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Climate Change and Heat-Related Morbidity in New Mexico in 2030

Brian Woods, BAS, Tony Fristachi, MS, Stephanie Moraga-McHaley, MS, Garry Kelley, MS
Epidemiology and Response Division
New Mexico Department of Health

Global climate model projections suggest that the annual maximum temperatures in New Mexico (NM) are expected to increase at a rate of 0.048 degrees Fahrenheit (°F) per year (95% CI: 0.019°F, 0.080°F), among other climatological changes.[1] However, from 1970 to 2015 it is estimated that New Mexico's average annual maximum temperature has increased 3.3° F, making it the second-fastest-warming state in the nation at a rate of 0.066°F per year.[2]

Further, the last decade was the warmest on record, with increases in both extremely hot days and warm nights.[3] The National Oceanic and Atmospheric Administration (NOAA) reports that the percentage of days in which temperatures in the American Southwest exceeded the upper and/or lower tenth percentile for average temperatures have increased from 20.7% from 2001-2005 during the months of April through September to 42.4% from 2014-2018 during the same months.[4] The number of warm nights where the minimum temperature exceeded 70°F doubled from an 1990-1994 average of 4 days annually to 8 days annually in 2010-2014.

Recent studies have shown that individuals are at an increased risk for heat-related illnesses (HRI) when there are consecutive days that exceed 90°F.[5] HRI are a set of preventable health conditions ranging from mild (e.g. heat exhaustion, heat edema, heat cramps) to potentially lethal heat stroke that occurs when the core body temperature rises to 104°F as its thermoregulation mechanisms fail.[9] Between 1979 and 2011, New Mexico has experienced, on average annually, 93 days where the daily maximum temperature exceeded 90°F, though not all of these were consecutive days.[6] NOAA forecasts that the number of these severe hot days will increase at a rate of 1 day per year.[7] New Mexico can therefore expect 111 days to exceed 90°F by 2030; 121 days by 2040; and 131 days by 2050.

As temperatures increase globally, daily temperatures and extreme heat events become more frequent, longer, and severe. Consequently, experts foresee more HRI and deaths.[8] This report estimates a doubling of HRI morbidity based on forecasted temperatures and historical HRI trends in New Mexico.

Methods

An HRI morbidity case is defined as any emergency department visit (ED) or inpatient hospitalization (H) with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes of 992.0-992.9, E900.0, or E900.9 and/or International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes of T67.0-T67.9; X30.0 or X32.0. These codes were identified and validated based on previous analyses. Any cases with coding for heat exposures from man-made origin (ICD-9-CM code of E900.1 or ICD-10-CM of W92.0), out-of-state ED and hospitalization records, and ED records indicating discharge as inpatient to the hospital (n=18) were excluded from the analysis. Morbidity data were provided by the Community and Health Systems Epidemiology Bureau, Epidemiology and Response Division, New Mexico Department of Health.

Admission date for the HRI case was used to identify the closest NOAA meteorological station's daily maximum ambient temperature[10] in the following order: 1) resident municipality/local, 2) small area designation, and 3) county. A resident's address was used as a proxy for where the HRI actually happened, as this type of coding is very incomplete in ED and hospitalization records. Once temperatures were assigned, heat case data were stratified by daily maximum temperatures (rounded to the whole integer), sex, age groups (0-14, 15-44, 45-64 and 65 years and older) and year (2012-2015). The HRI morbidity model used is of the general linear form:

$$HRI_{(0,1)} = \beta_0 + \beta_1 Temperature + \beta_2 Sex + \beta_3 Age + \beta_4 Time + \varepsilon$$

To estimate the number of cases due to projected increases in temperatures, variation in demographic structure (e.g. population estimates, age strata) were not incorporated into the projection as the model complexity is beyond the scope of this analysis. Initial inspection also indicated a non-linear relationship and thus a log transformation was applied. A backward-stepwise regression model of the log transform of HRI case counts by maximum daily temperatures and covariates year, ages, sex and all two-way interactions were developed and utilized to predict future increases in HRI case counts.

Results

We identified 1,335 HRI morbidity cases during 2012-2015 (see Figure 1) after excluding 111 (8%) non-residents. These cases included 1,219 ED visits (91%), after excluding ED visits that resulted in hospital admissions (18), plus 116 hospitalizations (9%). Prior to matching with NOAA data for missing city and county information there were numerous cases that did not match with temperature data and appeared to have place of occurrence codes consistent with possible homelessness; derelict houses for example. On close inspection of original ED records, 6 had address as homeless, and after including NOAA data, one did not match up with temperature data because there was no reported temperature that day for the city listed. That one case was assigned to the city of the hospital reporting the HRI case.

Heat Exhaustion NOS (not otherwise specified) accounted for the majority of cases (63% overall) and 65% of ED visits and 43% of hospitalizations. Heatstroke, one of the most serious forms of HRI, accounted for 9% of ED visits and 36% of hospitalizations. Results from the analysis of the regression model showed a significant association between HRI and ambient temperature increase with a disproportionate risk for those individuals 15 to 44 years old (R-squared= 0.81, see Table 1 and Figure 2). Analysis indicated that between 2012 and 2015 there was a non-significant decrease in temperatures, sex was not a significant predictor of HRI, and other age groups did not have an association.

