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The role of insurance status in the association between short-term temperature exposure and myocardial infarction hospitalizations in New York State

Nina M. Flores[a*], Vivian Do[a], Sebastian T. Rowland[a,b], Joan A. Casey[a,c], Marianthi A. Kioumourtzoglou[a]

Introduction: Myocardial infarction (MI) is a leading cause of morbidity and mortality in the United States and its risk increases with extreme temperatures. Climate change causes variability in weather patterns, including extreme temperature events that disproportionately affect socioeconomically disadvantaged communities. Many studies on the health effects of extreme temperatures have considered community-level socioeconomic disadvantage.

Objectives: To evaluate effect modification of the relationship between short-term ambient temperature and MI, by individual-level insurance status (insured vs. uninsured).

Methods: We identified MI hospitalizations and insurance status across New York State (NYS) hospitals from 1995 to 2015 in the New York Department of Health Statewide Planning and Research Cooperative System database, using *International Classification of Diseases* codes. We linked short-term ambient temperature (averaging the 6 hours preceding the event [MI hospitalization]) or nonevent control period in patient residential zip codes. We employed a time-stratified case-crossover study design for both insured and uninsured strata, and then compared the group-specific rate ratios.

Results: Over the study period, there were 1,095,051 primary MI admissions, 966,475 (88%) among insured patients. During extremely cold temperatures (<5.8 °C) insured patients experienced reduced rates of MI; this was not observed among the uninsured counterparts. At warmer temperatures starting at the 65th percentile (15.7 °C), uninsured patients had higher rates than insured patients (e.g., for a 6-hour pre-event average temperature increase from the median to the 75th percentile, the rate of MI increased was 2.0% [0.0%–4.0%] higher in uninsured group).

Conclusions: Uninsured individuals may face disproportionate rates of MI hospitalization during extreme temperatures.

Keywords: Case-crossover; Effect modification; Insurance; Myocardial infarction; Status; Temperature

Introduction

Myocardial infarction (MI) is a leading cause of morbidity and mortality both worldwide and within the United States.[1,2] Both cold and heat exposures can elevate the risk of MI,[1,3] and short-term changes in ambient temperature can play a role in triggering acute events like MI.[4] Climate change has been linked to variability in weather patterns resulting in more frequent and severe extreme temperatures; such extreme temperatures have—and will likely continue to—disproportionately affect socioeconomically disadvantaged communities.[5] Most studies examining effect modification by socioeconomic status (SES) of the temperature-MI association to date have leveraged administrative data. However, SES information like income or educational attainment is rarely recorded in administrative databases.[6] Therefore, few analyses on extreme temperatures, MI, and disadvantaged communities have had access to individual-level socioeconomic information and instead, often use areal (e.g., zip code tabulation area,[7] census tract[8]) assessments of disadvantage. Both individual and community-level SES likely matter for health, and previous research highlighted the utility of payer information that captures the use of need-based insurance or lack of insurance for nearly all admissions; such data could capture individual vulnerability.[6] An understanding of how health insurance status modifies the impact of ambient temperature on

[a]Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, New York, New York; [b]Physicians, Scientists, and Engineers (PSE) for Healthy Energy, Oakland, California; and [c]Department of Environmental and Occupational Health Sciences, University of Washington School of Public Health, Seattle, Washington

N.M.F. and V.D. contributed equally.

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*Corresponding Author. Address: Columbia University Mailman School of Public Health, 722 W 168th St, New York, NY 10032. E-mail: nf2497@cumc.columbia.edu (N.M. Flores).

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What this study adds

Our study adds to literature evaluating disparate impacts of extreme temperatures by leveraging insurance status to approximate individual-level socioeconomic information. Here, we use insurance status, for NYS hospital discharges across 20 years to assess how being uninsured versus insured impacts temperature-related MI rates. We identify that (a) individuals without insurance experienced higher temperature-related MI rates and (b) increased rates for MI, especially among uninsured, begins at temperatures lower than those used by the US National Weather Service to issue extreme heat advisories, warnings, and watches.

MI hospitalization may provide insight into temperature-related health disparities.[9–11]

In the United States, health insurance can both directly shape healthcare access/utilization and correlate with other metrics of SES.[12,13] Those without insurance face barriers to care (e.g., providers only accepting insurance, high out-of-pocket costs) and may be forced to delay or go without necessary medical care (medications, screenings, visits).[14] Delayed care can hide new health problems or worsen existing health conditions.[15,16] The chronic stress of being uninsured can also exacerbate adverse health conditions.[17–19] Having insurance and, by extension, fewer barriers to accessing healthcare has been directly linked to improved health.[20] For instance, analyses of 29 states that expanded Medicaid eligibility by 2016 reported significantly fewer cardiovascular-related deaths, compared with 19 nonexpansion states[21]—highlighting how we may expect differences in cardiovascular morbidity across insurance coverage.

