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Assessing the Effect of Cold Weather on Rural Cardiovascular Disease Deaths in Vermont

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1 ABSTRACT

Objective: To study Vermont mortality and temperature data to determine if there is an increased incidence of cardiovascular disease related death on categorically cold streak days among rural residents.

Methods: A retrospective study was conducted using a cohort of Vermont CVD deaths between 2009-2017 subset with corresponding daily temperature data. CVD deaths that occurred on a categorical cold streak day were then identified and analyzed using a Poisson Regression to assess the relationship between ambient temperature changes, CVD mortality, and rurality.

Results: As compared to non-cold streak days, risk of CVD mortality was 4% higher on cold streak days (P <0.001). These results were disproportionate among rural residents (P<0.001). However, when controlling for cold streak days, rurality, and tobacco use, the excess risk of CVD deaths was 4.5% lower for each successive year of age.

Conclusion: Our findings highlight an increased risk of CVD death among rural residents on cold-streak days. However, further research is needed to understand why CVD death on cold-streak days was less likely with every year increase in age among our sample.

2 INTRODUCTION

Cardiovascular disease (CVD) is ranked the leading cause of mortality in Vermont and nationwide, with rural Americans experiencing a disproportionate level of risk.[1,2] In 2017 alone, 1,434 Vermont deaths were attributed to heart disease; with an age-adjusted death rate of 164.5 per 100,000 people.[1] Due to the elevated public health risk this presents, the etiology and pertinent associations of this trend have been researched on a global scale. The relationship between ambient temperature differentials and CVD mortality risk is a recurring theme in relevant research.[3] However, while many studies have examined the elevated risk of CVD mortality due to heat waves, fewer have examined similar outcomes following cold weather trends.

Research between 2006 –2010 demonstrated overall death risk increased by approximately 30-50% during winter months among cardiovascular inpatients aged ≥ 65 yrs.[3] A study in the Czech Republic between 1986–2006 found that cold-spells were associated with positive mean excess CVD mortality in all age groups.[4] An analysis of 11.3 million hospitalizations in Switzerland found a pattern of fewer CVD-related deaths and hospitalizations occurring in the summer, with more acute myocardial infarctions and stroke related deaths in the winter.[5] Coined the “Winter Cardiovascular Disease Phenomenon” (WCVDP), incidence of cardiovascular mortality during cold-snaps has yet to be examined in Vermont.[6] Additionally, limited research has evaluated the impact of rurality on winter CVD mortality.

With a mean annual temperature of 45.85°F, and an average age 5 years older than the national average, Vermont residents are likely to be impacted by risk factors responsible for heart disease.[7] Further, with approximately 60% of the state's population residing in rural areas, Vermont data provides a unique viewpoint for researchers.[8] We review Vermont specific data regarding CVD mortality following cold weather variations to determine if there is an increased incidence of CVD death on cold streak days among rural residents.

3 METHODS

A retrospective cohort study was leveraged to assess the relationship between cold-spells and CVD deaths using de-identified mortality data collected by the Vermont Department of Health between 2009-2017. Within the Electronic Death Reporting System (EDRS) dataset, 14,430 cases with CVD as primary cause of death were selected from the total of 49,469. These diagnoses included coronary artery disease, cerebrovascular accident, rheumatic heart disease, congenital heart disease, deep vein thrombosis, and congestive heart failure, spanning ICD10 codes I10 through I87. After excluding those receiving hospice care at the time of their death, nonresidents, and those under age 18, there was a total of 3,643 deaths.

Weather data was extracted from the National Oceanic and Atmospheric Administration (NOAA) Climate Online Search from Montpelier, Vermont; a central location, to approximate conditions throughout the state. Cold streak weather patterns are defined as a period of ≥3 consecutive days with daily minimum temperature below the 5th percentile of the individual frequency distribution. Using a Stata macro code, weather data was processed to provide an output of numeric values for cold streak days. Resulting weather variables were linked to the EDRS dataset by date of death.

SPSS was used to summarize demographic characteristics of deceased individuals using the variables of sex, age, ethnicity, race, and cigarette use. The town of residence of each case was classified as urban or rural using the rural urban commuting area (RUCA) codes.[9] A Poisson regression analysis was used to estimate relative risk of CVD mortality in relation to cold streak days with gender, RUCA, tobacco use, and age as covariates.

The University of Vermont Institutional Review Board has reviewed this project and determined that it qualifies as exempt from additional review.

4 RESULTS

From the 3,643 adult Vermont residents with a CVD death outcome, there were 1,503 (41.30%) males and 2,140 (58.70%) females, of which 674 (18.5%) used tobacco and 2,969 (81.5%) did not use tobacco. Rural residents (n=2,690, 73.8%) outnumbered urban residents (n=953, 26.2%). The mean age was 86.7 years of age (standard deviation of 8.93). Demographics by rurality and cold-streak deaths by rurality tables are shown in supplemental materials.

From 2009-2017, 3,286 days were counted with 3,203 as non-cold streak days and 83 as cold streak days. Among the days of follow up, 3,542 (97.2%) CVD deaths were on non-cold streak days and 101 (2.8%) CVD deaths were on cold streak days. Relative to non-cold streak days, the relative risk of CVD mortality was 4% higher on cold streak days, $p<0.001$ (Table 1). Additionally, males, rural residents and tobacco users were more likely to have died of CVD, compared to urban residents, women, and non-smokers ($p<0.001$). For every one-year increase in age, the relative risk of CVD mortality was 4.5% lower (Table 1).

Table 1. Relative Risks and 95% Confidence Intervals for Cardiovascular Disease Mortality on Cold-streak Days.

