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Supplementary appendix

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Global, regional, and national burden of mortality associated with cold spells from 2000-19: a three-stage modelling study

Supplementary appendix

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Mortality data collection and integration

We obtained the data on all individual deaths (date and cause of death) in Australia between 2009-2019 from the Australian Cause of Death Unit Record File (COD URF), in New Zealand between 2000-2018 from the New Zealand Ministry of Health, in Brazil between 2000-2019 from the Brazil Mortality Information System (Sistema de Informação sobre Mortalidade, SIM), in Canada between 2000-2015 from the Vital Statistics Deaths Database of Statistics Canada and in Chile between 2000-2015 from the Chilean Ministry of Health Epidemiology Department. For a time-series analysis, we aggregated the individual death data at location and daily level based on the administrative boundary with a proper area size for each country (Statistical Area Level 3 [SA3] for Australia [n = 316], territorial authority [TA] for New Zealand [n = 63], immediate region for Brazil [n = 510] and Chile (n = 15), and second-level administrative divisions [regions or districts within the provinces and territories] for Canada [n = 288]).

We also obtained daily mortality data for each city from the most updated Multi-Country Multi-City (MCC) Collaborative Research Network database. The MCC network is a continuously expanding international network that collects daily mortality counts from relevant authorities of multiple countries globally. The details of MCC dataset have been described in our previous work [1,2]. For each city MCC network, daily counts of all-cause mortality were collected and non-external causes (International Classification of Diseases [ICD], 9th Revision codes 0-799 or ICD-10 codes A00-R99) mortality were alternatively collected when all-cause mortality was unavailable. Additionally, mortality counts were collected specifically for cardiovascular (ICD-10 codes I00–I99) and respiratory (ICD-10 codes J00-J99) causes. The most updated MCC database has all-cause mortality or non-external mortality data from 794 cities from 43 countries. MCC cities in Australia, New Zealand, Brazil, Canada and Chile were not included to avoid duplication.

Mortality data was also collected for each demographic surveillance systems (HDSS) sites from the International Network for the Demographic Evaluation of Populations and their Health (INDEPTH) Network. The INDEPTH Network provides all-cause mortality counts data in 2000-2016, which were retrieved from 32 health and demographic surveillance systems (HDSS) sites in Africa and Asia that were not overlapped with the MCC database. The health data were

representative of the whole population in each HDSS site, and more information had been presented by previous publications [3,4].

Consequently, the integrated global dataset covers 1960 locations from 59 countries or territories. Among these 1960 locations, the all-cause mortality data in 140 locations (7.1%) was represented by non-external mortality.

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Table S1. Descriptive statistics of the 1960 locations during the coldest six consecutive months by continent and country (or region).

