Cold-Related Illness and Deaths in Wisconsin, 2013–2023

Elaina M. Andreychak, MPH; Carrie D. Tomasallo, PhD, MPH; Sheryl A. Bedno, MD, DrPH

ABSTRACT

Introduction: Despite the increased frequency and intensity of heat waves in the United States, cold-related illness and deaths continue to be important health risks, especially in Wisconsin where cold weather is prevalent. This analysis explores trends and characteristics of cold-related illness and deaths related to environmental exposures in the state from October 2013 through April 2023.

Methods: Wisconsin hospital discharge data and vital records were used to identify cases of cold-related illness and death that occurred during 2013–2023. We compared trends over time, correlations with temperature, and differences in demographic characteristics between clinical outcomes using linear models and chi-square tests.

Results: We found an average rate of 13.6 emergency department visits per 100 000 population, 5.2 hospitalizations per 100 000 population, and 0.9 deaths per 100 000 population associated with cold-related illness during this period. The rate of death from cold-related illness has significantly increased since 2013 ($R^2 = 0.84$). Cases had high rates of co-occurring chronic conditions, with 67.3% (n = 8110) of all cases having at least 1 comorbidity. American Indian and Black races had the highest rates of all 3 clinical outcomes due to cold-related illness.

Conclusions: Cold-related illness and deaths are prevalent in Wisconsin, especially among the American Indian and Black communities and in people with chronic conditions. Housing status should be noted in medical records and examination reports to help improve data about people experiencing homelessness. Clinicians should be prepared to see patients with cold-related illness, even on days without extremely cold temperatures.

INTRODUCTION

Exposure to cold weather can cause a variety of cold-related illnesses, including hypothermia (abnormally low body temperature), frostbite (tissue damage caused by freezing), and chilblains (damage to capillary beds in the skin).[1] It is well known that cold exposure is especially dangerous for older adults and children under 5 years of age, people experiencing homelessness, and people with chronic conditions, in part due to weakened physiological adaptability and socioeconomic factors of these groups.[2-6] People who use drugs or consume alcohol also may be more at risk for complications related to cold exposure, as these substances can alter a person's ability to respond to the cold.[7] Additionally, cold exposure may contribute to cardiovascular mortality and is an important cause of morbidity in outdoor occupations and military training.[8-10]

Heat waves are projected to become more prevalent in the United States, which will likely increase the morbidity and mortality from heat-related illness; however, cold-related illness and deaths will still be prevalent, especially in states that experience extreme cold and rapid temperature changes.[2] The risk of hypothermia is influenced by air temperature and wind chill. Hypothermia risk increases during prolonged exposures to air temperatures below 32 °F; however, hypothermia also has been reported in temperatures as high as 60 °F during windy conditions.[7] Those who are affected at warmer temperatures often are elderly, very young, or have other underlying heath conditions.[7] During 2006 to 2010, there were 3332 deaths due to excessive heat com-

• • •

Author Affiliations: University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin (Andreychak, Tomasallo); Bureau of Environmental and Occupational Health, Wisconsin Division of Public Health, Madison, Wisconsin (Andreychak, Tomasallo, Bedno).

Corresponding Author: Elaina M. Andreychak, MPH, 1 W Wilson St, Room 150, Madison, WI 53703; phone 608.266.9752; email elaina.andreychak@dhs.wisconsin.gov; ORCID ID 0000-0001-6729-7396

pared to 6660 deaths due to excessive cold.[11] Among older adults (≥65 years) in the US, hypothermia was attributed to higher rates of inpatient admissions, longer hospital stays, and higher health costs than hyperthermia.[12] In future years, both hot and cold temperature extremes will continue to represent important health risks.[2]

Although climatologists estimate Wisconsin winters will warm 4 °F to 11 °F by mid-21st century, this may not impact the occurrence of cold-related illnesses and deaths.[13] Moreover, there have been recent polar vortex events in Wisconsin that correlated with short-term increases in cold-related emergency department (ED) visits.[14]