Additionally, health insurance status can serve as a proxy for social and economic determinants of health, as patterns of insurance coverage throughout the United States reflect histories of social and economic injustice.[12,13] The ability to gain and maintain insurance coverage depends on one's income, occupation, age, cultural/linguistic adaptation, and marital status; therefore, in the United States, vulnerable subpopulations (e.g., individuals experiencing homelessness, temporary contractors, undocumented immigrants) are more likely to be uninsured.[22,23] Steep coverage disparities exist across racial/ethnic and socioeconomic groups.[12] Non-Hispanic Black individuals are 2× and Hispanic individuals are 3× as likely to be uninsured compared with non-Hispanic White individuals (14.3%, 24.9%, 7.7%, respectively).[24] Additionally, those in poverty are nearly 2× as likely to be uninsured compared with those living above the federal poverty line (17.2 vs. 8.6%),[25] and similar trends have been observed in New York State (NYS).[26] Therefore, for the purposes of this analysis, we assume that most uninsured NYS residents are socioeconomically vulnerable, although the group may also include a small number of very high SES individuals who choose to be uninsured.

Unlike other metrics for individual-level social vulnerability (e.g., income, race, education attained), insurance status is reliably recorded for all NYS hospital discharges. Here, we used insurance status to understand if the socioeconomic and healthcare disadvantages associated with being uninsured impacts temperature-related MI rates. We hypothesized that uninsured individuals experience greater rate of MI at high and low temperatures compared with insured individuals.

Methods

Study population

We obtained NYS hospital records from the NYS Department of Health Statewide Planning and Research Cooperative System (SPARCS) for dates spanning 1 January 1995, to 31 December 2015, which we have previously described.[4] Briefly, SPARCS is a comprehensive all-payer database covering ~98% of hospitals and diagnostic and treatment centers in NYS. SPARCS collects patient demographic information including residential address, age, sex (male, female, unknown), self-reported race/ethnicity (Black, White, Hispanic, Asian, or other), health insurance type (public, private, self-pay, workers' compensation), and medical information including date/time of admission, diagnoses, and presenting comorbidities.[27] After excluding patients younger than 18 years and patients with incomplete, missing, or incorrectly transcribed residential address ZIP codes (US postal codes), date, or hour of admission, our study population contained 1,095,051 MI hospitalizations. Columbia University Institutional Review Board Approval was obtained, and informed consent was waived.

Case ascertainment

MI cases were identified using the reported *International Classification of Diseases* (ICD) codes in the first four diagnostic positions. Cases before 2015 were determined by the ICD-9 revision code, 410, and in 2015, cases were transitioned to the ICD-10 revision code, I21. Reinfarctions were included unless admissions were within 2 days of a previous MI admission for that patient to avoid readmissions for the same event. We assumed MI events occurred 3 hours before the recorded time of hospital admissions, informed by previous findings that non-ST-elevated MI (non-STEMI) admissions have a median delay of 2.6 hours.[4,28] Patients were also excluded if admitted with "newborn" or "trauma" admission types.

Temperature exposure assessment

We obtained hourly ambient temperature estimates and spatiotemporal covariates from the North American Land Data Assimilation System (NLDAS) Forcing at a spatial resolution of 0.125° grids.[29] Hourly temperatures were aggregated spatially to ZIP code tabulation areas using area-weighted averaging, and we calculated average temperatures (°C) for the exposure windows 6, 12, 24, and 48 hours before events. For our main analysis, we focused on the 6-hour window, as previous studies have identified this as the most critical window in the temperature-MI association.[4] Relative humidity (RH), a potential meteorological confounder in the temperature-MI relationship, was calculated from the NLDAS Forcing's specific humidity, pressure, and temperature for each window. Using each patient's ZIP code of residence, we created window-specific exposure profiles of temperature and RH for the case and control periods. All models adjusted for RH.

Insurance status assessment

We inferred insurance status from payment sources to create two groups—one we expected to have socioeconomic and healthcare advantages and the other to have socioeconomic and healthcare disadvantages. If a patient's only payment source for an admission was self-pay or worker's compensation, then the patient was grouped into the uninsured group. We included workers' compensation claims in this group, because the use of workers' compensation may reflect more hazardous work environments (e.g., stress, working outdoors, performing labor intensive activities) associated with socioeconomic disadvantage. All other subjects had some sort of public (e.g., Medicaid, Medicare) or private (e.g., Aetna, BlueCross BlueShield) insurance coverage and were classified as the insured group.

