# Recent Trends in Heat-Related Mortality in the United States: An Update through 2018

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**Abstract**

In recent decades, there is a broad consensus in the literature that heat-related mortality overall has declined relative to the magnitude of the heat event. This said, as society is aging and the climate is warming, it is uncertain that this trajectory can be sustained moving forward, particularly as historically rare events become more common. To explore more recent trends, using a recently extended data set, we explored trends in anomalous mortality associated with extreme heat event days for the period 1975-2018 across the largest 107 metropolitan areas of the United States. We defined heat using an excess heat factor, and once events were identified, used a distributed-lag nonlinear model (DLNM) to assess mortality response over a cumulative 10-day period. In addition to total mortality, we also assessed subsets of those 65+ and 45-64, each of which were subdivided by sex. Results indicate that, overall, heat-related mortality associated with any given heat event day is decreasing. The most substantive decreases in mortality are those 65 and older, which may be associated with greater awareness as well as that population being the target of most intervention systems. Indeed, in many locations heat-related mortality among women 65 and older is no longer statistically significant. In contrast, while overall rates are lower, such trends are not seen in those aged 45-64. In particular, there is an increase in mortality among men 45–64 of 11.3 deaths per year across the US, most concentrated in southern and southwestern US cities. Overall, however, the general decreases in heat related mortality are being offset somewhat by the increase in heat event days, particularly since 2010. Given the impacts of the heat events since 2018 over the US West in particular, it is clear that heat-related mortality is not something confined to the past.

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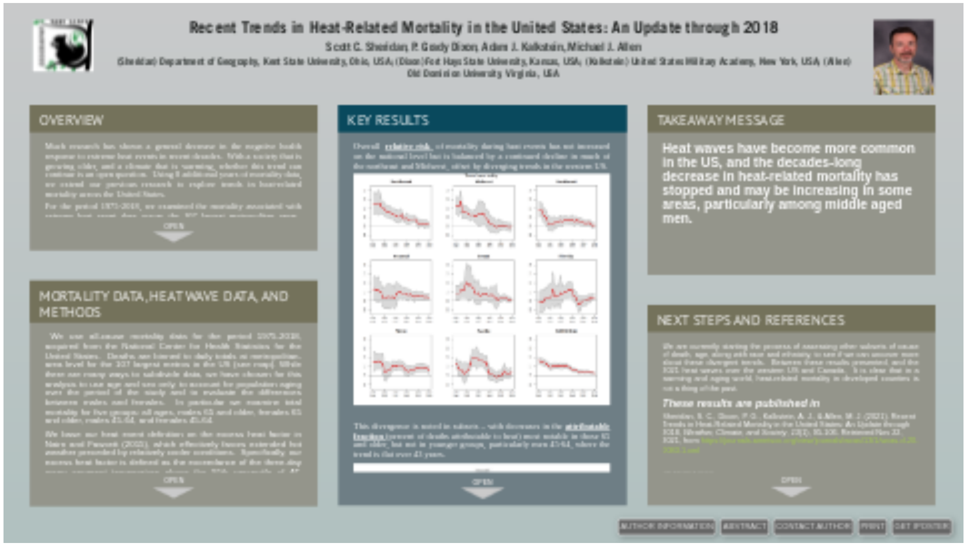