	No. of locations	Study period	Total deaths	Cold spell days (mean with range) per year
Africa				
Burkina Faso	3	2000-2015	8329	17 (17, 18)
Ethiopia	6	2006-2016	7439	12 (8, 17)
Ghana	3	2000-2014	13926	6 (2, 8)
Ivory Coast	1	2009-2016	1519	4 (4, 4)
Kenya	2	2003-2015	5676	7 (1, 13)
Malawi	1	2003-2016	1708	18 (18, 18)
Mozambique	1	2010-2015	2131	11 (11, 11)
Nigeria	1	2011-2014	5296	23 (23, 23)
Senegal	3	2000-2016	4319	11 (8, 14)
South Africa	55	2000-2016	3912082	9 (5, 13)
Tanzania	3	2000-2014	13427	12 (8, 16)
The Gambia	1	2000-2015	2681	14 (14, 14)
Uganda	1	2005-2015	2865	4 (4, 4)
Americas				
Argentina	3	2005-2015	372996	13 (13, 14)
Brazil	510	2000-2019	11722287	10 (4, 14)
Canada	288	2000-2015	1982709	12 (8, 18)
Chile	15	2016-2019	232037	15 (11, 20)
Colombia	5	2000-2013	425458	5 (1, 11)
Costa Rica	1	2000-2017	15529	7 (7, 7)
Ecuador	2	2014-2018	55708	6 (2, 9)
Guatemala	1	2009-2016	31344	15 (15, 15)
Mexico	10	2000-2014	1426344	10 (5, 25)
Panama	1	2013-2016	5833	3 (3, 3)
Paraguay	1	2004-2019	25326	13 (13, 13)
Peru	18	2008-2014	321338	8 (2, 14)
Puertorico	1	2009-2016	13323	16 (16, 16)
USA	211	2000-2006	4520483	13 (3, 17)
Uruguay	1	2012-2016	85414	13 (13, 13)
Asia				
Bangladesh	1	2005-2016	2615	17 (17, 17)
China	15	2000-2015	579621	17 (6, 26)
India	1	2009-2016	1801	18 (18, 18)
Iran	2	2002-2015	415719	15 (13, 17)
Israel	1	2000-2019	104364	13 (13, 13)
Japan	65	2000-2015	4627859	12 (7, 18)
Kuwait	1	2000-2016	39358	15 (15, 15)
Philippines	13	2006-2019	412516	8 (3, 11)
South Korea	36	2000-2018	1385632	13 (10, 14)
Taiwan	6	2000-2018	900221	13 (10, 15)
Thailand	62	2000-2008	817785	14 (2, 19)
Vietnam	3	2004-2013	53990	12 (5, 17)
Europe				
Czech Republic	4	2000-2015	263005	15 (15, 16)
Estonia	5	2000-2018	77286	15 (15, 15)
Finland	1	2000-2014	56979	14 (14, 14)
France	22	2000-2015	951962	13 (3, 15)
Germany	12	2000-2015	1106284	16 (14, 17)
Greece	1	2001-2010	150737	15 (15, 15)
Ireland	6	2000-2007	176940	12 (10, 14)

Italy	18	2006-2015	427317	13 (10, 17)
Moldova	4	2001-2010	31240	16 (16, 17)
Netherland	5	2000-2016	177543	15 (14, 16)
Norway	1	2000-2018	44188	15 (15, 15)
Portugal	6	2000-2018	531704	13 (12, 13)
Romania	8	2000-2016	365109	16 (14, 16)
Spain	52	2000-2014	995908	14 (11, 16)
Sweden	3	2000-2016	238348	14 (13, 16)
Switzerland	8	2000-2013	91249	15 (14, 16)
UK	70	2000-2016	1947740	14 (13, 15)
Oceania				
Australia	316	2009-2017	702832	12 (8, 18)
New Zealand	63	2000-2018	299984	12 (10, 14)

Table S2. Meta-regression models for explaining variation in overall cold spell effects: Cochran Q test for heterogeneity, I^2 statistics for residual heterogeneity.

Model	*P* value for Q test	I^2 (%)
None	<0.001	55.8
Single predicator		
Continent	<0.001	42.4
GDP per capita	<0.001	44.3
ns (yearly average daily mean temperature, df = 3)	<0.001	39.4
ns (range of daily mean temperature, df = 3)	<0.001	37.6
Köppen–Geiger climate classification zone1	<0.001	41.0
ns (latitude, df = 5)	<0.001	41.6
ns (longitude, df = 5)	<0.001	42.2
Full	<0.001	25.1

Table S3. Annual average number of cold spell days and average change of cold spell days during the coldest six consecutive months in 2000-19 by continent and region.