Category	Variable	Relative Risk	95% Wald Confidence Interval
Weather	Cold Streak Day	1.040	1.038-1.042
	Non-cold Streak Day$_R$	1	
Gender	Male	1.091	1.09-1.091
	Female$_R$	1	
Residence	Rural	1.059	1.058-1.060

	Urban[R]	1	
Tobacco Use	Yes	1.082	1.081-1.082
	No[R]	1	
Age (years) Scale		0.955	0.955-0.955

[R] = Reference Category
Dependent Variables = CVD death outcomes.

Goodness of Fit test showed a value/df at 4884.066. Omnibus test results indicated statistical significance with $p<0.001$. For model of effects test, each variable represents a statistical significance ($p<0.001$) with cold streak, gender, RUCA, tobacco use, and age.

5 DISCUSSION

We observed a 4% higher relative risk of death on cold streak days, as well as excess burden of CVD deaths among those living in rural areas. Our analysis showed that when controlling for cold streak days, rurality, and tobacco use, the excess risk of CVD deaths was 4.5% lower for each successive year of age. These results are consistent with the concept of the WCVDP and support the conclusion that ambient temperature changes may negatively impact individuals suffering from CVD. However, our findings regarding WCVDP death among the aging population is inconsistent with previous research potentially attributed to competing risk factors; and presents novel findings for Vermont specific mortality data.[4]

5.1 PUBLIC HEALTH IMPLICATIONS

Vermont presents a unique socio-geographic perspective for in-depth analysis of ambient temperature changes on CVD death rates as the state projects that by 2030, 1 in 4 individuals will be above the age of 65.[12] While previous research is consistent with increased risk of cold streak death in older individuals, our data suggests the opposite.[5] These results provide a framework for studies to further investigate the impact of weather on additional Vermont morbidity and mortality risks. This study also contributes to a growing body of research highlighting the physiological impact of weather extremes, as well as the exploration of rural-health outcomes.[2,5]

An additional consideration of these findings includes the impact of climate change on these results. With health risks associated with climate change rising, research assessing the relationship between ambient temperature changes and mortality are becoming increasingly relevant. As our results indicate, cold-weather mortality among rural CVD patients is a present risk, but further research is needed to understand how this association changes over time.

5.2 LIMITATIONS

While our research produced original findings, there were limitations to our methodology. Possible additional confounders, including the impact of snowfall, physical activity, socioeconomic status, and homelessness status were not evaluated in our analysis. Weather data was only taken from Montpelier, Vermont, and temperature differentials between this area and Northern Vermont can often be great. Therefore, categorization of cold-streak days may be inaccurate for deaths occurring in other geographical regions in Vermont. Further, our designation of cold-streak days does not take into account the potential for lag effect, which has shown to contribute to a 19% increase in sudden cardiac death in previous research.[11,12] Additional research is needed to further understand the role of lag effects on winter CVD deaths in Vermont.

6 REFERENCES

1. Stats of the State of Vermont. Centers for Disease Control and Prevention. https://www.cdc.gov/nchs/pressroom/states/vermont/vermont.htm. Published April 9, 2018. Accessed October 26, 2019.

2. Rural Americans at higher risk of death from five leading causes. Centers for Disease Control and Prevention. https://www.cdc.gov/media/releases/2017/p0112-rural-death-risk.html. Published January 12, 2017. Accessed April 1, 2020.

3. Xu B, Liu H, Su N, et al. Association between winter season and risk of death from cardiovascular diseases: a study in more than half a million inpatients in Beijing, China. *BMC Cadiovasc Disord* 2013;13(1). doi:10.1186/1471-2261-13-93.

4. Kysely J, Pokorna L, Kyncl J, Kriz B. Excess cardiovascular mortality associated with cold spells in the Czech Republic. *BMC Public Health*. 2009;9(1). doi:10.1186/1471-2458-9-19.

5. Stewart S, Keates AK, Redfern A, Mcmurray JJV. Seasonal variations in cardiovascular disease. *Nat Rev Cardiol*. 2017;14(11):654-664. doi:10.1038/nrcardio.2017.76

6. Fares A. Winter cardiovascular diseases phenomenon. *N Am J Med Sci* 2013;5(4):266. doi:10.4103/1947-2714.110430.

7. Vermont Climate and Health Profile Report. Vermont Department of Health. September 2016. https://www.healthvermont.gov/sites/default/files/documents/pdf/ENV_CH_ProfileReport.pdf

8. Vermont: 2010: Population and Housing Unit Counts. U.S Census Bureau; 2012. https://www.census.gov/prod/cen2010/cph-2-47.pdf. Accessed April 1, 2020.

9. WWAMI Medical Education Program Rural Health Research Center. Rural Urban Commuting Area Codes. https://depts.washington.edu/uwruca/ruca-uses.php. Accessed February 16, 2020.

10. Smith-Dieng A. 2018 VT State Plan on Aging. Vermont Agency of Human Services Department of Disabilities, Aging and Independent Living (DAIL); 2018 https://asd.vermont.gov/sites/asd/files/documents/VT%20State%20Plan%20on%20Aging_2018_FINAL%20APPROVED_1.pdf. Accessed April 5, 2020.

11. Ryti NRI, Mäkikyrö EMS, Antikainen H, et al. Risk of sudden cardiac death in relation to season-specific cold spells: a case–crossover study in Finland. *BMJ Open*. 2017;0:e017398. doi:10.1136/ bmjopen-2017-017398

12. Huang J, Wang J, Yu W. The Lag Effects and Vulnerabilities of Temperature Effects on Cardiovascular Disease Mortality in a Subtropical Climate Zone in China. *Int J Environ Res Public Health* 2014;11(4):3982-3994. doi:10.3390/ijerph110403982.