Despite the prevalence of cold weather in Wisconsin, we do not routinely analyze the burden and risk factors for cold-related illness and death. We also had not examined the utility of the case definition piloted by the Cold-Related Illness Content Work Group within the Centers for Disease Control and Prevention's (CDC) Environmental Public Health Tracking Network, which established the cold season in Kentucky, Massachusetts, New Jersey, New Mexico, New York, Vermont, and Wisconsin as the months of October through April.[15] The purpose of this analysis was to determine if this standard cold season window (October–April) appropriately captures cold-related illness and death in Wisconsin and to add to our understanding of cold-related illness and death in Wisconsin by describing the burden and characteristics of cold-related ED visits, hospitalizations, and deaths during the 2013-2023 cold seasons.

METHODS

We used Wisconsin hospital discharge and vital records data to identify cold-related cases during July 1, 2013 through June 30, 2023, including the clinical outcomes ED visits, hospitalizations, and deaths. We classified cases using the *International Classification of Diseases* (ICD), *9th and 10th Revisions, Clinical Modification* (ICD-9-CM and ICD-10-CM) codes from the case definition developed by the Council of State and Territorial Epidemiologists.[15]

A cold-related illness or death case was defined as an ED visit, hospitalization, or death record containing a primary diagnosis, other diagnoses, or E code with an ICD-9-CM code of E901.0, E901.8, E901.9, or E988.3 (accident due to excessive cold), 991.0-991.3 (frostbite), 991.6 (hypothermia), 991.5 (chilblains), 991.4, 991.8, or 991.9 (other effects of reduced temperature); or an ICD-10-CM code of X31 (exposure to excessive cold), T33 or T34 (frostbite), T68 (hypothermia), T69.1 (chilblains), or T69 (other effects of reduced temperature). We excluded nonresidents of Wisconsin and records with codes with E901.1 or W93 (excessive cold of human-made origin). ED visits were defined as treat-and-release visits and observation stays where the patient did not die, and hospitalizations were defined as inpatient stays where the patient did not die. Deaths were defined as vital records where the manner of death was "accident."

First, we conducted a descriptive analysis to compare the characteristics of cases that occurred during the standard cold season versus the non-cold season. Cold season cases were defined as cases with admission or death dates during the months of October through April, and non-cold season cases were defined as cases with admission or death dates during the months of May through September. We compared demographic characteristics and primary diagnosis codes of cold season cases with non-cold season cases and tested for statistically significant differences using chi-square tests at $P = 0.05$.

Next, we limited our analytic population to cases that had occurred during the cold season months. We calculated age-adjusted incidence rates using the direct method with population estimates from the US Census Bureau, stratified by clinical outcome (ED visit, hospitalization, or death). We tested for trends in rates over time using a linear regression model. We compared age-adjusted case rates of the 3 clinical outcomes by race, ethnicity, and sex, and we compared crude rates by age.

We used daily weather data from the National Weather Service to match each case with the average temperature and the departure from expected temperature that occurred on the date of admission or death. We used Pearson's correlation to test the relationship between number of cases and the average temperature and the average departure from expected temperature. We analyzed the differences in case temperatures by clinical outcome using 2-tailed *t* tests.

We identified cases with co-occurring chronic conditions and risk factors, including cardiovascular disease, diabetes, drug and alcohol use, respiratory conditions, and mental illnesses, using ICD-9 and ICD-10 codes found in the primary diagnosis, other diagnoses, and E code fields. We used chi square tests to calculate the odds of hospitalization or death in cases with chronic conditions compared to ED visits. We also analyzed and compared the co-occurrence of alcohol use between hospitalizations or deaths and ED visits.

We quantified homelessness in our analytic sample using the Z code Z59, which applied to both ICD-9 and ICD-10 codes. We compared the presence of this code in our analytic sample to the rest of the hospitalized population during the corresponding time period using We compared demographic characteristics and primary diagnosis codes of cold season cases with non-cold season cases and tested for statistically significant differences using chi-square at $P = 0.05$.