	Annual number of cold spell days (range)	Average change of cold spell days (range)
Global	24 (0, 51)	-0.20 (-2.40, 2.50)
Africa	17 (0, 49)	-0.07 (-1.40, 1.60)
Northern Africa	25 (0, 49)	0.00 (-1.40, 1.00)
Sub-Saharan Africa	14 (0, 47)	-0.10 (-1.14, 1.60)
Americas	22 (0, 50)	-0.10 (-1.86, 1.67)
Latin America and the Caribbean	15 (0, 34)	-0.17 (-1.58, 1.67)
Northern America	27 (4, 50)	-0.06 (-1.86, 1.17)
Asia	26 (0, 51)	-0.10 (-1.83, 2.50)
Central Asia	29 (17, 44)	-0.14 (-1.69, 1.75)
Eastern Asia	27 (14, 48)	-0.11 (-1.50, 1.75)
South-eastern Asia	15 (0, 43)	-0.12 (-1.40, 2.06)
Southern Asia	29 (7, 51)	0.16 (-1.33, 2.50)
Western Asia	28 (16, 48)	-0.40 (-1.83, 1.45)
Europe	29 (6, 48)	-0.48 (-2.33, 1.80)
Eastern Europe	31 (18, 48)	-0.46 (-2.33, 1.80)
Northern Europe	24 (15, 31)	-0.54 (-1.86, 1.00)
Southern Europe	29 (20, 46)	-0.49 (-1.50, 0.50)
Western Europe	26 (6, 44)	-0.40 (-1.43, 0.67)
Oceania	18 (1, 30)	0.00 (-2.40, 1.75)
Australia and New Zealand	19 (4, 30)	0.03 (-2.40, 1.75)
Melanesia	10 (1, 28)	-0.23 (-1.00, 0.00)
Micronesia	7 (2, 11)	-0.04 (-0.21, 0.00)
Polynesia	19 (17, 21)	-0.29 (-0.82, 0.00)

Table S4. Annual excess deaths with 95% eCI associated with cold spells by continent and region during different period.

	2000-2003	2004-2007	2008-2011	2012-2015	2016-2019
Global	149413 (113583, 186417)	196029 (149084, 244363)	275509 (215876, 336787)	225925 (171761, 281801)	182784 (142571, 224084)
Americas	18363 (14646, 22185)	26400 (20737, 32219)	31426 (24932, 38094)	23586 (18436, 28901)	24548 (19245, 29995)
Northern America	8216 (6215, 10283)	11263 (8248, 14377)	14919 (11291, 18662)	13822 (10187, 17591)	11023 (8118, 14020)
Latin America and the Caribbean	10147 (8105, 12251)	15138 (11992, 18374)	16507 (13071, 20036)	9763 (7797, 11796)	13525 (10659, 16466)
Asia	77726 (58304, 97804)	106803 (80777, 133525)	165079 (126639, 204555)	144779 (108457, 182138)	118918 (91712, 146839)
Central Asia	788 (399, 1190)	1197 (533, 1891)	1576 (770, 2414)	1407 (667, 2184)	547 (232, 874)
Eastern Asia	26190 (20027, 32552)	49871 (39695, 60324)	84133 (66040, 102736)	52758 (40532, 65361)	48726 (38566, 59156)
Southern Asia	40433 (30522, 50691)	42111 (30337, 54228)	64469 (47183, 82265)	75885 (54882, 97477)	59390 (44142, 75043)
Western Asia	3073 (1485, 4736)	5752 (3169, 8448)	5569 (3304, 7923)	5573 (3292, 7961)	4521 (2588, 6552)
South-eastern Asia	7242 (4159, 10454)	7872 (4776, 11070)	9331 (5960, 12808)	9155 (5881, 12521)	5734 (3790, 7727)
Europe	45365 (35821, 55228)	52425 (41856, 63347)	69721 (56288, 83556)	48419 (38918, 58270)	34366 (27571, 41387)
Southern Europe	7458 (6058, 8900)	11361 (9266, 13510)	9639 (7905, 11415)	7343 (6084, 8639)	6714 (5535, 7920)
Eastern Europe	24531 (17650, 31716)	24557 (17847, 31557)	31856 (23001, 41083)	24306 (17751, 31175)	15903 (11504, 20502)
Northern Europe	4840 (3996, 5706)	4668 (3794, 5565)	10263 (8651, 11933)	5688 (4666, 6737)	3761 (3113, 4429)
Western Europe	8535 (7286, 9806)	11838 (10023, 13699)	17963 (15555, 20394)	11082 (9592, 12610)	7988 (6822, 9175)
Africa	7761 (1495, 14324)	9999 (1247, 19201)	8942 (2455, 15783)	8845 (863, 17268)	4595 (215, 9171)
Northern Africa	1510 (-154, 3273)	2621 (-477, 5927)	1276 (-140, 2767)	2080 (-439, 4750)	1545 (-505, 3698)
Sub-Saharan Africa	6252 (1108, 11651)	7378 (965, 14123)	7666 (2033, 13646)	6765 (607, 13280)	3050 (341, 5891)
Oceania	198 (67, 333)	401 (198, 615)	341 (146, 546)	296 (144, 456)	357 (164, 558)
Australia and New Zealand	169 (58, 283)	400 (185, 626)	327 (149, 516)	292 (139, 453)	356 (150, 571)
Other regions in Oceania	29 (-3, 62)	2 (-4, 8)	13 (-19, 49)	4 (-9, 18)	1 (-3, 6)