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**PRESENTED AT:**

# OVERVIEW

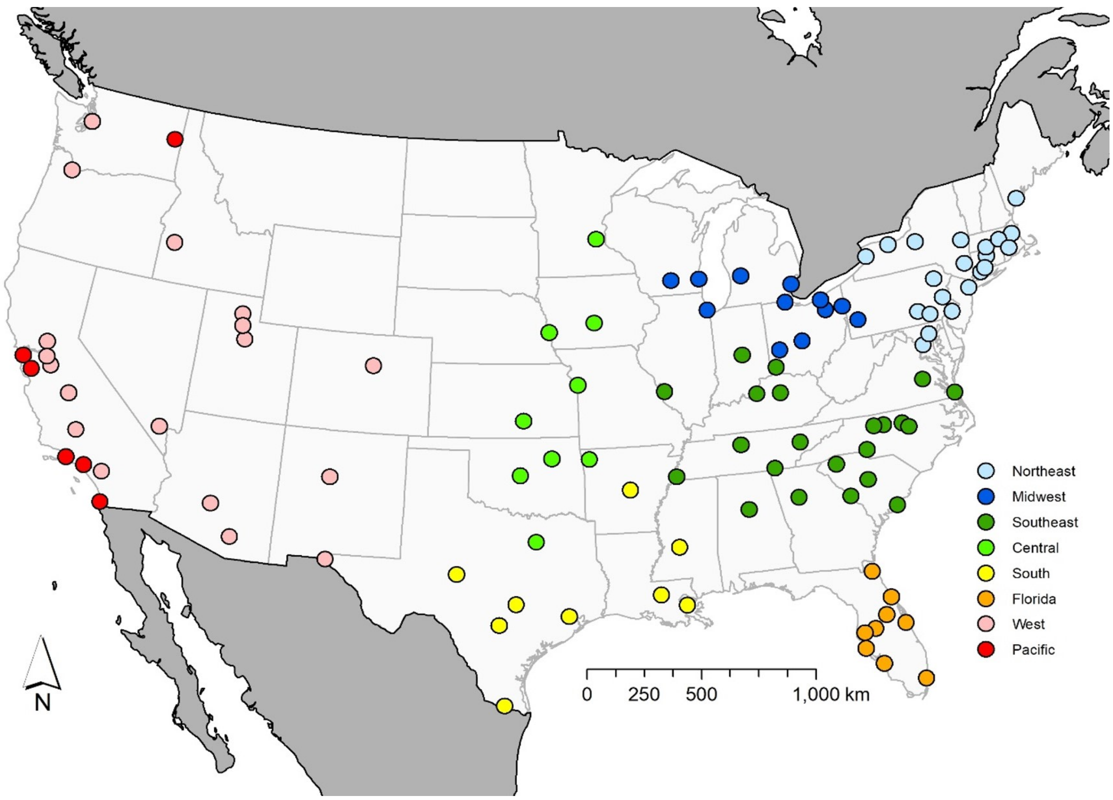
Much research has shown a general decrease in the negative health response to extreme heat events in recent decades. With a society that is growing older, and a climate that is warming, whether this trend can continue is an open question. Using 8 additional years of mortality data, we extend our previous research to explore trends in heat-related mortality across the United States.

For the period 1975-2018, we examined the mortality associated with extreme heat event days across the 107 largest metropolitan areas. Mortality response was assessed over a cumulative 10-day lag period following events that were defined using thresholds of the Excess Heat Factor, using a distributed-lag non-linear model. We analyzed total mortality and subsets of age and sex.

## MORTALITY DATA, HEAT WAVE DATA, AND METHODS

We use all-cause mortality data for the period 1975-2018, acquired from the National Center for Health Statistics for the United States. Deaths are binned to daily totals at metropolitan-area level for the 107 largest metros in the US (see map). While there are many ways to subdivide data, we have chosen for this analysis to use age and sex only, to account for population aging over the period of the study and to evaluate the differences between males and females. In particular we examine total mortality for five groups: all ages, males 65 and older, females 65 and older, males 45-64, and females 45-64.

We base our heat event definition on the excess heat factor in Nairn and Fawcett (2015), which effectively favors extended hot weather preceded by relatively cooler conditions. Specifically, our excess heat factor is defined as the exceedance of the three-day mean apparent temperature above the 95th percentile of AT, multiplied by the difference between the three-day mean AT and the mean of the 30 days prior. A day is defined as an extreme heat event (EHE) day if the EHF exceeds the 85th percentile of all positive EHF values for a location over the climatological period. Across the cities studied here, the 95th percentile of daily mean AT ranges from 16.8 °C in San Francisco to 36.2 °C in Phoenix.




We first calculated relative risks of mortality on EHE days for:

- Each of the 107 metropolitan areas;
- Mortality totals: all age, males over 65, females over 65, males 45-64, and females 45-64; and
- Each of 36 rolling 9-year periods (1975-1983, 1976-1984 … 2010-2018).