All analyses were performed using SAS version 9.4 software (SAS Institute Inc, Cary, North Carolina).

RESULTS

Comparing Cold Season and Non-Cold Season Cases

There were 13 565 cold-related illnesses and deaths that occurred from July 1, 2013 through June 30, 2023. The majority (89%, n = 12 054) of cases occurred during the standard cold season,

Table 1. Distribution of Characteristics for Cold-Related Illness Cases by Season of Occurrence, July 1, 2013–June 30, 2023

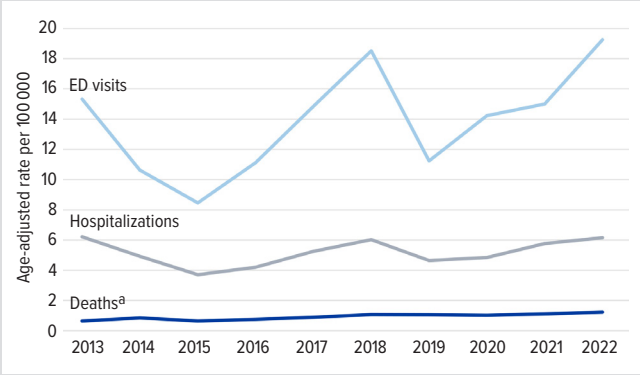
Characteristics	Cold Season n (%)	Non-Cold Season n (%)	*P* value
Total	12 054 (100)	1511 (100)	—
Clinical outcome			
Emergency department visit	8043 (66.7)	887 (58.7)	<0.0001
Hospitalization	3375 (28.0)	572 (37.9)	
Death	636 (5.3)	52 (3.4)	
Male sex	8417 (69.8)	938 (62.1)	<0.0001
Race[a]			
American Indian	266 (2.3)	26 (1.8)	<0.0001
Asian	133 (1.1)	21 (1.4)	
Black	2931 (25.2)	273 (18.8)	
White	8298 (71.4)	1135 (78.0)	
Hispanic ethnicity	577 (4.8)	74 (4.9)	0.7682
Age group			
0–4	236 (2.0)	60 (4.0)	<0.0001
5–14	349 (2.9)	34 (2.3)	
15–34	3406 (28.3)	290 (19.2)	
35–64	5490 (45.5)	437 (28.9)	
65+	2571 (21.3)	690 (45.7)	
Cold-related illness is primary diagnosis	6728 (55.8)	526 (34.8)	<0.0001
Co-occurring cardiovascular disease	3436 (28.5)	568 (37.6)	<0.0001
Co-occurring respiratory disease	1769 (14.7)	297 (19.7)	<0.0001
Co-occurring diabetes	1334 (11.1)	282 (18.7)	<0.0001
Co-occurring mental illness	5608 (46.5)	661 (43.7)	0.0412
Co-occurring drug use	2626 (21.8)	313 (20.7)	0.3410
Any co-occurring chronic illness	8110 (67.3)	1132 (74.9)	<0.0001
Co-occurring alcohol use	2443 (20.3)	307 (20.3)	0.9633
Person experiencing homelessness	1353 (11.2)	120 (7.9)	0.0001

[a]Cases with Other or Unknown race were excluded when calculating race percentages.

Table 2. Age-adjusted Rates (AAR) per 100 000 Population for Cold-Season Cases by Clinical Outcome, October 2013–April 2023

