained from weather stations located within the urban area managed by Korea Meteorological Administration.
Kuwait	Mortality data was provided by the National Center for Health Information, Ministry of Health, Kuwait. Temperature data was based on two sources: the Directorate General of Civil Aviation (Kuwait Airport) and Kuwait's Environmental Public Authority.
Mexico	Mortality data was obtained from the National Institute of Statistics, Geography and Informatics. Temperature data was obtained from Servicio Meteorológico Nacional (SMN) and the Instituto Nacional de Ecología y Cambio Climático (INECC).
Norway	Mortality data was provided by the Norwegian Cause of Death registry. Mean daily temperature is based on an observational modeled dataset from the Norwegian Meteorological Institute.
Panama	Mortality data was provided by Instituto Nacional de Estadística y Censo, Centro de Información Estadística. Temperature data were provided by the Empresa de Transmisión Eléctrica, S.A. (ETESA).
Paraguay	Mortality data was provided by the Ministerio de Salud Pública y Bienestar Social, Dirección General de Información Estratégica en Salud, Subsistema de Información de Estadísticas Vitales. Temperature data was obtained from the Global Historical Climatology Network (NOAA/WMO).
Philippines	Mortality data was provided by the Philippine Statistics Agency. Temperature data was obtained from National Oceanic and Atmospheric Administration (NOAA).
Portugal	Mortality data was provided by Statistics Portugal. Temperature data was based on measurements collected from the National Oceanic and Atmospheric Administration (NOAA).
South Africa	Mortality data was obtained from Statistics South Africa, who had no role in the study. Temperature data was collected from the Agricultural Research Council (ARC) of South Africa and the National Oceanic and Atmospheric Administration (NOAA).
Spain	Mortality data were obtained from the Spain National Institute of Statistics. Temperature data was collected from the Spain National Meteorology Agency.
Switzerland	Mortality data was provided by the Federal Office of Statistics (Switzerland). Temperature data was collected from the IDA web database (Federal Office of Meteorology and Climatology, MeteoSwiss).

Sweden	Mortality data was provided by the Swedish Cause of Death Register at the Swedish National Board of Health and Welfare. Temperature data was based on measurements obtained from the Environment and Health Administration.
Thailand	Mortality data was obtained from the Ministry of Public Health, Thailand. Temperature data was obtained from the Meteorological Department, Ministry of Information and Communication Technology.
Taiwan	Mortality data was provided from the National Death Registry of Taiwan. Temperature data was provided by the Taiwan Environmental Protection Administration.
UK	Mortality data was obtained from the Office of National Statistics. Temperature data were downloaded from the British Atmospheric Data Centre.
USA	Mortality data was obtained from the National Center for Health Statistics (NCHS). Temperature data was obtained from the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA).
Vietnam	Mortality data was provided by Provincial Department of Health. Temperature data was obtained from the National Oceanic and Atmospheric Administration's (NOAA) National Climate Data Center (NCDC).

**Supplementary Table 2 Summary of data for each country.**

<b>Country</b>	<b>Period</b>	<b>Locations</b>	<b>Income group</b>	<b>Total deaths</b>	<b>Min. and max. temperature</b>	<b>All cause age groups</b>	<b>Cause specific age groups</b>
Argentina	2005-2015	3	middle	688061	0.4,33.9	2	0
Brazil	1997-2011	1	middle	540335	7.8,28.5	6	6
Canada	1986-2015	26	high	3733749	-38.9,32.5	6	6
China	1996-2015	10	middle	781372	-22,34	4	0
Colombia	1998-2013	5	middle	956539	10.5,31.1	0	0
Costa Rica	2000-2017	1	middle	31117	18.3,27.5	6	6
Czech Republic	1994-2015	4	middle	711910	-21.6,30.8	4	4
Ecuador	2014-2018	2	middle	112264	10.1,30.2	6	6
Estonia	1997-2015	5	high	146347	-27.9,27.3	6	6
Finland	1994-2011	1	high	130395	-22.9,25.5	2	2
France	2000-2014	18	high	1639262	-13,32.4	2	2
Greece	2001-2010	1	high	287969	-6.7,36.4	6	6
Ireland	1984-2007	6	high	1058215	-6.2,22.9	3	3
Iran	2004-2013	1	middle	121585	-14.7,33.3	2	0
Italy	2001-2010	16	high	645420	-10.7,39.5	0	0
Japan	1972-2015	47	high	39943041	-14.1,33.8	3	3
South Korea	1992-2015	7	high	2246041	-15.5,33.1	3	3
Kuwait	2000-2016	1	high	73748	5.2,44	3	0
Mexico	1998-2014	10	middle	2983952	0.4,35.3	3	3
Norway	1969-2016	1	high	263544	-25.7,23.7	2	0
Panama	2013-2016	1	middle	11457	23.4,31.6	6	6
Paraguay	2004-2016	1	middle	39713	5.6,34.4	6	6
Philippines	2006-2010	4	middle	275189	-2,33.3	0	0
Portugal	1980-2012	2	high	1122252	0.8,34.3	2	0
South Africa	1997-2013	52	middle	8509130	-1.1,34.7	6	6
Spain	2009-2013	50	high	620010	-9.8,35.1	6	6