Study design and statistical analysis

To examine whether insurance status modifies the effect of ambient temperature on MI, we employed a bidirectional case-crossover study design paired with a conditional logistic model and ran stratified analyses by insurance status. In the case-crossover design, exposure during and before case hours (here, hours with an MI event) are compared with exposure during and before control hours (hours without an MI event) for the same individual matched on hour, day of week, month, and year. By design, the case-crossover design controls for time invariant factors (e.g., race, income) and temporal trends.[30] We accounted for the nonlinear relationship between temperature and MI by incorporating natural splines for temperature and relative humidity. The degrees of freedom for each model were chosen based on biologic plausibility and using the Akaike information criterion (AIC), a model selection tool that considers both model fit and complexity[31] across the range of 1–7 degrees of freedom. We selected 3 degrees of freedom to nonlinearly model temperature and 2 degrees of freedom to nonlinearly model relative humidity.

Insurance status-specific rate ratios were estimated comparing the rate of an MI at every 5th percentile temperature spanning the overall temperature distribution to the median temperature (reference), which was 10.6 °C, 10.3 °C, 10.6 °C, and 10.5 °C for the 6-, 12-, 24-, and 48-hour windows, respectively (Appendix Table 2; http://links.lww.com/EE/A229). To assess potential presence of effect modification by insurance status, we ran stratified models. The temperature rate ratios were compared between the insured and uninsured strata via a z-test and by calculating the ratio of relative rates, which uses the strata-specific beta estimates and standard errors, as previously described.[32] All analyses were performed using R statistical software version 4.1.0 (R Project for Statistical Computing, Vienna, Austria). Additionally, we ran a sensitivity analysis categorizing insurance status to be uninsured, publicly insured, and privately insured and another analysis stratifying by age (<65, 65+). Statistical significance was assessed at $\alpha = 0.05$. Code for analysis is available (https://github.com/nina-flores/temperature-insurance).

Results

Study population and ambient temperature conditions

Over the study period, there were 1,095,051 primary MI admissions, of which 966,475 (88.3%) were among insured patients and 128,578 (11.7%) among uninsured (Table 1, Appendix Table 1; http://links.lww.com/EE/A229). Median ambient temperatures in the time periods (6, 12, 24, and 48 hours) before an MI were slightly lower for uninsured patients relative to insured patients. Over half of total MIs occurred in males (55%), and among the uninsured patients, most MIs happened among men (70%). More than half of the cases occurred in individuals above 65 years of age (65%), however, among those uninsured, only 14% of the cases were above 65 years of age. The mean (SD), median (interquartile range [IQR]), 5th and 95th percentile, and minimal and maximal ambient temperatures during the case and control periods for the 6-hour window are available in Table 2, and all other windows are available in Appendix Table 2 (http://links.lww.com/EE/A229).

Table 1.

Characteristics of NYS MI according to insurance status (1995–2015)

Variable	Overall, N = 1,095,051[a]	Insurance status: Any insurance, N = 966,475[a]	Insurance status: No insurance (self-pay or work comp), N = 128,576[a]
ZCTA[b]-level characteristics			
Ambient temperature (°C) 6 hours before MI	10.5 (2.2–18.9)	10.5 (2.2–18.9)	10.4 (2.1–18.8)
Relative humidity (%) 6 hours before MI	0.8 (0.7–0.9)	0.8 (0.7–0.9)	0.8 (0.7–0.9)
Patient-level characteristics			
Sex			
Female	492,379 (45%)	454,138 (47%)	38,241 (30%)
Male	602,640 (55%)	512,312 (53%)	90,328 (70%)
Unknown	32 (<0.1%)	25 (<0.1%)	7 (<0.1%)
Age, years			
<65	388,319 (35%)	278,327 (29%)	109,992 (86%)
≥65	706,732 (65%)	688,148 (71%)	18,584 (14%)

[a]Median (IQR); n (%).
[b]ZCTA indicates zip code tabulation area.

Table 2.

Descriptive statistics of ambient temperatures (°C) in the 6 hours before case and control periods

Period	Mean (SD)	Median (IQR)	5th and 95th percentile	Range
Case	10.4 (10.2)	10.5 (16.7)	–5.8 to 26	–29.9 to 38.0
Control	10.5 (10.2)	10.6 (16.7)	–5.8 to 26	–32.6 to 38.4

Ambient temperature and MI rates

Insured patients

Among insured patients, we observed significant increases in the rate of an MI event at high temperatures beginning at the 90th and 95th percentile ambient temperatures for the 6- and 12-hour windows, respectively (Figure 1). We found that for a 6-hour pre-event average temperature increase from the median (10.6 °C) to the 90th percentile (23.7 °C), the rate of MI increased by 1.1% (0.1%–2.1%) with stronger associations at higher temperatures (95th vs. median: 1.7% [0.5%–3.1%], maximum vs. median: 6.6 [2.8%–10.5%]; Figure 1B). For a 12-hour pre-event average temperature increase from the median (10.3 °C) to the 95th percentile (25.0 °C), the rate of MI increased by 1.3% (0.0%–2.6%) also with stronger associations at higher temperatures (maximum vs. median: 6.0% [2.3%–9.9%]; Figure 1D). Associations at high temperature were not observed for the 24- and 48-hour windows of exposure (Appendix Figure 1; http://links.lww.com/EE/A229). For temperatures below the median for the 6-, 12-, and 24-hour windows, we observed a positive and almost linear association between temperature and rate of MI.