Variable	ED Visits) AAR (95% CI)	Hospitalizations AAR (95% CI)	Deaths AAR (95% CI)
Total	13.6 (13.5–14.1)	5.2 (5.0–5.4)	0.9 (0.8–1.0)
Race			
American Indian	35.9 (30.7–41.9)	13.5 (10.3–17.8)	3.6 (2.1–6.3)
Asian	6.6 (5.1–8.3)	2.4 (1.5–3.7)	0.1 (0.0–0.8)
Black	64.4 (61.8–67.2)	15.3 (13.9–16.7)	1.7 (1.3–2.3)
White	10.8 (10.5–11.1)	4.6 (4.4–4.7)	0.9 (0.8–1.0)
Ethnicity			
Hispanic	10.2 (9.2–11.2)	3.6 (3.0–4.1)	0.5 (0.3–0.7)
Non-Hispanic	13.8 (13.5–14.1)	5.8 (5.6–6)	1.1 (1.0–1.2)
Sex			
Male	19.7 (19.2–20.3)	7.8 (7.4–8.1)	1.7 (1.5–1.8)
Female	8.0 (7.6–8.3)	3.9 (3.7–4.1)	0.7 (0.6–0.8)
Age group (years)			
0–4	6.1 (5.2–6.9)	1.1 (0.7–1.4)	0.0 (0.0–0.0)
5–14	4.6 (4.1–5.1)	0.2 (0.1, 0.3)	0.01 (0.0–0.04)
15–34	18.3 (17.6–19.0)	3.7 (2.4–4.0)	0.4 (0.3–0.5)
35–64	16.3 (15.8–16.8)	6.8 (6.4–7.1)	1.1 (1.0–1.3)
65+	10.7 (10.9–11.3)	12.6 (11.9–13.3)	3.2 (2.9–3.6)

Figure 1. Trends of Age-adjusted Rates of Cold-Related Emergency Department Visits, Hospitalizations, and Deaths Over Time



[a]Significant trend ($P = 0.0002$)

October through April, while 1511 (11%) occurred during May through September. January had the highest incidence of cases, with 24% of all cases occurring in that month (n = 3282). Stratified by clinical outcome, 90% of cold-related ED visits, 85% of hospitalizations, and 92% of deaths occurred during the cold season. Non-cold season cases had a significantly higher proportion of hospitalizations, females, White race, and 0 to 4 and 65+ age groups compared to the cold seasont cases. Non-cold season cases also had higher proportions of people with any chronic conditions, especially cardiovascular diseases, respiratory diseases, and diabetes (Table 1). Cold season cases were significantly associated with having a cold-related illness as the primary diagnosis compared to non-cold season cases ($P < 0.0001$).

Burden of Cold-Related Illness

There were 12 054 cold-related ED visits, hospitalizations, and deaths that occurred during October through April. There were 8043 ED visits with an average statewide age-adjusted rate of 13.6 visits per 100000 population. There were 3375 hospitalizations with an average age-adjusted rate of 5.2 per 100 000, and there were 636 deaths with an average rate of 0.9 per 100 000. The trend of cold-related deaths significantly increased from 0.6 per 100 000 during the 2013-2014 season to 1.2 per 100 000 during the 2022-2023 season ($R^2 = 0.84$, $P = 0.0002$). The rates of ED visits also trended upward, but the increases were not statistically significant (Figure 1).

The most prevalent cold-related diagnosis code for ED visits and hospitalizations was exposure to excessive cold (78.3% and 74.5% of records, respectively). For deaths, 91.4% of records had hypothermia as a cause of death, and 91.4% had exposure to excessive cold (data not shown).

Rates differed between demographic groups (Table 2). The Black population had the highest age-adjusted rates of ED visits and hospitalizations compared to American Indian, Asian, and White races. The American Indian population had the highest rate of cold-related deaths at 3.6 per 100 000 (95% CI, 2.1-6.3). The

rate of ED visits in the Black population was 6 times higher than the rate of ED visits in the White population (64.4 per 100000 population vs 10.8 per 100 000 population) (Table 2). Non-Hispanic groups had higher rates of cold-related illness for all 3 clinical outcomes than Hispanic groups. Additionally, people aged 65 and older had the highest hospitalization and death rates compared to all other age groups, while people aged 15 to 34 years had the highest ED visit rates for cold-related illness. Death and hospitalization rates rose with age while ED visit rates peaked in middle age. Men had over twice the rates of cold-related ED visits, hospitalizations, and deaths than women.