Table S5. Annual excess death ratio (excess deaths per 1000 deaths) with 95% eCI associated with cold spells by continent and region during different period.

	2000-2003	2004-2007	2008-2011	2012-2015	2016-2019
Global	2.38 (1.81, 2.98)	3.01 (2.29, 3.76)	4.05 (3.17, 4.95)	3.21 (2.44, 4.00)	2.50 (1.95, 3.06)
Americas	2.14 (1.71, 2.59)	2.97 (2.33, 3.63)	3.39 (2.69, 4.12)	2.46 (1.93, 3.02)	2.48 (1.95, 3.03)
Northern America	2.57 (1.94, 3.22)	3.41 (2.50, 4.35)	4.35 (3.29, 5.44)	3.88 (2.86, 4.94)	3.00 (2.21, 3.82)
Latin America and the Caribbean	1.89 (1.51, 2.28)	2.71 (2.15, 3.29)	2.83 (2.24, 3.44)	1.63 (1.30, 1.97)	2.18 (1.71, 2.65)
Asia	2.05 (1.54, 2.58)	2.73 (2.06, 3.41)	4.04 (3.10, 5.00)	3.43 (2.57, 4.32)	2.73 (2.10, 3.37)
Central Asia	1.40 (0.71, 2.12)	2.05 (0.91, 3.24)	2.61 (1.28, 4.00)	2.26 (1.07, 3.51)	0.85 (0.36, 1.36)
Eastern Asia	1.76 (1.35, 2.19)	3.30 (2.63, 3.99)	5.44 (4.27, 6.65)	3.38 (2.60, 4.19)	3.09 (2.45, 3.76)
Southern Asia	2.72 (2.05, 3.41)	2.69 (1.94, 3.46)	3.88 (2.84, 4.95)	4.36 (3.15, 5.60)	3.25 (2.41, 4.10)
Western Asia	1.59 (0.77, 2.46)	2.74 (1.51, 4.03)	2.46 (1.46, 3.50)	2.26 (1.34, 3.23)	1.73 (0.99, 2.50)
South-eastern Asia	1.28 (0.73, 1.84)	1.36 (0.83, 1.91)	1.58 (1.01, 2.16)	1.49 (0.96, 2.04)	0.91 (0.60, 1.22)
Europe	6.12 (4.84, 7.45)	7.09 (5.66, 8.57)	9.45 (7.63, 11.32)	6.53 (5.25, 7.86)	4.60 (3.69, 5.54)
Southern Europe	4.93 (4.01, 5.89)	7.43 (6.06, 8.84)	6.22 (5.10, 7.37)	4.69 (3.89, 5.52)	4.23 (3.49, 4.99)
Eastern Europe	7.99 (5.75, 10.33)	8.15 (5.92, 10.47)	10.79 (7.79, 13.91)	8.29 (6.05, 10.63)	5.47 (3.96, 7.05)
Northern Europe	5.07 (4.19, 5.98)	4.81 (3.91, 5.74)	10.38 (8.75, 12.07)	5.64 (4.63, 6.68)	3.62 (2.99, 4.26)
Western Europe	4.55 (3.88, 5.23)	6.29 (5.33, 7.28)	9.51 (8.23, 10.80)	5.81 (5.03, 6.61)	4.12 (3.52, 4.74)
Africa	0.91 (0.17, 1.69)	1.08 (0.13, 2.08)	0.89 (0.24, 1.57)	0.81 (0.08, 1.58)	0.39 (0.02, 0.78)
Northern Africa	0.86 (-0.09, 1.87)	1.39 (-0.25, 3.13)	0.62 (-0.07, 1.35)	0.95 (-0.20, 2.17)	0.67 (-0.22, 1.60)
Sub-Saharan Africa	0.93 (0.16, 1.73)	1.00 (0.13, 1.92)	0.96 (0.25, 1.70)	0.77 (0.07, 1.52)	0.32 (0.04, 0.62)
Oceania	0.64 (0.22, 1.08)	1.22 (0.60, 1.87)	0.98 (0.42, 1.57)	0.79 (0.38, 1.22)	0.91 (0.42, 1.42)
Australia and New Zealand	0.71 (0.24, 1.19)	1.59 (0.74, 2.50)	1.24 (0.57, 1.96)	1.03 (0.49, 1.60)	1.19 (0.50, 1.92)
Other regions in Oceania	0.41 (-0.04, 0.89)	0.02 (-0.05, 0.10)	0.16 (-0.23, 0.57)	0.05 (-0.10, 0.20)	0.01 (-0.03, 0.06)