Uninsured patients

For uninsured patients, relative to the reference median temperature, we observed increased rate of MI at temperatures above the median, beginning as early as at the 75th percentile (19.0 °C) for the 6-hour window (Figure 1A). For a 6-hour pre-event average temperature increase from the median to the 75th percentile, the rate of MI increased by 2.0% (0.2%–3.8%) with stronger associations at higher temperatures (maximum vs. median: 11.2% [0.6%–22.9%]; Figure 1A). At lower temperatures, the rates were not considerably different from the reference for the uninsured patients.

Effect modification assessment by insurance status

At higher ambient temperatures (>90th percentile) for the 6-hour window, the rate of MI among uninsured individuals increased more sharply than for insured individuals (Figure 1, A and B). Additionally, we observed, starting at the 65th percentile (26.0 °C), that the association between a temperature increase and MI was greater among uninsured patients than insured patients (Appendix Table 3; http://links.lww.com/EE/A229). In the 12-hour window, we observed among uninsured patients a positive but not statistically significant association between increasing temperature and MI hospitalizations (Figure 1C). For the insured, we found that increasing temperatures were associated with higher rates of MI hospitalizations (Figure 1D). Except for a negative association among insured patients in the narrow temperature band (10.5 °C –22.9 °C) in the 48-hour period (Appendix Figure 1D; http://links.lww.com/EE/A229), we did not detect associations for the 24- and 48-hour periods at higher ambient temperatures (Appendix Figure 2; http://links.lww.com/EE/A229).

At temperatures below the median, the rate ratios between insured and uninsured patients were comparable until the 5th percentile temperatures, where the association of cold-related MI becomes noticeably elevated for uninsured patients relative to insured patients (Figure 2 and Appendix Table 3; http://links.lww.com/EE/A229). Among insured patients, we observed an inverse association at temperatures lower than the median temperature, while null or weak positive associations were observed for uninsured patients across all time windows (Figure 1 and Appendix Figure 1; http://links.lww.com/EE/A229). For lower temperatures, the largest difference in effect estimates between