Temperature

Cases occurred on days with wide-ranging average temperatures, from -23 °F to 72 °F. The average temperature on days when cases occurred was 22.9 °F. The average temperature for ED visit days was 3.2 degrees colder (95% CI, 2.5-3.8) than the days of deaths and hospitalizations.

There were similar findings for departure from expected temperatures. Cases occurred on days where temperatures ranged from 39 degrees below expected to 31 degrees above expected. On average, cases happened on days where the temperature was 5.4 degrees lower than expected (data not shown).

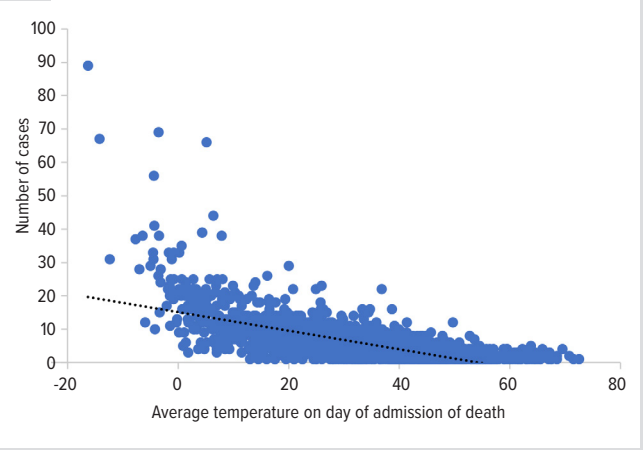
Average temperature and number of cases were strongly negatively correlated, with a correlation coefficient of -0.65 ($P < 0.0001$) (Figure 2). Departure from expected temperature and number of cases were moderately negatively correlated, with a correlation coefficient of -0.44 ($P < 0.0001$) (data not shown).

Chronic Conditions and Other Risk Factors

Cases had high rates of co-occurring chronic conditions, with 67.3% (n = 8110) of all cases having at least 1 diagnosis code for cardiovascular disease, diabetes, drug use, respiratory illness, or mental illness. Cases of cold-related illness with co-occurring chronic conditions were significantly more likely to be hospitalized or die than to have a treat-and-release ED visit ($P < 0.0001$). Having 1 chronic condition was significantly associated with increased odds of hospitalization or death from cold-related illness (OR 4.5; 95% CI, 4.0-5.1; $P < 0.0001$), and the odds increased incrementally with each additional chronic condition. For cases with 5 or more chronic conditions, the odds ratio for hospitalization or death was 22.2 (95% CI, 8.0-61.9). Co-occurring cardiovascular disease was significantly associated with increased odds of hospitalization or death from cold-related illness (OR 4.8; 95% CI, 4.4-5.2; $P < 0.0001$), as was co-occurring respiratory disease (OR 4.4; 95% CI, 4.0-4.9; $P < 0.0001$) (Table 3).

Alcohol use co-occurred with cold-related illness in 29.8% of hospitalizations and deaths and in 15.5% of ED visits. Co-occurring alcohol use was significantly associated with increased odds of cold-related hospitalization or death (OR 2.3; 95% CI, 2.1-2.5; $P < 0.0001$). The odds of a cold-related illness ED visit or hospitalization record containing a Z code for homelessness was higher compared to all other discharge records. Among cases, 14.7% of ED visit records and 4.2% of hospitalization records also contained a Z code for homelessness compared to 0.2% of all other ED visits and 0.4% of all other hospitalizations. Cold-related ED visit records were significantly associated with increased odds of containing a Z code for homelessness (OR 88; 95% CI, 82.4-93.6; $P < 0.0001$), as were cold-related hospitalization records (OR 12; 95% CI, 10.4-14.3; $P < 0.0001$) (results not shown).

Figure 2. Relationship Between Average Temperature of the Day of Admission or Death and the Number of Cold-Related Cases per day During the 2013–2023 Cold Seasons (n = 1999)



The plot displays a negative correlation between temperature and number of cases with Pearson's r = -0.65.