The exposure-response association was modelled through a binary indicator of EHE or non-EHE on each day. The lag-response effects of heat were modeled to fit a natural cubic B-spline with

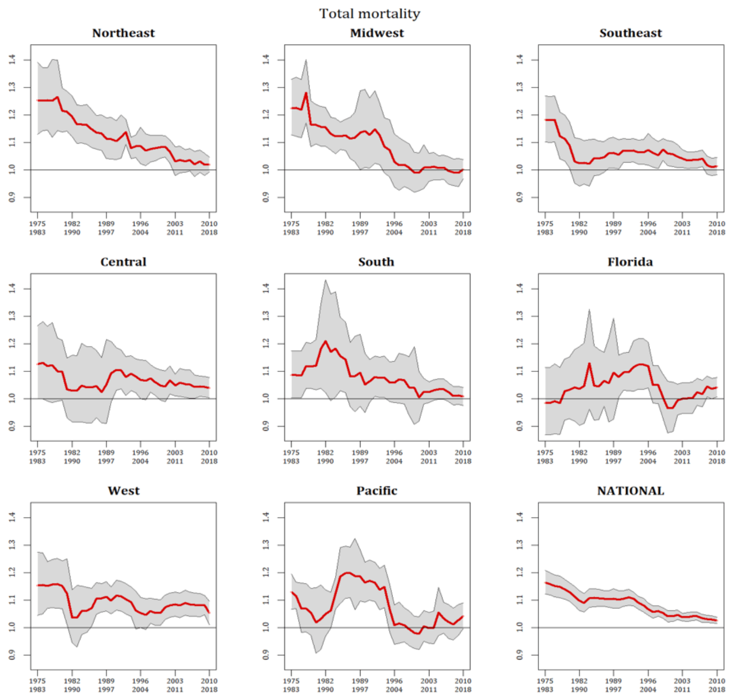
4 degrees of freedom over a 10-day lagged period following exposure (Gasparrini et al., 2010). The specific quasi-Poisson regression model used here is:

Log (mortality) = intercept + EHE + ns (time),

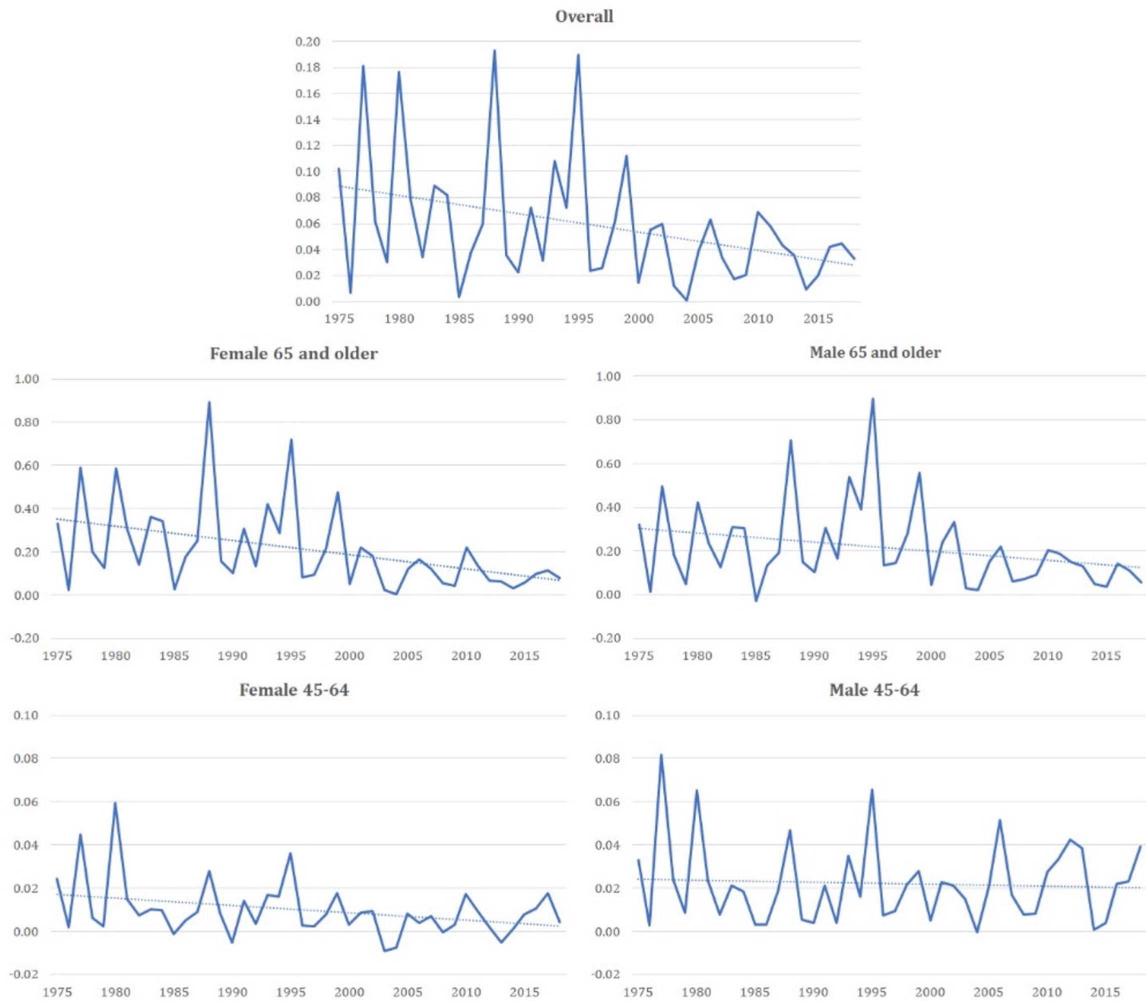
where mortality is the daily mortality total, ns (time) is a natural spline fit to the period with 9 df/year, and EHE, which is 1 during heat waves and 0 otherwise. Relative risks were calculated to assess the relative change in mortality on EHE days versus non-EHE days. To improve the robustness of the analyses, we then clustered the metropolitan areas into one of eight regions. We then calculated pooled relative risks at the regional level via meta-analysis, using a random-effects model fitted through restricted maximum likelihood.

