RESEARCH LETTER

CLIMATE CHANGE AND HEALTH

Cold-Related Deaths in the US

Although mean temperatures are increasing in the US, studies have found that climate change has been linked with more frequent episodes of severe winter weather in the US over the past few decades, which may in turn be associated with increased cold-related mortality.[1-3] However, little is known about the burden of cold-related mortality and how this varies across different population groups. This study assessed trends in cold-related mortality overall and by demographic characteristics between 1999 and 2022.

Supplemental content

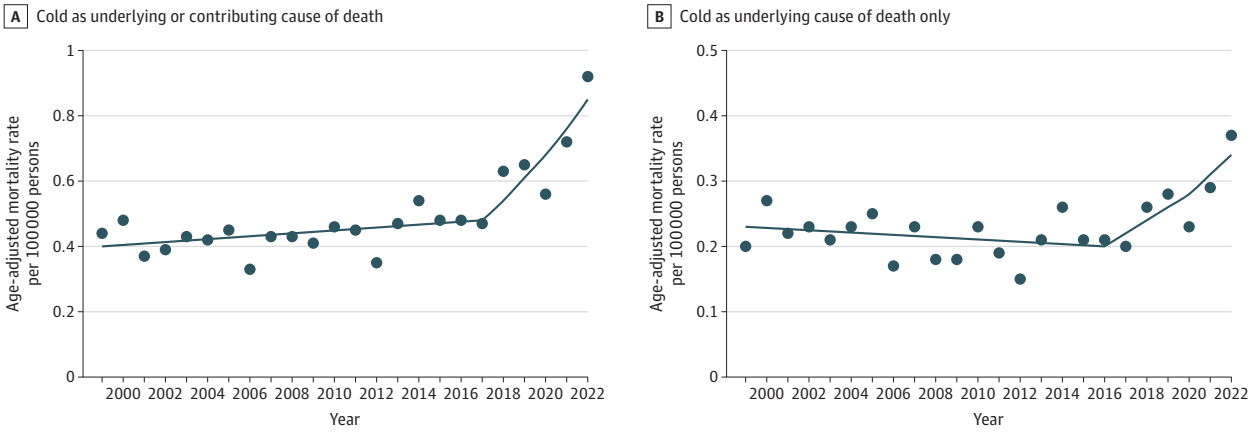
Methods | We used the Centers for Disease Control and Prevention's WONDER (Wide-Ranging Online Data for Epidemiologic Research) platform to analyze death certificates from 1999 to 2022 in which cold was recorded as either an underlying or contributing cause of death. Cold-related deaths were identified using the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* codes X31 (exposure to excessive natural cold), T68 (hypothermia), or T69 (other effects of reduced temperature), per the US Environmental Protection Agency definition.[4]

We obtained cold-related age-adjusted (to the 2000 US Census population) mortality rates (AAMRs) per 100 000 persons for the population overall and by age, sex, race, ethnicity, and region. Joinpoint regression was used to characterize trends and assess slope changes in AAMRs between 1999 and 2022, with results reported as annual percentage changes (APCs). A sensitivity analysis with cold as the underlying cause of death was performed. Statistical significance was defined as 2-sided $P < .05$. All analyses were performed using Joinpoint version 5.2.0. Institutional review board approval was not required (use of publicly available deidentified data).

Results | There were 63 550 429 deaths in the US between 1999 and 2022; a total of 40 079 deaths (0.06%) had cold recorded as an underlying or contributing cause of death. Cold-related AAMRs during this period increased from 0.44 (95% CI, 0.42-0.47) per 100 000 persons in 1999 to 0.92 (95% CI, 0.88-0.95) per 100 000 persons in 2022 (109% increase) (**Figure**). There was a 3.4% (95% CI, 2.4%-4.3%; $P < .001$) annual increase in the cold-related AAMR over the study period, with a nonsignificant increase from 1999 to 2017 (APC, 1.0% [95% CI, −0.9% to 2.2%]; $P = .20$) followed by a significant annual increase from 2017 to 2022 (APC, 12.1% [95% CI, 6.3%-27.1%]; $P < .001$). Results were consistent when cold was specified as the underlying cause of death only, with no change in AAMRs from 1999 to 2016 and a significant annual increase from 2016 to 2022 (APC, 9.1% [95% CI, 3.1%-27.9%]; $P = .001$).