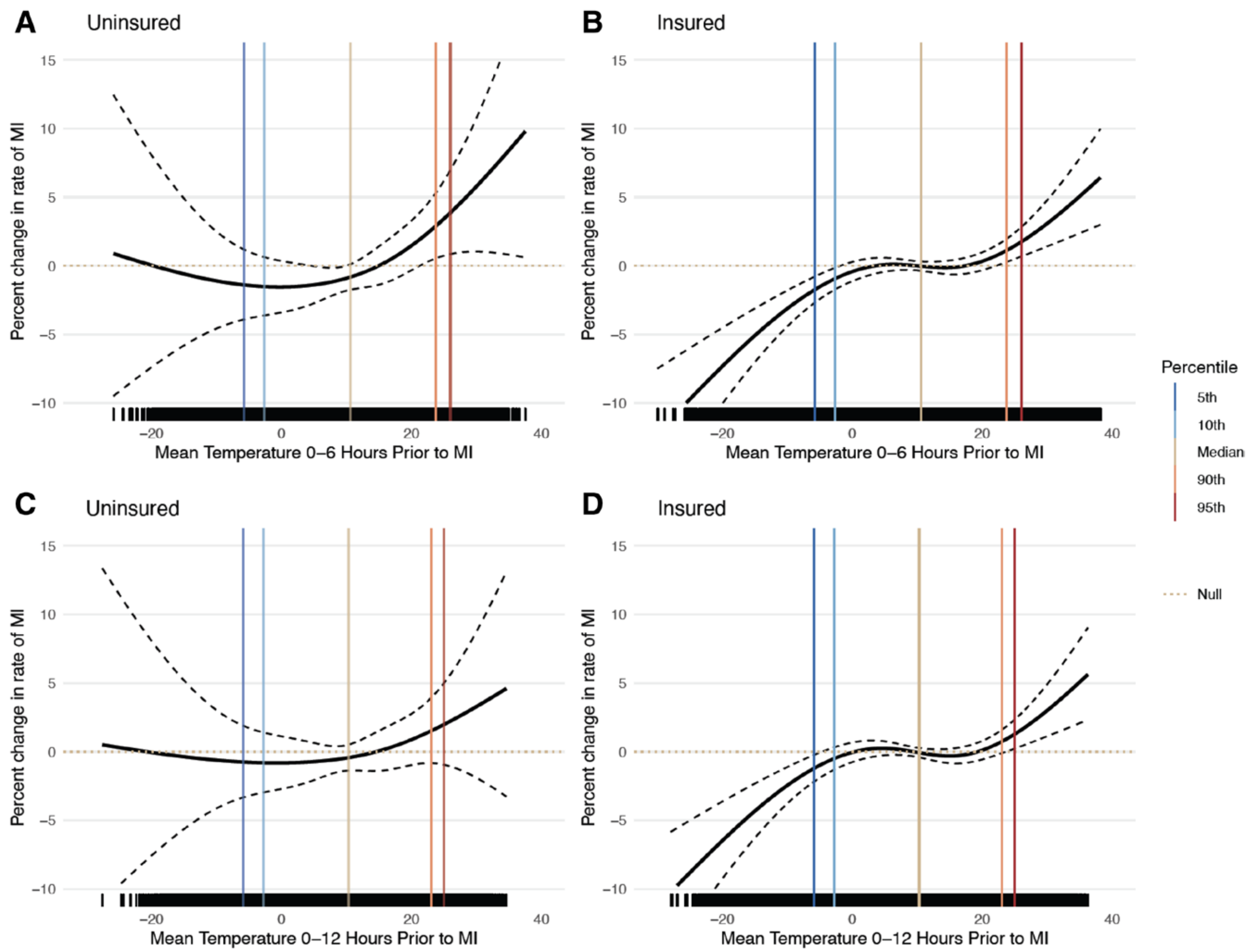

Figure 1. Ambient temperature and MIs by insurance status. The estimated percent change in the rate of MIs by the average mean temperature in the 6 hours before an MI for the uninsured (A) and insured (B) and the estimated percent change by the average mean temperature in the 12 hours before an MI for the uninsured (C) and insured (D). All models adjusted for RH. The null percent change of 0 is highlighted by the tan dotted line on the *x*-axis. The other four vertical lines highlight the 5th, 10th, 50th, 90th, and 95th percentile temperatures.

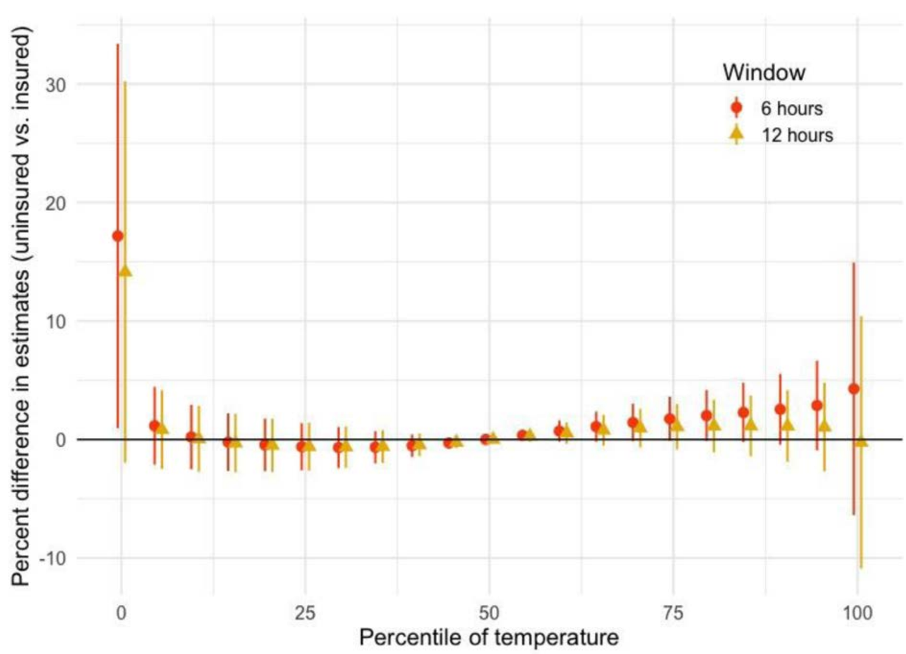

Figure 2. The percent difference in rate ratios and corresponding 95% confidence intervals comparing the uninsured to the insured strata estimates, comparing each percentile to the median (reference) temperature, adjusting for RH. For instance, at the 0th percentile temperature, relative to the median, the rate ratio for the uninsured group is 19% higher than the rate ratio for the insured group across that same temperature decrease for the 6-hour window.

insured and uninsured patients was at the minimal ambient temperature. At the coldest temperature for the 6-hour window (–32.6 °C), the estimate of temperature on MI was greater among uninsured patients than insured patients. This trend was observed in all time windows examined (Figure 2 and Appendix Table 3; http://links.lww.com/EE/A229).