DISCUSSION

We explored the differences between cold season and non-cold season cold-related illnesses and deaths using hospital discharge and vital records data. We found fundamental differences in demographics and co-occurring diseases between these groups, especially in the primary diagnoses. These characteristics (aged < 5 years, aged ≥ 65 years, and presence of comorbidities) are known risk factors of cold-related illness and death, and people with these characteristics are more likely to suffer hypothermia, even when the weather is warmer.[7] However, we found that 65% of non-cold season cases did not have cold-related illness or exposure as the principal diagnosis, compared to 44% of cold season cases. Non-cold season cases had higher proportions of endocrine diseases and infections listed as the primary diagnosis compared to cold season cases, leading us to hypothesize that some of the non-cold season cases are false positives (ie, cases that did not have exposure to environmental cold). In these cases, cold-related illness may be a result of the patient's primary condition, such as sepsis-induced hypothermia.[16,17] Therefore, we do not recommend expanding the surveillance window to

include cold-related illnesses that occur in the non-cold season until we conduct further research using more detailed medical records to understand why cold-related illness occurs during warmer months.

During the October–April cold season, the burden of cold-related ED visits, hospitalizations, and deaths in Wisconsin was similar to findings in Minnesota, which was expected due to its proximity and similar climate.[3] The trends for all 3 clinical outcomes showed increases over time. We found that the highest rates of cold-related illnesses occurred in males, older adults, and among the Black and American Indian populations, which is consistent with previous literature.[2] These populations are known to have higher rates of chronic conditions and people experiencing homelessness, which could contribute to their susceptibility to cold-related illness; however, this area deserves further research.

Table 3. Comorbidities Associated With Higher Risk of Hospitalization and Deaths, October 2013–April 2023

Variable	Total n (%)	Hospitalizations and Deaths n (%)	ED Visits n (%)	OR (95% CI)[a]
Total	12 054 (100)	3375 (28.0)	8043 (66.7)	—
Number of co-occurring chronic conditions				
0	3944 (32.7)	442 (11.2)	3503 (88.8)	ref
1	3279 (27.2)	1196 (36.5)	2083 (63.5)	4.5 (4.0–5.1)
2	3301 (27.4)	1461 (44.3)	1840 (55.7)	6.3 (5.6–7.1)
3	1247 (10.3)	734 (58.9)	513 (41.1)	11.3 (9.8–13.2)
4	264 (2.2)	164 (62.1)	100 (37.9)	13.0 (9.9–17.0)
5+	19 (0.2)	14 (73.7)	5 (26.3)	22.2 (8.0–61.9)
Co-occurring cardiovascular disease?[b]	3436 (28.5)	2027 (59.0)	1409 (41.0)	4.8 (4.4–5.2)
Co-occurring respiratory disease?[b]	1769 (14.7)	1120 (63.3)	649 (36.7)	4.4 (4.0–4.9)
Co-occurring diabetes?[b]	1334 (11.1)	589 (44.2)	745 (55.8)	1.7 (1.5–1.9)
Co-occurring mental illness?[b]	5608 (46.5)	2104 (37.5)	3504 (62.5)	1.4 (1.3–1.5)
Co-occurring drug use?[b]	2626 (21.8)	1206 (45.9)	1420 (54.1)	2.0 (1.8–2.2)
Any co-occurring chronic illness?[b]	8110 (67.3)	3569 (44.0)	4541 (56.0)	6.2 (5.6–6.9)
Co-occurring alcohol use?[b]	2443 (20.3)	1197 (49.0)	1246 (51.0)	2.3 (2.1–2.5)
Person experiencing homelessness?[b]	1353 (11.2)	168 (12.4)	1185 (87.6)	0.3 (0.2–0.3)

[a] All *P* values significant at $P < 0.0001$.
[b] Yes versus no.
Abbreviation: ED, emegency department.