Cold-related AAMRs were highest among adults 75 years or older (4.23 [95% CI, 3.97-4.49] per 100 000 persons in 2022), although adults aged 45 to 74 years experienced the largest annual increase (APC, 4.8% [95% CI, 3.7%-5.6%]; $P < .001$) between 1999 and 2022 (**Table**). Males had higher AAMRs than females, although both groups experienced significant increases over the study period. Across racial and ethnic groups, the highest cold-related AAMRs were observed among American Indian or Alaska Native (6.26 [95% CI, 5.25-7.27] per 100 000 persons in 2022) and Black (1.50 [95% CI, 1.38-1.62] per 100 000 persons in 2022) people. However, annual increases in cold-related AAMRs were largest among Hispanic (APC, 4.1% [95% CI, 3.2%-5.3%]; $P < .001$) and White (APC, 3.9% [95% CI, 2.9%-4.7%]; $P < .001$) people. Across regions,

Figure. Age-Adjusted Cold-Related Mortality Rates in the US, 1999-2022



Mortality rates were age-adjusted to the US population in 2000. Cold-related mortality rates are plotted as dots, with a Joinpoint model plotted as a line and a single Joinpoint in either 2017 (panel A) or 2016 (panel B).

Table. Cold-Related Mortality in the US by Age, Sex, Race, Ethnicity, and Region, 1999-2022[a]

	Total deaths, No.	AAMR per 100 000 persons (95% CI)		APC (95% CI), %	*P* value
		1999	2022		
Overall	40 079	0.44 (0.42 to 0.47)	0.92 (0.88 to 0.95)	3.4 (2.4 to 4.3)	<.001
Age, y					
≤24	1896	0.06 (0.04 to 0.08)	0.05 (0.04 to 0.06)	1.7 (−1.3 to 4.8)	.22
25-44	6334	0.21 (0.18 to 0.24)	0.66 (0.61 to 0.72)	3.7 (2.2 to 5.0)	<.001
45-74	19 441	0.58 (0.52 to 0.63)	1.54 (1.47 to 1.61)	4.8 (3.7 to 5.6)	<.001
≥75	12 351	3.23 (2.95 to 3.50)	4.23 (3.97 to 4.49)	2.0 (1.0 to 3.0)	<.001
Sex					
Male	13 032	0.69 (0.64 to 0.74)	1.34 (1.28 to 1.39)	3.0 (2.2 to 3.9)	<.001
Female	27 047	0.23 (0.21 to 0.26)	0.51 (0.48 to 0.54)	3.1 (2.2 to 4.0)	<.001
Race and ethnicity[b]					
American Indian or Alaska Native	2389	4.48 (3.40 to 5.79)	6.26 (5.25 to 7.27)	1.0 (0.2 to 3.1)	.02
Black	6259	1.00 (0.88 to 1.13)	1.50 (1.38 to 1.62)	1.5 (0.3 to 2.8)	.02
Hispanic	2217	0.21 (0.14 to 0.29)	0.51 (0.45 to 0.57)	4.1 (3.2 to 5.3)	<.001
White	28 235	0.37 (0.35 to 0.40)	0.88 (0.84 to 0.92)	3.9 (2.9 to 4.7)	<.001
Region					
Northeast	7095	0.50 (0.44 to 0.56)	0.77 (0.70 to 0.84)	1.9 (0.6 to 3.1)	.008
Midwest	11 729	0.51 (0.46 to 0.57)	1.41 (1.32 to 1.49)	4.3 (2.8 to 5.6)	<.001
South	11 367	0.37 (0.33 to 0.41)	0.71 (0.67 to 0.75)	2.5 (1.0 to 3.9)	.002
West	9888	0.47 (0.41 to 0.52)	0.94 (0.88 to 1.01)	3.6 (2.6 to 4.6)	<.001

Abbreviations: AAMR, age-adjusted mortality rate; APC, annual percentage change.

[a] Cold-related mortality was identified as all deaths with cold listed as an underlying or contributing cause using *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* codes X31, T68, and T69.

[b] Race and ethnicity were assessed in this study because of local-level data demonstrating that racial and ethnic minority populations were disproportionately impacted by cold exposure.[5] Race and ethnicity were recorded on death certificates and provided by the Centers for Disease Control and Prevention following 1997 Office of Management and Budget standards for the collection of data on race and ethnicity.

the Midwest experienced the highest mortality rates (1.41 [95% CI, 1.32-1.49] per 100 000 persons in 2022) and the largest annual increase (APC, 4.3% [95% CI, 2.8%-5.6%]; $P < .001$).

Discussion | Cold-related mortality rates more than doubled in the US between 1999 and 2022. Prior research suggests that cold temperatures account for most temperature-related mortality.[3] This study identified an increase in such deaths over the past 6 years. The underlying drivers of this trend warrant further research and may include more frequent extreme winter weather events and/or the rising burden of risk factors for cold-related mortality such as homelessness, social isolation, and substance use.[5]

Cold-related mortality was highest among older adults, who are more susceptible to cold weather due to limited thermoregulatory response and greater prevalence of chronic conditions.[6] The burden of cold-related deaths was also high among American Indian, Alaska Native, and Black people, consistent with the disproportionate exposure of racial and ethnic minority groups to structural risk factors such as lack of home insulation or heat.[5] The recent and rapid increase in cold-related deaths warrants public health interventions to improve access to warming centers and indoor heating for vulnerable populations.

Limitations of this study include potential underestimation of cold-related mortality using death certificates and lack of data about individual-level risk factors.

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