# KEY RESULTS

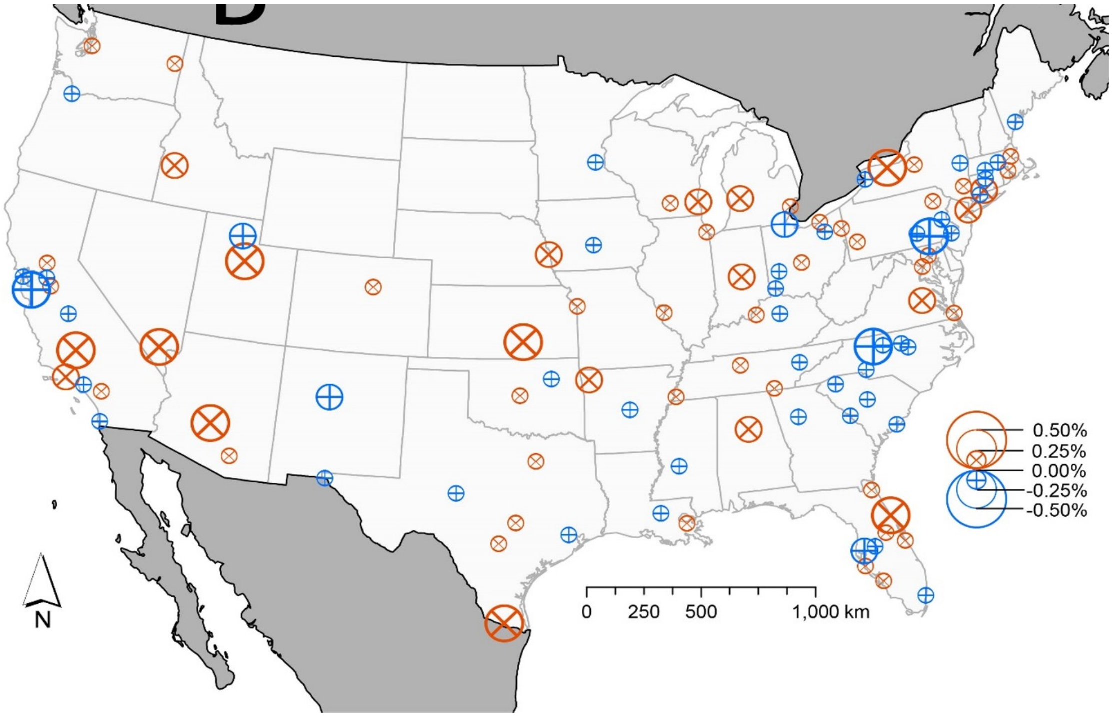
Overall **relative risk** of mortality during heat events has not increased on the national level but is balanced by a continued decline in much of the northeast and Midwest, offset by diverging trends in the western US.