We found that cold-related illnesses occurred on days that were colder than average; however, many cases occurred on days that were not extremely cold, which is also consistent with previous studies. This suggests that, even with climate change potentially making Wisconsin winters milder, cold-related illnesses may still be just as prevalent.[7] While we found it surprising to observe cold-related illness cases occurring on days with an average temperature as warm as 72 °F, previous studies have shown that older adults with health conditions could become hypothermic at temperatures as high as 75 °F.[7] Additionally, evidence from the Cold-Related Illness Contact Work Group pilot suggests that some cold-related illnesses that occur during warmer weather may be related to cold water exposure; in such situations, the water temperature may be much lower than the ambient air temperature leading to hypothermia.[15] Finally, it is possible that there was some lag time between cold-weather exposure and admission or death date, which would make the day-of temperature inaccurate for understanding the weather events that caused the cold-related illness or death. Future analyses should consider incorporating lag time between cold weather events and health care utilization to see if the correlation between temperature and case counts is improved.

We established a negative correlation between temperature and case counts; however, most cases occurred on days where the temperature was only slightly below the expected average temperature. Furthermore, we found that the correlation between case counts and temperature was not as strong among hospitalizations and deaths compared to ED visits. This finding suggests that preventing cold-related illness is less about predicting extreme weather and more about and protecting vulnerable populations. The people most affected by cold-related illness were older, had chronic conditions, were experiencing homelessness, or were a part of a population experiencing the effects of structural racism on health.[18] We also found high proportions of drug and alcohol use and mental health conditions in our analytic population. These are well-known factors that exacerbate cold-related illnesses because they impair a person's judgement to seek shelter and wear warm and protective clothing in cold weather.[19]

A major limitation of this analysis was that homelessness is not identified consistently in hospital discharge and vital records data. This Z code was used by only 3% of hospitals in our database, which resulted in a vast underestimate of the true burden. People experiencing homelessness are more at risk of cold-related illness and death and may utilize emergency services to escape the cold.[6,7,12,17,19] Further research and better methods for identifying homelessness in surveillance data are essential for understanding the true burden of cold-related illnesses in the homeless population. Medical examiners can help improve data on homelessness by indicating a patient's housing status on the death certificate.

CONCLUSIONS

Cold-related illness and deaths in Wisconsin are prevalent but preventable. This analysis demonstrated that older people, those who have chronic conditions, and people experiencing homelessness are especially susceptible to cold-related illness. It also revealed a large racial disparity in the burden of cold-related illness. Cold-related illnesses and deaths occur across a wide range of outdoor temperatures and especially affect vulnerable populations who have limited resources and access to health care.

Hospital discharge and vital records data can be used to track and monitor cold-related illness, and this analysis provides a framework for other agencies to perform a similar surveillance in their jurisdictions. Although the frequency and intensity of heat waves is expected to increase, Wisconsin clinicians should still be prepared to see patients with cold-related illnesses—even on days that are not extremely cold.

Financial Disclosures: None declared.

Funding/Support: None declared.

REFERENCES

1. National Institute for Occupational Safety and Health. Cold-related illnesses in workers. Centers of Disease Control and Prevention. September 4, 2024. Accessed September 30, 2025. https://www.cdc.gov/niosh/cold-stress/about/related-illness.html

2. O'Neill MS, Ebi KL. Temperature extremes and health: impacts of climate variability and change in the United States. *J Occup Environ Med*. 2009;51(1):13-25. doi:10.1097/JOM.0b013e318173e122

3. Kircher M, Konen T, Carr J. Assessing the burden of cold-related illness and death in Minnesota. *J Environ Health.* 2023;86(4):8-14.