Sensitivity analyses

In our age-stratified sensitivity analysis, we found that age stratification attenuated some of the observed association, in both strata. However, we still found a suggestive association, albeit not statistically significant, that disparities exist across insurance status. Further, disparities between insurance status strata appeared stronger among those over 65 at low temperatures (Appendix Figure 3; http://links.lww.com/EE/A229 and Appendix Table 4; http://links.lww.com/EE/A229). In our sensitivity analyses further investigating the identified relationship by considering (a) uninsured versus privately insured, (b) uninsured versus publicly insured, and (c) publicly versus privately insured comparisons, we found that our main findings comparing the uninsured group to the insured group overall were similar to those comparing the insured group to the privately insured or publicly insured, alone (Appendix Figures 4 and 5; http://links.lww.com/EE/A229). When comparing the publicly and privately insured strata, we found that the publicly insured group had lower rates of MI at lower temperatures, whereas there were no differences between the two groups at higher temperatures. Finally, in a sensitivity analysis among those younger than 65, the results from the uninsured versus publicly insured, and publicly insured versus privately insured comparisons were in similar directions as in the results for all ages (Appendix Figures 6 and 7; http://links.lww.com/EE/A229). However, among those younger than 65, we found no difference in MI rates among those uninsured and privately insured, as the difference in this comparison was attenuated.

Discussion

In this study, we examined the potential role of insurance status on the short-term temperature—MI hospitalization association, considering exposure windows that prior research identifies as particularly important.[4] Most MI admissions in NYS during our study period occurred among those with insurance (i.e., public or private insurance coverage), while ~12% were uninsured (i.e., self-pay or workers' compensation). We found that the rate of MI was generally higher among uninsured patients relative to insured patients at high (>90th percentile) and low (<5th percentile) ambient temperatures, which may highlight how structural and individual factors interplay with climate-driven risks.

Increases and decreases in temperature prompt biologic responses that can affect cardiovascular disease risk, but SES factors can modify the extent to which ambient temperature impacts cardiovascular health. High ambient temperatures can (a) increase cardiac demand as the body attempts to decrease internal temperature and (b) reduce sleep quality, both of which have independently been associated with poor cardiovascular health.[33,34] Additional biologic pathways linking hot temperatures to adverse health are through changed high density lipid/low density lipid levels and activation of the autonomic nervous system.[35] Cold temperatures can worsen cardiovascular health by increasing blood pressure and triggering inflammation.[36,37] However, the distinct variability reported in temperature-related morbidity/mortality across race/ethnicity and socioeconomic groups in previous studies—and insurance status, in the present study—is not rooted in difference in biology; instead, these differences reflect differential health access and adaptive capacities among certain communities and individuals, which may come with aspects of biologic relevance (e.g., psychosocial stress, exposure levels, baseline health statuses).

To understand temperature-related MI rates among socioeconomically disadvantaged individuals with administrative data, we used payer information to determine insurance status. A growing literature has highlighted the utility of using payer information as an imperfect proxy for individual-level socioeconomic information, which is not captured in most administrative databases. Many studies have considered area-level (e.g., ZIP code tabulation area,[7] census tract[8]) assessments of disadvantage, but these may be in disagreement with a patient's individual reality[38]; therefore, we need both area-level and individual-level studies to more fully understand the health impacts of extreme temperatures. Since eligibility for medical assistance programs like Medicaid is often determined by state or federal poverty definitions, some studies have used payment through medical assistance programs as a proxy for individual socioeconomic disadvantage.[6,9,39,40] As certain vulnerable individuals may struggle to obtain/maintain either public or private insurance, some studies have used uninsured status as an imperfect proxy for individual socioeconomic disadvantage, highlighting disparities in respiratory and cancer outcomes among those without insurance.[9–11,41,42] Specifically, individuals experiencing economic and social disadvantage without insurance may be even more disadvantaged compared with those with insurance, including public insurance such as Medicaid as they likely lack the resources and time to overcome the administrative burdens required to enter and stay covered under these federal programs.[43,44] When comparing the publicly versus privately insured strata, we found no differences between the two groups at higher temperatures, whereas, when comparing the uninsured strata to those insured (either publicly or privately), we found evidence of higher rates among the uninsured; this suggests that there is a unique burden among uninsured individuals, perhaps even outside being low-income. However, when viewing this association among those younger than 65 years of age, we found no difference between the insured and uninsured individuals, suggesting that the increased rates of MI among the uninsured may be driven by individuals over 65.