Table S6. Annual excess death rate (excess deaths per 100000 population per year) with 95% eCI associated with cold spells by continent and region during different period.

	2000-2003	2004-2007	2008-2011	2012-2015	2016-2019
Global	2.38 (1.77, 3.02)	3.03 (2.26, 3.83)	3.87 (2.94, 4.82)	3.17 (2.37, 3.98)	2.56 (1.97, 3.16)
Americas	2.25 (1.71, 2.82)	3.06 (2.25, 3.91)	3.50 (2.61, 4.43)	2.44 (1.77, 3.14)	2.63 (1.93, 3.36)
Northern America	2.71 (1.98, 3.46)	3.43 (2.37, 4.53)	4.43 (3.21, 5.70)	3.72 (2.53, 4.94)	3.10 (2.17, 4.07)
Latin America and the Caribbean	1.98 (1.47, 2.51)	2.84 (2.06, 3.66)	2.96 (2.14, 3.81)	1.69 (1.23, 2.17)	2.35 (1.69, 3.04)
Asia	1.95 (1.42, 2.49)	2.55 (1.86, 3.25)	3.70 (2.74, 4.68)	3.32 (2.45, 4.23)	2.68 (2.03, 3.34)
Central Asia	1.12 (0.53, 1.73)	1.77 (0.79, 2.76)	1.62 (0.60, 2.67)	1.30 (0.45, 2.20)	0.74 (0.35, 1.13)
Eastern Asia	1.20 (0.84, 1.58)	2.56 (1.91, 3.22)	4.18 (3.08, 5.32)	2.56 (1.87, 3.27)	2.44 (1.82, 3.07)
Southern Asia	3.02 (2.30, 3.76)	2.99 (2.17, 3.82)	4.32 (3.19, 5.48)	4.93 (3.60, 6.30)	3.69 (2.79, 4.61)
Western Asia	2.22 (1.39, 3.07)	3.54 (2.33, 4.81)	2.95 (1.96, 3.99)	2.82 (1.90, 3.78)	2.22 (1.48, 2.99)
South-eastern Asia	1.09 (0.44, 1.76)	1.05 (0.43, 1.70)	1.19 (0.55, 1.86)	1.11 (0.51, 1.75)	0.74 (0.39, 1.10)
Europe	6.39 (5.12, 7.70)	7.85 (6.43, 9.30)	9.38 (7.57, 11.25)	6.77 (5.50, 8.08)	5.17 (4.27, 6.11)
Southern Europe	7.39 (6.42, 8.39)	10.69 (9.26, 12.16)	9.02 (7.84, 10.22)	6.79 (5.94, 7.66)	6.18 (5.40, 6.98)
Eastern Europe	6.62 (4.44, 8.90)	7.10 (4.94, 9.35)	8.48 (5.51, 11.60)	6.79 (4.60, 9.08)	4.87 (3.39, 6.43)
Northern Europe	5.22 (4.39, 6.07)	5.29 (4.44, 6.16)	10.11 (8.55, 11.72)	6.32 (5.36, 7.30)	3.98 (3.39, 4.58)
Western Europe	5.79 (5.12, 6.47)	8.05 (7.07, 9.05)	10.69 (9.44, 11.98)	6.96 (6.18, 7.77)	5.42 (4.80, 6.05)
Africa	1.03 (0.10, 2.02)	1.26 (0.14, 2.45)	0.96 (0.22, 1.75)	0.79 (0.09, 1.54)	0.44 (0.02, 0.90)
Northern Africa	0.99 (-0.13, 2.18)	1.71 (-0.19, 3.72)	0.73 (-0.06, 1.56)	1.19 (-0.07, 2.55)	0.94 (-0.11, 2.07)
Sub-Saharan Africa	1.05 (0.07, 2.09)	1.15 (0.10, 2.26)	1.02 (0.21, 1.89)	0.69 (0.06, 1.37)	0.32 (0.00, 0.66)
Oceania	0.75 (0.28, 1.24)	1.33 (0.66, 2.04)	1.16 (0.53, 1.83)	0.93 (0.48, 1.40)	1.02 (0.49, 1.57)
Australia and New Zealand	0.80 (0.31, 1.32)	1.72 (0.80, 2.69)	1.36 (0.63, 2.13)	1.17 (0.59, 1.79)	1.33 (0.60, 2.11)
Other regions in Oceania	0.57 (0.02, 1.18)	0.09 (-0.05, 0.24)	0.52 (-0.03, 1.11)	0.15 (-0.04, 0.35)	0.04 (-0.02, 0.10)