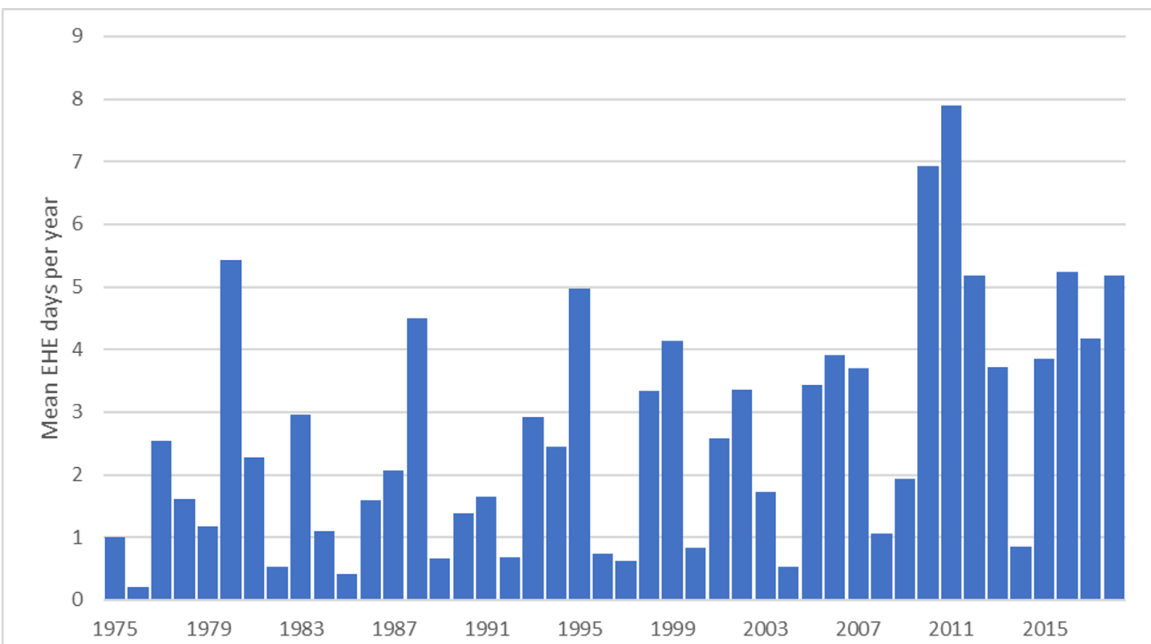

This divergence is noted in subsets – with decreases in the **attributable fraction** (percent of deaths attributable to heat) most notable in those 65 and older, but not in younger groups, particularly men 45-64, where the trend is flat over 43 years.




The **attributable fraction for men 45-64** since 2010 is at its peak in many metropolitan areas, particularly many across the inland western regions.




The **mean number of EHE days** per metropolitan area has increased over the period of study, and the 2010s are notable for a much greater mean number of events than all previous decades studied.




As a result, while **mean estimated annual overall mortality from heat** in the 2010s has not changed much from the previous decade, it reflects a continued decrease in those 65 and older, and an increase in those 45-64, particularly men.

| | All Ages | F 45-64 | M 45-64 | F 65+ | M 65+ |
|---|---|---|---|---|---|
| 1975-1980 | 1143 | 91 | 144 | 567 | 265 |
| 1981-1990 | 849 | 37 | 74 | 453 | 225 |
| 1991-2000 | 1042 | 58 | 123 | 426 | 336 |
| 2001-2010 | 571 | 21 | 118 | 206 | 165 |
| 2011-2018 | 606 | 35 | 168 | 165 | 144 |

## TAKEAWAY MESSAGE

**Heat waves have become more common in the US, and the decades-long decrease in heat-related mortality has stopped and may be increasing in some areas, particularly among middle aged men.**

# NEXT STEPS AND REFERENCES

We are currently starting the process of assessing other subsets of cause of death, age, along with race and ethnicity, to see if we can uncover more about these divergent trends.  Between these results presented, and the 2021 heat waves over the western US and Canada,  It is clear that in a warming and aging world, heat-related mortality in developed counties is not a thing of the past.