Discussion

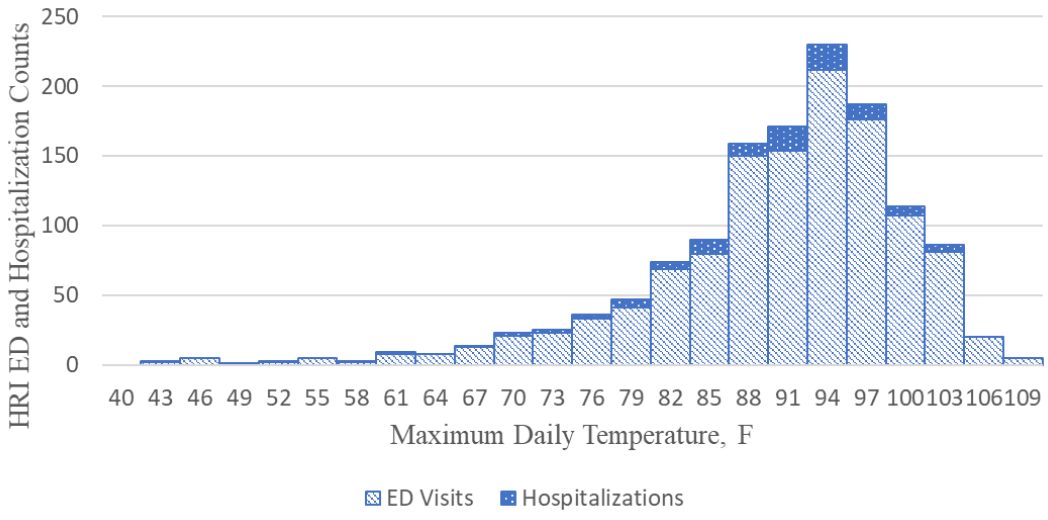
By 2100, New Mexico's average annual temperatures are expected to increase anywhere from 3.5°F to 12°F according to the NOAA Global climate model projections.[11] New Mexico's mean annual temperatures currently range from 64°F in the southeast to 40°F in the high mountains and valleys of the north.

Given the model-projected average annual increase in daily temperatures of 0.048°F per year (95% CI: 0.019°F, 0.080°F) for New Mexico[12] between 2015 and 2030, we would expect an increase of 0.72 °F.

By increasing the temperature and holding all other model parameters constant, we can expect an additional 335 (95% CI: 316.3, 455.5) HRI emergency room visits and/or hospitalization morbidity cases for treatment, slightly more than twice the baseline.

Between 2012 and 2015, there were an average 300 ED visits and 28 hospitalizations for HRI per year, (total=328 HRI). Based on the model, we would therefore expect a total HRI caseload of 663 HRI ED visits and hospitalizations, (an additional 335 ED visits plus 29 hospitalizations), by 2030. This projected increase is 101% over the average number of cases from 2012-2015.

Figure 1. New Mexico HRI ED Visits and Hospitalizations by Maximum Daily Temperatures, 2012-2015



Conclusions

Global and local climate projections forecast continued increases of maximum and average annual ambient temperatures in New Mexico over time. Based solely on this current projected temperature increase, New Mexico can expect a significant excess in the number of residents with HRI seeking medical treatment. There may be as many as 22 additional cas-

es per year, or 335 additional HRI in the 15 years, on average. The young working ages (15-44 years old) are likely to be the most impacted. However, if climate change is accelerating at a non-linear rate, the increases in HRI estimates could be higher.

Non-residents who are not acclimated to our temperatures or altitudes, while not included in this analysis, may be even more impacted by the variation in climate conditions in New Mexico and therefore should be especially informed through HRI preventive messaging. Likewise, homeless persons who were excluded from the analysis, may be disproportionately impacted due to increased vulnerability to climate effects.

Recommendations

HRI is one of numerous adverse health outcomes associated with climate change. However, in New Mexico, HRI and temperature analysis can be used to help determine how the state must develop adaptation strategies. NMDOH ERD must provide this type of data to assist in building resilience against climate effects in New Mexico.

Governor Michelle Lujan-Grisham signed an executive order in 2019 to address climate change and energy waste prevention. Among other requirements, the order directs state agencies to "integrate climate change mitigation and adaptation practices into their programs and operations." The Department of Health is developing a climate adaptation plan that identifies ways that the health impacts of climate change can be reduced, especially among the state's vulnerable residents. DOH has already developed risk messaging for climate change emergent events, such as heat waves, and is developing strategies to prepare and inform the public on best practices to prevent HRI. DOH and others will broaden this work to engage local emergency managers to coordinate response preparation, increasing residents' ability to weather extreme heat events safely.

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Table 1. HRI and Ambient Daily Maximum Temperature Regression Model:
HRI = Logit $^{-1}$ [Temperature (^{o}F) + Age (15 - 44) + Year + $\mathcal{E}$]

Variable	Coefficient	Standard Error	p-Value	95% CI
Temperature (^{o}F)	0.0163	0.00148	<0.0001	(0.013387, 0.019182)
15-44 years old	0.2397	0.03769	<0.0001	(0.165245, 0.313292)
Year	-0.0003	0.00007	<0.0001	(0.000430, 0.000167)

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Michael G. Landen, M.D., M.P.H.
State Epidemiologist & Editor

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Figure 2. New Mexico HRI ED Visits and Hospitalizations by Age Group, 2012-2015