Table S7. Annual excess deaths, excess death ratio (excess deaths per 1000 deaths) and excess death rate (excess deaths per 100000 population per year) with 95% eCI associated with cold spells over 2000-19 by Köppen–Geiger climate classification.

Climate classification	Annual excess deaths	Annual excess death ratio	Annual excess death rate
Group A: Tropical climates	32832 (21730, 44268)	1.98 (1.25, 2.74)	1.57 (0.99, 2.17)
Group B: Dry climates	26212 (16313, 36493)	3.32 (1.96, 4.74)	2.44 (1.43, 3.49)
Group C: Temperate climates	114801 (93684, 136487)	5.17 (4.14, 6.24)	4.04 (3.23, 4.87)
Group D: Continental climates	31832 (22536, 41488)	4.54 (3.10, 6.05)	4.26 (2.91, 5.67)
Group E: Polar and alpine climates	255 (5, 524)	2.24 (-0.14, 4.83)	1.63 (-0.10, 3.51)

Table S8. Temporal change in annual excess deaths with 95% eCI associated with cold spells for the leading 20 countries around the world in 2000-19.

	2000-2009	2010-2019	2000-2019
China	41760 (32588, 51212)	52420 (40341, 64872)	47090 (37305, 57152)
India	30385 (21730, 39315)	51987 (36681, 67760)	41186 (30149, 52532)
Russia	13907 (9082, 18999)	14240 (9312, 19459)	14073 (9581, 18806)
United States	9540 (6929, 12242)	12332 (9002, 15779)	10936 (8200, 13761)
Pakistan	5711 (4148, 7342)	8339 (5993, 10755)	7025 (5227, 8882)
Germany	4795 (4072, 5530)	6790 (5832, 7761)	5793 (5019, 6576)
Bangladesh	3794 (2945, 4667)	6005 (4705, 7350)	4899 (3911, 5918)
Brazil	4181 (3302, 5086)	5363 (4137, 6622)	4772 (3802, 5765)
Japan	2766 (1849, 3719)	4250 (2812, 5733)	3508 (2423, 4628)
France	3252 (2731, 3785)	3399 (2874, 3937)	3326 (2844, 3818)
United Kingdom	2783 (2259, 3323)	3808 (3173, 4464)	3296 (2762, 3845)
Ukraine	3162 (2177, 4176)	2940 (2066, 3839)	3051 (2195, 3930)
Italy	3093 (2400, 3805)	2770 (2198, 3358)	2932 (2350, 3529)
Mexico	2533 (1986, 3098)	2670 (2125, 3233)	2602 (2099, 3119)
Spain	2677 (2245, 3118)	2320 (1939, 2711)	2498 (2124, 2881)
Poland	1911 (1585, 2244)	2931 (2473, 3401)	2421 (2060, 2790)
Argentina	2550 (2163, 2949)	2265 (1926, 2619)	2407 (2073, 2753)
Vietnam	1834 (1337, 2344)	2384 (1756, 3027)	2109 (1590, 2639)
South Africa	2166 (1113, 3276)	1496 (816, 2211)	1831 (1033, 2668)
Turkey	1911 (866, 3008)	1430 (692, 2207)	1670 (850, 2532)