## ***These results are published in***

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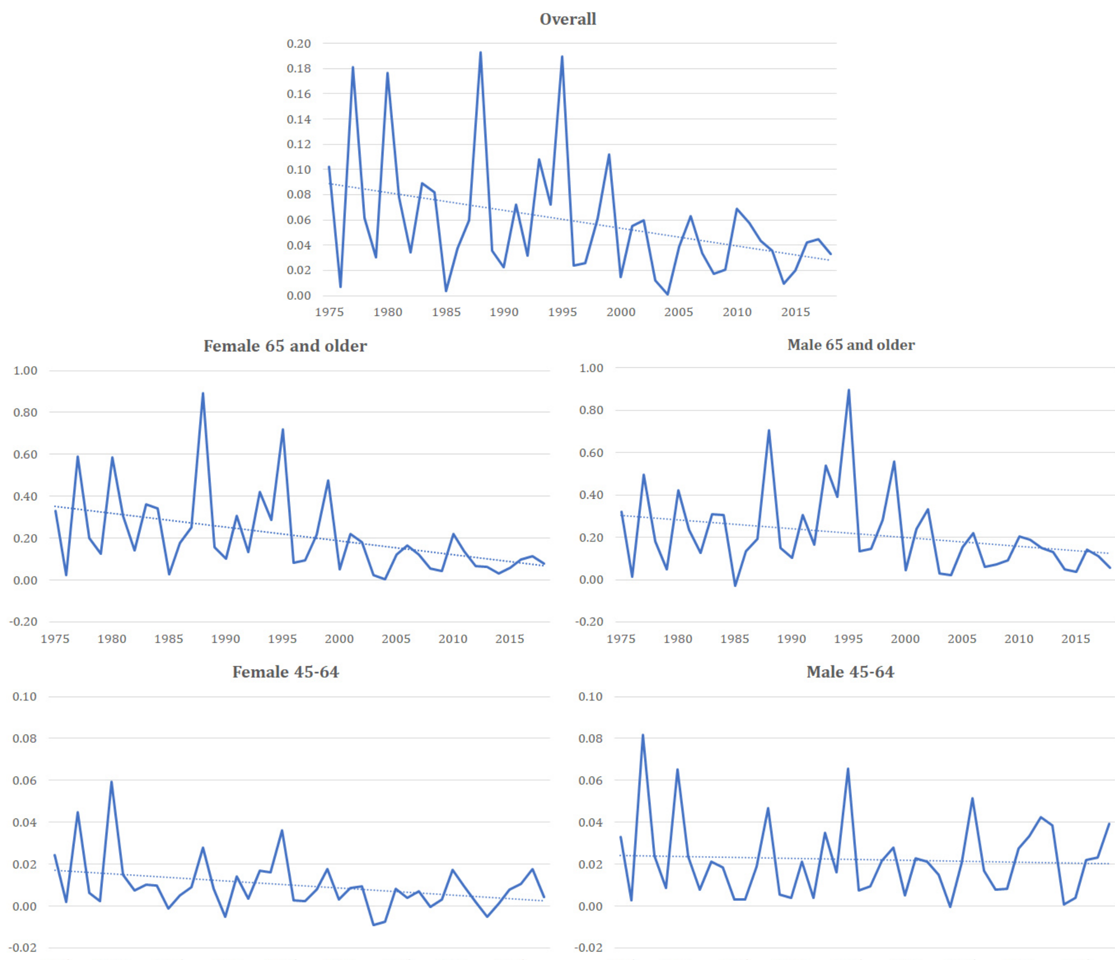


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