Switzerland	1995-2013	8	high	243638	-14.9,29	4	0
Sweden	1990-2016	3	high	760527	-17.1,27.2	5	5
Thailand	1999-2008	62	middle	1827853	11.2,35.7	0	0
Taiwan	1994-2014	3	high	909321	8.1,33	2	2
UK	1990-2016	70	high	6167312	-9.9,27.9	7	7
USA	1987-2000	108	high	10794553	-31.1,41.4	3	3
Vietnam	2009-2013	2	middle	108173	14.4,33.9	3	0

**Supplementary Table 3. Akaike Information Criteria when age is modelled as (1) a linear function, (2) a natural spline with a single knot at age 65, and (3) a natural spline with two internal knots at age 50 and 65.**

	<b>All causes</b>	<b>Cardiovascular</b>	<b>Respiratory</b>	<b>Non-cardiorespiratory</b>
<b>Linear</b>	5653.8	8011.5	10858.3	7619.9
<b>One knot (65)</b>	5645.5	8016.8	10863.3	7617.3
<b>Two knots (50,75)</b>	5638.2	8012.5	10851.7	7616.8

**Supplementary Table 4. Minimum mortality temperature percentiles corresponding to Figure 2 of the main text.**

	<b>All causes</b>	<b>Cardiovascular</b>	<b>Respiratory</b>	<b>Non-cardiorespiratory</b>
<b>All ages</b>	85	87	84	84
<b>Age 40</b>	92	99	80	25
<b>Age 55</b>	87	90	86	86
<b>Age 70</b>	87	89	82	88
<b>Age 85</b>	87	88	86	88