Extreme temperatures have been linked to mortality, cardiovascular, and MI risks through nonlinear relations (J, U, or V shaped) where the risk of an event is higher at both high and low extremes.[1] Our study found evidence for health disparities by insurance status at both temperature extremes. For subdaily windows and in particular the 6-hour window, an increase in temperature was associated with higher rate of an MI event overall, with suggestive evidence of a stronger effect among uninsured patients. As insurance status can reflect socioeconomic resources (e.g., having an occupation that pays for health insurance) and social disadvantage, our findings align with literature finding that, across the United States, extreme temperatures—particularly extreme heat—disproportionately affect historically marginalized communities and those with socioeconomic disadvantage. In analyses of Medicare participants residing in 135 US cities from 1985 to 2006, individual (non-White, female, preexisting medical conditions) and ZIP-code level (low % of greenspace, higher % poverty, higher % non-White) indicators of disadvantage were associated with elevated risk of heat-related mortality.[7] Similarly, a study of heat-related mortality across 50 US cities from 1989 to 2000 found that Black individuals, females, and individuals without a college degree experienced higher risk of extreme temperature-related cardiovascular-related mortality.[45] The results of these large-scale, multicity studies agree with the findings of a range of single city heat risk analyses in the United States.[45–47]

Additionally, we found that at the coldest temperatures, MI rates were also higher among the uninsured group compared with their insured counterparts. Less literature explores how socioeconomic disadvantage may modify the health effects of cold exposure compared with heat. A study of seven US cities from 1986 to 1993 found that death rates were higher among

Black individuals than White individuals and higher among individuals with high school education or less compared with those with post-high school education during cold and hot temperatures.[48] However, another study of 50 US cities from 1989 to 2000 found that individual factors such as sex, race, education, and presenting comorbidities modified the effect of extreme heat, but not of extreme cold, on mortality.[45] Differences in findings may be due to the use of different exposure windows or measures across studies. Previous studies have observed delayed (>48 hours) health responses to lower temperatures. In overall analyses using the same dataset as our present study,[4] a protective association was found between short-term temperature decreases (≤48-hour windows) and MI, but a harmful association was supported for ultra-short temperature decreases (~1-hour exposure) using the daily minimal rather than the daily mean temperature and the same design. Our analyses showed different trends among the uninsured and insured, suggesting that uninsured individuals experienced worse health outcomes from both short- (>48 hours) and very short-term (<48 hours) cold exposures compared with insured individuals.

The differences we observed in temperature-related MI rates between insurance status strata may be due to different healthcare access, baseline health statuses, stress levels, other harmful coexposures, and adaptive capacities among certain communities and individuals. Stress related to being uninsured in the United States can lead to adverse health outcomes. Psychological stress is a known risk factor for MI.[49] Biological, emotional, or psychological stress can increase inflammation and activate the sympathetic nervous system thereby increasing heart rate, blood pressure, and myocardial oxygen demand.[49,50] An analysis of 2001–2010 National Health Interview Survey data found that those without insurance and those with public insurance had higher average scores on the K6 scale—a metric used to determine psychological distress.[18] Similarly, a survey among 3,440 US adults found that those without insurance reported significantly higher average stress levels compared with their insured counterparts.[51] Furthermore, changes in insurance status can also be stressful for individuals, as insurance status is often linked to employment, income, and marital status.[22] As such, a change to insurance status may reflect stressful events like job loss, divorce, or spousal death.[22] US data suggests that a change in health insurance status within the past year was related to higher levels of psychological distress.[18] Therefore, being uninsured or underinsured may be a source of stress for individuals, contributing to adverse health conditions like MI.

Insurance status may also reflect other environmental conditions that can modify the relationship between temperature and MI hospitalizations. As uninsured populations are more likely to be non-White and low-income,[22] those without insurance may also be more likely to live in neighborhoods and buildings more vulnerable to climate-driven events such as extreme heat. As a result of redlining, segregation, and gentrification, historically marginalized communities often face poorer housing quality, which may contribute to a hotter indoor environment, even at the same ambient temperature of other groups.[52,53] Beyond residential exposures, insurance status may also proxy for different occupational exposures among insured and uninsured groups. The highest rates of uninsured workers are in agriculture, construction, service, and building maintenance occupations,[54] occupations with potentially hazardous environments. This could disproportionately expose uninsured individuals to heightened emotional or physiological stressors.