Table S9. Temporal change in annual excess death ratio (excess deaths per 1000 deaths) with 95% eCI associated with cold spells for the leading 20 countries around the world in 2000-19.

	2000-2009	2010-2019	2000-2019
Iceland	13.15 (9.95, 16.59)	7.64 (5.67, 9.77)	10.40 (8.01, 12.94)
Paraguay	9.40 (8.23, 10.62)	9.24 (8.07, 10.43)	9.32 (8.24, 10.43)
Uruguay	9.47 (8.28, 10.72)	7.92 (6.89, 8.98)	8.70 (7.67, 9.76)
Finland	7.60 (5.98, 9.29)	9.00 (7.05, 11.07)	8.30 (6.65, 10.02)
Norway	6.59 (5.25, 7.99)	9.20 (7.22, 11.25)	7.89 (6.37, 9.48)
Argentina	8.49 (7.21, 9.82)	7.15 (6.08, 8.27)	7.82 (6.74, 8.95)
Portugal	8.90 (7.59, 10.23)	6.61 (5.66, 7.60)	7.76 (6.71, 8.82)
Estonia	6.05 (4.75, 7.37)	7.88 (6.24, 9.56)	6.96 (5.61, 8.35)
Mongolia	5.96 (3.51, 8.56)	7.93 (4.69, 11.37)	6.95 (4.32, 9.72)
Sweden	5.56 (4.43, 6.71)	8.22 (6.63, 9.88)	6.89 (5.64, 8.18)
Latvia	5.50 (4.41, 6.61)	8.07 (6.56, 9.63)	6.78 (5.59, 8.01)
Belgium	5.77 (4.97, 6.58)	7.60 (6.63, 8.59)	6.68 (5.87, 7.51)
Germany	5.67 (4.81, 6.54)	7.60 (6.53, 8.69)	6.64 (5.75, 7.54)
Lithuania	5.54 (4.48, 6.61)	7.60 (6.20, 9.03)	6.57 (5.44, 7.72)
Netherlands	5.60 (4.79, 6.44)	7.28 (6.30, 8.28)	6.44 (5.62, 7.28)
Spain	7.16 (6.01, 8.34)	5.71 (4.77, 6.67)	6.44 (5.47, 7.42)
Poland	5.18 (4.29, 6.08)	7.53 (6.36, 8.74)	6.36 (5.41, 7.32)
Denmark	4.51 (3.61, 5.43)	8.20 (6.77, 9.68)	6.35 (5.28, 7.46)
Malta	6.98 (5.60, 8.43)	5.46 (4.39, 6.54)	6.22 (5.10, 7.39)
Cape Verde	5.14 (2.51, 7.97)	7.27 (3.55, 11.37)	6.21 (3.27, 9.38)

Table S10. Sensitivity analyses of global annual excess deaths, excess death ratio and excess death rate with 95% eCI associated with cold spells in 2000-19.

	Annual excess deaths	Annual excess death ratio	Annual excess death rate
Df of cold spells			
Df=4	195415 (163829, 231351)	2.88 (2.41, 3.41)	3.62 (3.03, 4.28)
Df=5	190502 (159019, 226372)	2.80 (2.34, 3.33)	3.53 (2.94, 4.19)
Lag of cold spells			
30	226058 (182786, 275756)	3.33 (2.69, 4.06)	4.18 (3.38, 5.10)
Cold seasons			
Four consecutive months	202933 (169787, 240694)	2.99 (2.50, 3.54)	3.76 (3.14, 4.45)
Five consecutive months	210398 (178408, 246814)	3.10 (2.63, 3.63)	3.89 (3.30, 4.57)