4. Lane K, Ito K, Johnson S, Gibson EA, Tang A, Matte T. Burden and risk factors for cold-related illness and death in New York City. *Int J Environ Res Public Health.* 2018;15(4):632. doi:10.3390/ijerph15040632

5. Jurkovich GJ. Environmental cold-induced injury. *Surg Clin North Am.* 2007;87(1):247-267. doi:10.1016/j.suc.2006.10.003

6. Zhang P, Wiens K, Wang R, et al. Cold weather conditions and risk of hypothermia among people experiencing homelessness: implications for prevention strategies. *Int J Environ Res Public Health*. 2019;16(18):3259. doi:10.3390/ijerph16183259

7. Nixdorf-Miller A, Hunsaker DM, Hunsaker JC 3rd. Hypothermia and hyperthermia medicolegal investigation of morbidity and mortality from exposure to environmental temperature extremes. *Arch Pathol Lab Med*. 2006;130(9):1297-1304. doi:10.5858/2006-130-1297-HAHMIO

8. Gorjanc ML, Flanders WD, VanDerslice J, Hersh J, Malilay J. Effects of temperature and snowfall on mortality in Pennsylvania. *Am J Epidemiol*. 1999;149(12):1152-1160. doi:10.1093/oxfordjournals.aje.a009770

9. Mäkinen TM, Hassi J. Health problems in cold work. *Ind Health*. 2009;47(3):207-220. doi:10.2486/indhealth.47.207

10. DeGroot DW, Rappole CA, McHenry P, Englert RM. Seasonal trends for environmental illness incidence in the U.S. Army. *Mil Med.* 2022;187(5-6):e672-e677. doi:10.1093/milmed/usab072

11. Berko J, Ingram DD, Saha S, Parker JD. Deaths attributed to heat, cold, and other weather events in the United States, 2006-2010. *Natl Health Stat Report.* 2014;(76):1-15.

12. Noe RS, Jin JO, Wolkin AF. Exposure to natural cold and heat: hypothermia and hyperthermia Medicare claims, United States, 2004-2005. *Am J Public Health.* 2012;102(4):e11-e18. doi:10.2105/AJPH.2011.300557

13. Wisconsin Initiative on Climate Change Impacts. Wisconsin's Changing Climate: Impacts and Solutions for a Warmer Climate. University of Wisconsin Board of Regents; 2022. Accessed June 5, 2024. https://wicci.wisc.edu/2021-assessment-report/full-report/

14. Christenson M, Thelan M, Vogt C, Meiman J. Extreme Cold in Wisconsin: Trends, Surveillance, and Prevention. Wisconsin Environmental Public Health Tracking Program; 2020. Surveillance Brief. Accessed June 5, 2024. https://www.dhs.wisconsin.gov/publications/p02577.pdf

15. Adekoya N, Braun C, Harris-Franklin L, et al. Cold-Related Illness Query: Guidance for Implementing Cold-Related Illness Syndromic Surveillance in Public Health Practice. Council of State and Territorial Epidemiologists; 2019. Accessed June 6, 2024. https://cdn.ymaws.com/www.cste.org/resource/resmgr/climate/CRI_Syndrome_Definition_Guid.pdf

16. Aslam AF, Aslam AK, Vasavada BC, Khan IA. Hypothermia: evaluation, electrocardiographic manifestations, and management. *Am J Med*. 2006;119(4):297-301. doi:10.1016/j.amjmed.2005.09.062

17. Meiman J, Anderson H, Tomasallo C; Centers for Disease Control and Prevention. Hypothermia-related deaths--Wisconsin, 2014, and United States, 2003-2013. *MMWR Morb Mortal Wkly Rep.* 2015;64(6):141-143.

18. Bailey ZD, Krieger N, Agénor M, Graves J, Linos N, Bassett MT. Structural racism and health inequities in the USA: evidence and interventions. *Lancet*. 2017;389(10077):1453-1463. doi:10.1016/S0140-6736(17)30569-X

19. Haney C. Beyond "Snow Shoveler's Infarction": broadening perspectives on winter health risks. *Geogr Compass.* 2020;14(7):e12494. doi:10.1111/gec3.12494

advancing the art & science of medicine in the midwest

WMJ

WMJ (ISSN 2379-3961) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

Visit www.wmjonline.org to learn more.