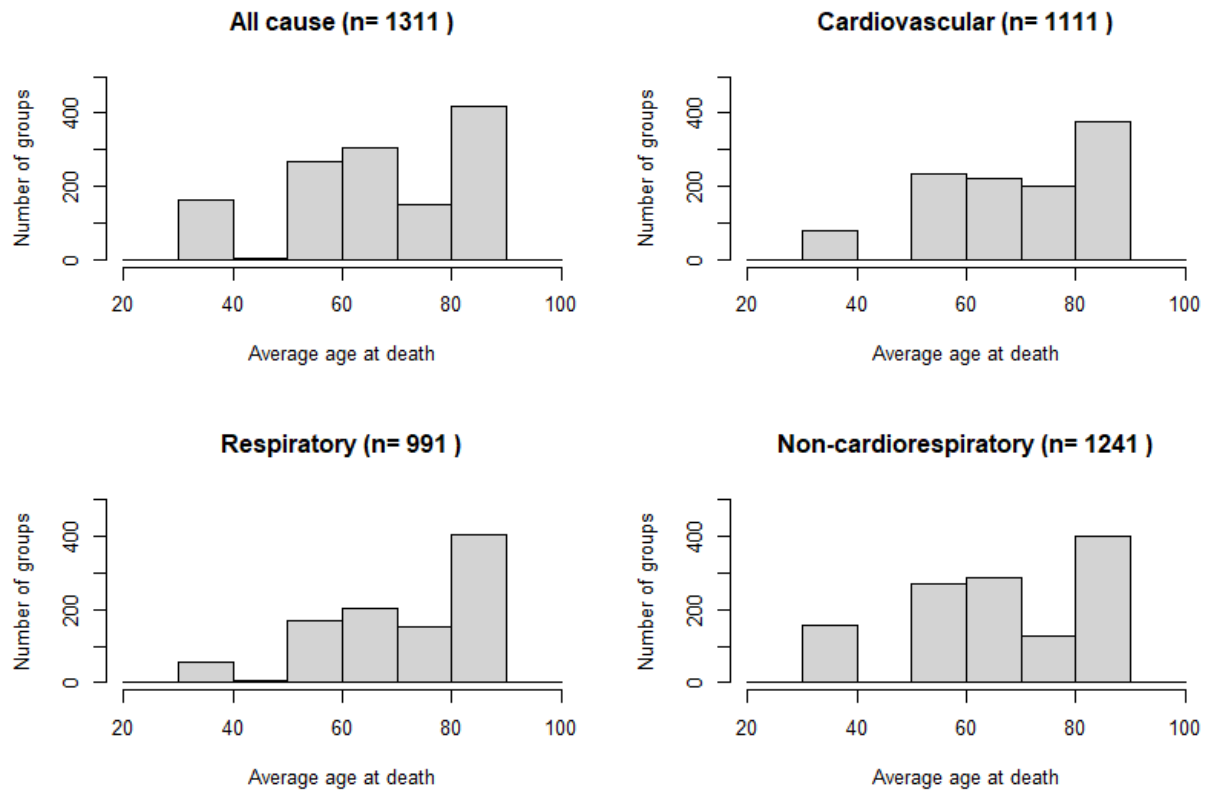


**Supplementary Table 5. Relative risks with 95% confidence intervals for extreme cold and heat, represented by the 1<sup>st</sup> and 99<sup>th</sup> percentile temperature, respectively, compared to the minimum mortality temperature.**

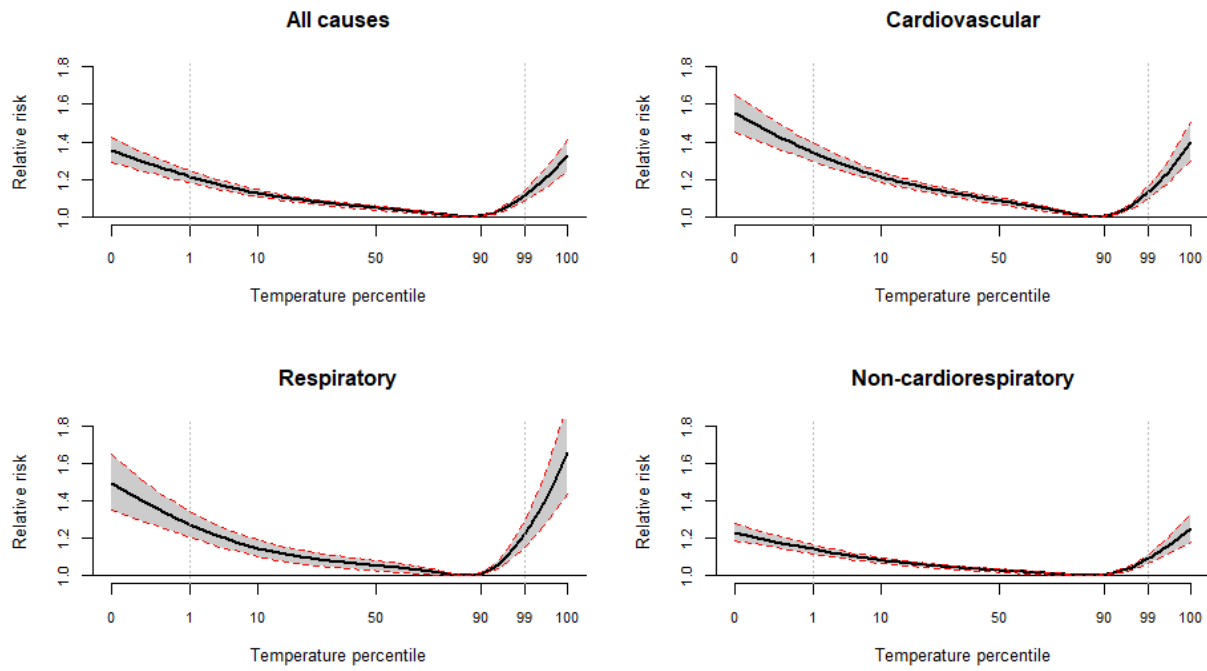
	<b>Extreme cold</b>	<b>Extreme heat</b>
All causes, all ages	1.22 (1.18,1.25)	1.11 (1.09,1.14)
Cardiovascular, all ages	1.34 (1.29,1.39)	1.13 (1.10,1.17)
Respiratory, all ages	1.27 (1.21,1.34)	1.22 (1.15,1.29)
Non-cardiorespiratory, all ages	1.14 (1.12,1.17)	1.09 (1.07,1.12)
All causes age 40	1.01 (0.97,1.05)	1.06 (1.03,1.09)
All causes age 55	1.12 (1.08,1.16)	1.09 (1.06,1.12)
All causes age 70	1.22 (1.18,1.26)	1.09 (1.06,1.12)
All causes age 85	1.31 (1.27,1.35)	1.16 (1.13,1.19)
Cardiovascular age 40	1.16 (1.03,1.30)	1.00 (1.00,1.00)
Cardiovascular age 55	1.23 (1.16,1.29)	1.09 (1.06,1.13)
Cardiovascular age 70	1.33 (1.27,1.39)	1.09 (1.05,1.12)
Cardiovascular age 85	1.37 (1.32,1.43)	1.15 (1.12,1.18)
Respiratory age 40	1.10 (1.00,1.22)	1.14 (1.04,1.26)
Respiratory age 55	1.19 (1.09,1.30)	1.22 (1.14,1.31)
Respiratory age 70	1.21 (1.13,1.29)	1.12 (1.05,1.20)
Respiratory age 85	1.32 (1.24,1.40)	1.25 (1.18,1.32)
Non-cardiorespiratory age 40	0.99 (0.96,1.02)	1.05 (1.01,1.09)
Non-cardiorespiratory age 55	1.09 (1.05,1.13)	1.07 (1.04,1.10)
Non-cardiorespiratory age 70	1.14 (1.10,1.18)	1.06 (1.03,1.09)
Non-cardiorespiratory age 85	1.22 (1.18,1.27)	1.11 (1.08,1.15)