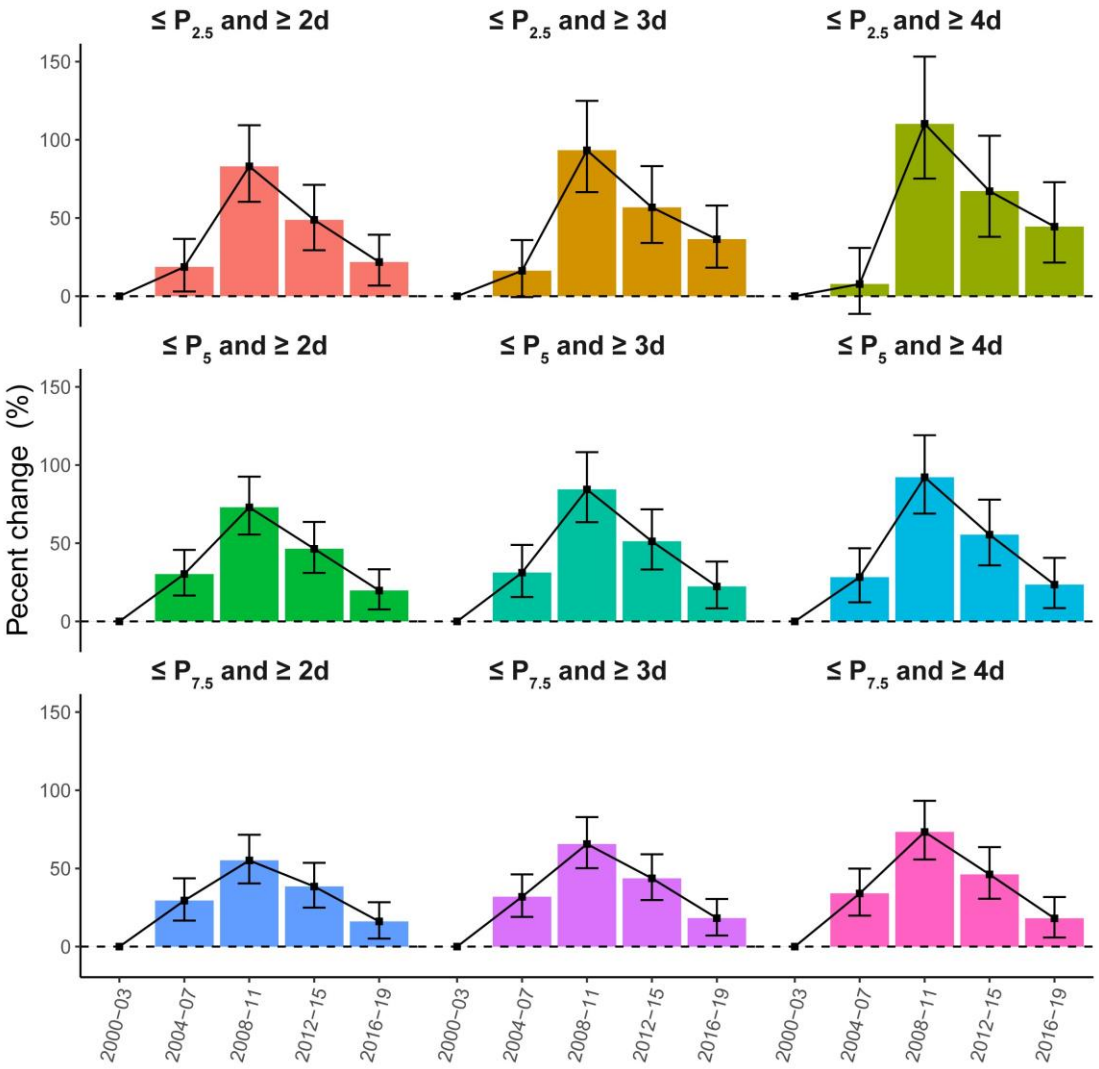

Figure S1. Sensitivity analyses of percent change in global annual excess deaths associated with cold spells compared to 2000-03 average using different cold spell definitions.

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