Uninsured individuals, due to lower SES, may have a lesser ability to mitigate the health effects of temperature. In the face of extreme temperatures, temperature controlling devices (e.g., air conditioners) can be essential in reducing temperature effects on health. However, these options may be costly, and therefore unavailable to some.[55] For example, New York City residents of public housing are disproportionately impacted by heat exposures but also have limited resources to reduce exposure[55]; over 50% of the residents are located in neighborhoods with the highest heat risks,[56] but less than 50% have air conditioners in their homes.[57] Studies have shown increased rates of heat-related deaths in areas with reduced air conditioner prevalence and that air conditioner prevalence is lower among Black households compared with White households.[58,59] Furthermore, despite NYC laws requiring temperatures of at least 62°F in the cold season, an analysis of heat and hot water complaints from 2019 to 2022 found that the most complaints were in communities more heavily populated by low-income individuals and individuals of color.[60]

Prior studies have linked insurance status and coverage to improved health outcomes, and our study findings suggest a similar pattern that insured individuals have lower temperature-related risk of MI compared with uninsured individuals. Such findings are important as accessibility of insurance in the United States is amenable to policy intervention. For instance, the Affordable Care Act (ACA), a federal program that expanded Medicare and Medicaid, increased insurance rates among low-income adults[61] and non-White individuals.[62] Importantly, by increasing access to preventive and primary care (e.g., prescriptions), cardiovascular patients experienced decreased mortality rates.[21,63] These findings demonstrate the critical role that reliable healthcare coverage plays for individuals in managing their health status, particularly patients with cardiovascular conditions. Interestingly, we found that, overall, uninsured individuals were more vulnerable than both privately and publicly insured individuals. In sensitivity analyses, we also found in a comparison of those uninsured younger than 65 versus publicly insured younger than 65 (a group, we expect to be socioeconomically vulnerable) that the insured group had higher rates of MI—which may reflect the importance of access to health services.[64] Taken together, our study builds upon a breadth of literature highlighting the disproportionate burden of climate change borne by socioeconomically disadvantaged individuals. Meaningfully reducing climate-driven risks would require a multifaceted approach including increasing healthcare access, baseline health, and adaptive capacities of communities.

Our analysis had limitations. First, for purposes of this analysis, we assume that most uninsured NYS residents are socioeconomically vulnerable, but it is likely individuals with very high income may also choose to not be insured. However, high-income individuals likely comprise a small proportion of uninsured individuals. In 2020, nationally, 17% of those uninsured had incomes below the federal poverty line whereas only 3% of those uninsured had incomes in the highest income group.[25] As the uninsured group in this study includes both low- and high-SES uninsured individuals, our results may be attenuated. Second, we did not have information on age beyond whether a person was above/below 65 years of age, and thus could not investigate how this effect modification varies across age groups beyond these classifications. The above/below 65 breakdown, however, did provide some important nuance to our findings. For example, among those younger than 65, we did not find a difference in MI rates among those privately insured and uninsured. This may be because younger than 65 is a heterogeneous age group that largely includes younger adults who are less likely to experience MIs; whereas older adults may generally be more biologically susceptible to adverse heat-related illnesses and -related conditions like MIs[65]—possibly making the effect more observable. Third, there was potential misclassification of MI based on ICD-codes and based on assumptions related to the timing of event, previously outlined.[4] Fourth, we are unable to consider reinfarctions due to data limitations. Prior studies using the same SPARCS data for similar years reported that only 6% of cases were classified as reinfarctions, and their sensitivity analyses excluding reinfarctions did not affect results.[4] Given the low reinfarction prevalence and previous investigations in other studies, we do not anticipate that including reinfarctions will impact our findings and conclusions. Finally, our results may not be generalizable to places with climates or sociodemographic profiles different than NYS.

Conclusions

Our study used statewide patient-level data and found that insurance status modifies the effect of temperature on rates for MI at both temperature extremes. By examining insurance status, we add to the growing body of literature that focuses on social factors that shape the impact of temperature on cardiovascular outcomes. We found that during extremely cold temperatures insured patients experienced lower rates of MI, not shared by the uninsured counterparts. We also observed increased hospitalization rates at warmer temperatures among the uninsured versus insured population. Of note, we found that, regardless of age, increased rates of MI, especially among uninsured, begins at temperatures lower than those used by the National Weather Services to issue advisories, warnings, and watches. This is alarming in the context of climate change, which is projected to continue increasing the number of extremely hot days per year and adversely affects disadvantaged communities relative to others.[5] Efforts to inform the public about temperature-related adverse health outcomes should account for the differential effects by insurance status (and more broadly, SES). Additionally, as insurance status is clearly linked to policy, expanding insurance access could minimize the impact of extreme temperatures on MI hospitalizations among vulnerable individuals.

Conflicts of interest statement

The authors declare that they have no conflicts of interest with regard to the content of this report.

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All code used for the analyses is available on the corresponding author's GitHub (https://github.com/nina-flores/temperature-insurance). The meteorological data used in the analyses are publicly available (https://ldas.gsfc.nasa.gov/nldas/v2/forcing). Health data from analyses may be available following institutional review board approval.

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