**Supplementary Table 6. Excess mortality fractions by age and cause, including 95% confidence intervals.**

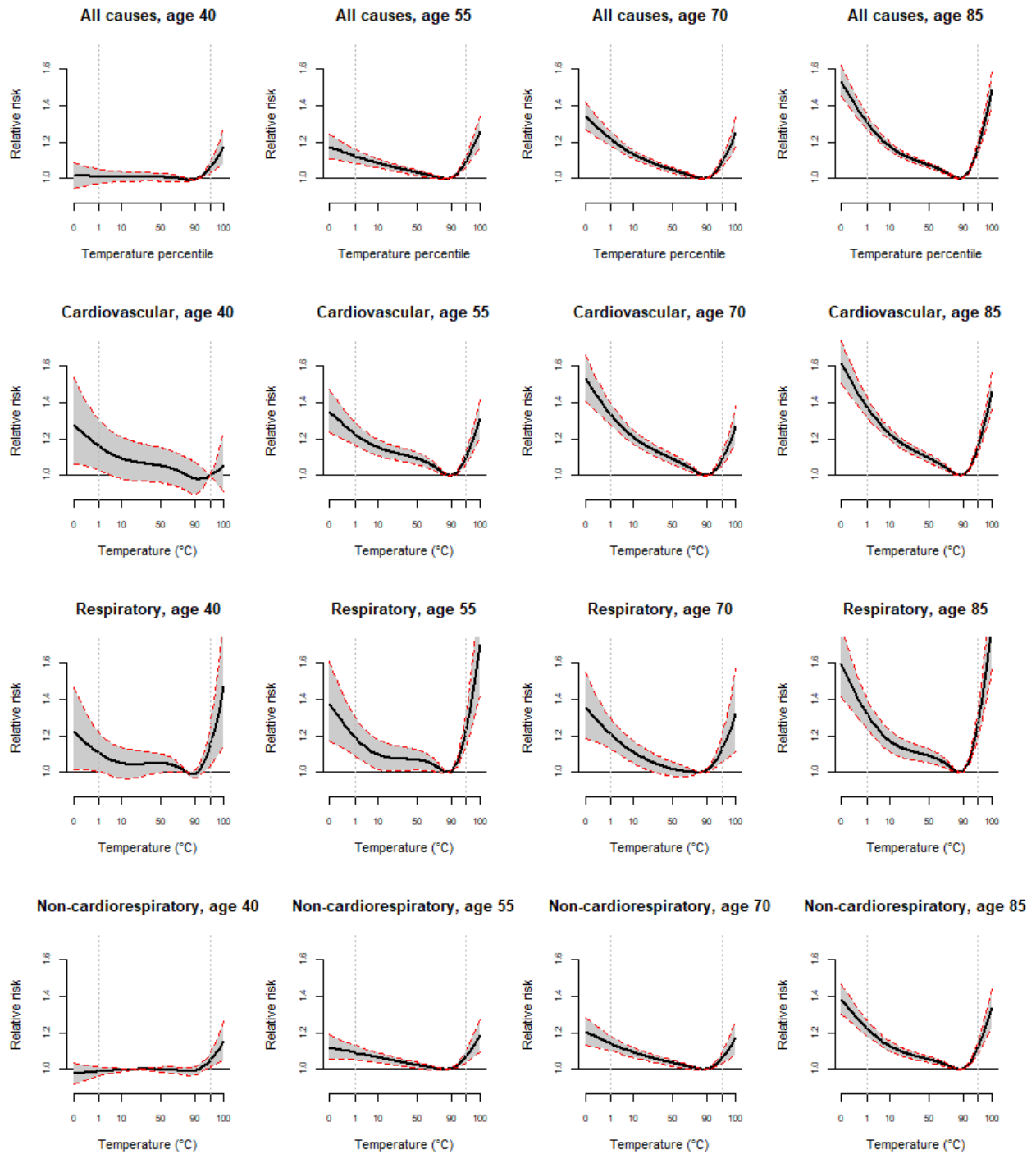
	<b>Cold</b>	<b>Heat</b>
<b>All causes 30-44</b>	3.25 (2.54, 3.78)	0.43 (0.28,0.55)
<b>All causes 45-59</b>	6.10 (5.72, 6.44)	0.28 (0.25,0.31)
<b>All causes 60_74</b>	6.59 (6.17, 6.89)	0.28 (0.25,0.30)
<b>All causes 75+</b>	9.08 (8.83, 9.29)	0.46 (0.43,0.48)
<b>Cardiovascular 30-44</b>	10.54 (8.57,12.12)	0.01 (-0.06,0.08)
<b>Cardiovascular 45-59</b>	12.42 (12.03,12.77)	0.41 (0.38,0.45)
<b>Cardiovascular 60_74</b>	9.26 (8.88, 9.57)	0.30 (0.27,0.33)
<b>Cardiovascular 75+</b>	12.85 (12.58,13.06)	0.54 (0.51,0.57)
<b>Respiratory 30-44</b>	7.56 (5.36, 9.13)	0.43 (0.26,0.57)
<b>Respiratory 45-59</b>	5.66 (5.02, 6.14)	1.22 (0.88,1.50)
<b>Respiratory 60_74</b>	6.44 (5.73, 6.95)	1.05 (0.87,1.19)
<b>Respiratory 75+</b>	8.17 (7.68, 8.52)	0.78 (0.69,0.83)
<b>Non-cardiorespiratory 30-44</b>	2.07 (1.35, 2.67)	0.78 (0.50,1.01)
<b>Non-cardiorespiratory 45-59</b>	3.87 (3.46, 4.22)	0.25 (0.15,0.33)
<b>Non-cardiorespiratory 60_74</b>	5.19 (4.70, 5.57)	0.17 (0.14,0.20)
<b>Non-cardiorespiratory 75+</b>	6.26 (6.00, 6.49)	0.29 (0.26,0.31)



**Fig. S1. Histograms of the number of age-by-cause groups across locations in each analysis, by average age at death. The model convergence rate was >98% for each cause.**



**Fig. S2 Overall cumulative relative risk curves by cause for all ages combined, with 95% confidence intervals.**



**Fig. S3 Overall cumulative relative risk curves by age and cause, with 95% confidence intervals.**