Investigating excess mortality among older U.S. adults during and after the anomalously severe 1980 heat wave

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ABSTRACT

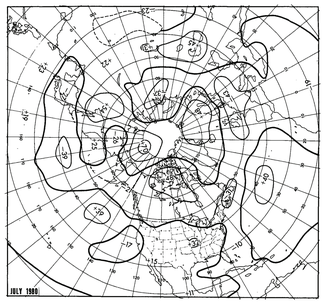
AN ABNORMALLY PROTRACTED HEAT WAVE in the summer of 1980 was responsible for thousands of deaths in the United States. As an analog to future extreme heat events, this incident may offer insight into short-term variations in mortality in the face of an intensifying environmental hazard. However, we know little about how this heat wave affected mortality apart from a few geographically localized studies. This research applies exploratory data analyses on two sources of national mortality data to estimate the number of excess deaths in 1980 among older men aged 65 to 79 and evaluate the heat wave's role in generating them. Intriguingly, results suggest that while 1980 saw higher than usual mortality, most of it appears due to conditions at the end of the year (e.g., cold weather, flu) rather than the heat wave.

RESEARCH QUESTION

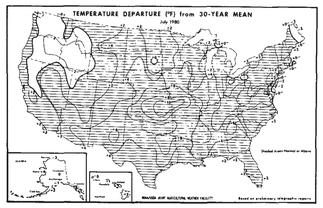
Between June and September of 1980, large parts of the continental United States experienced a prolonged heat wave unlike any seen in decades [1–2]. With a summer mortality rate seven times greater than usual [3], this heat wave has been described as the deadliest such event in the nation's history. Reports suggest up to **10,000 heat-related excess deaths** [4] occurred, although evidence for this claim is scant. However, we know excess heat-related deaths were quantified for the some of the most heat-stricken cities, including Dallas and St. Louis, where researchers had access to coroner or medical examiner records [5–7].

Such outcomes, extrapolated to the rest of the country, could potentially substantiate the claim of deadliest heat wave. Instead of aggregating heat-related death records from the 2,000+ coroner/medical examiner jurisdictions in the U.S., however, we may be able to obtain a similar conclusion using nationally aggregated data on all-cause deaths to identify a spike in mortality during the summer of 1980 sufficient to temporarily affect the seasonal mortality pattern or the national declining mortality trend.

The research presented here is a foray into answering the question, **Were there excess deaths in 1980 and, if so, how many might have been linked to the summer heat wave?** The initial focus is on men dying between the ages of 65 and 79, a subgroup that lies within the age range most vulnerable to heat-related death [8–9], and is highly represented in the datasets used in this study.



ABOVE: Departure from normal of mean 700-millibar height (m) in the northern hemisphere for July 1980 [10]. Except in Northern California, Florida (minus the panhandle), and New England, most of the continental U.S. experienced higher-than-normal air pressure, which resulted in warmer and drier conditions on the ground.



ABOVE: Temperature departure (°F) from 30-yr mean for July 1980 [10]. Most parts of the country experienced higher-than-normal daytime temperatures, especially in the Central and Southern Plains.

DATA & METHODS

Nationally aggregated mortality data come from U.S. Mortality Database (USMDB) life tables [11] and the Social Security Administration Death Master File (DMF) for the four years before and after 1980. The latter data were accessed through the CenSoc project at UC Berkeley [12]. A summary of the methods used follows below; please refer to the ancillary handout for a fuller description of the data cleaning and analyses employed herein.

Step 1: Compute and plot national age-specific death rates (ASDRs) and counts at age 65 and older
For ASDR denominators, I used the Census Bureau's national midyear population estimates [13]. To conform to the Bureau's age pyramid structure, I also stratified deaths by quinquennial age groups (65–69, 70–74, etc.). Plots were used to determine if 1980 mortality differed notably from preceding or subsequent years.

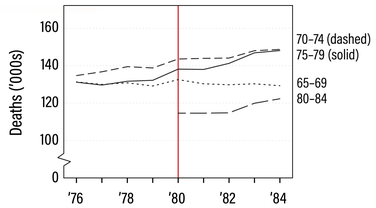
Step 2: Use counterfactual ASDRs and death counts for 1980 to estimate excess mortality
I fit a cubic spline using the annual death rates and counts for the four years before and after the heat wave to interpolate new values for 1980. These counterfactuals were used to quantify the amount of possible excess mortality.

Step 3: Decompose TS-formatted ASDRs and death counts to distribute 1980 mortality across months
In the event of possible excess mortality, actual ASDRs and counts were formatted into monthly time series and decomposed for seasonal examination. To obtain these data, age at death was measured as the number of months elapsed since the month and year of birth.

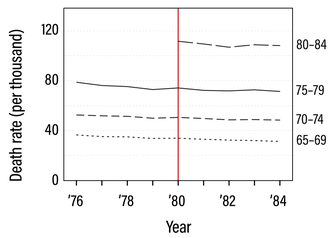
RESULTS

As shown in plots ❶ and ❷, an out-of-trend increase in all-cause mortality in 1980 can be seen in the DMF death counts and ASDRs, although it is more distinct in the count data. Men aged 75–79 appeared to experience a greater amount of excess mortality than younger age groups. (Due to coverage limitations in the DMF, deaths of men aged 80+ are underrepresented prior to 1980, so I truncate their trend lines. For brevity, USMDB ASDR plots are not shown, as they were largely similar to the DMF plots.

❶ **DMF death counts**

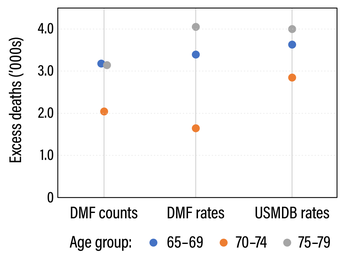


❷ **DMF ASDRs**



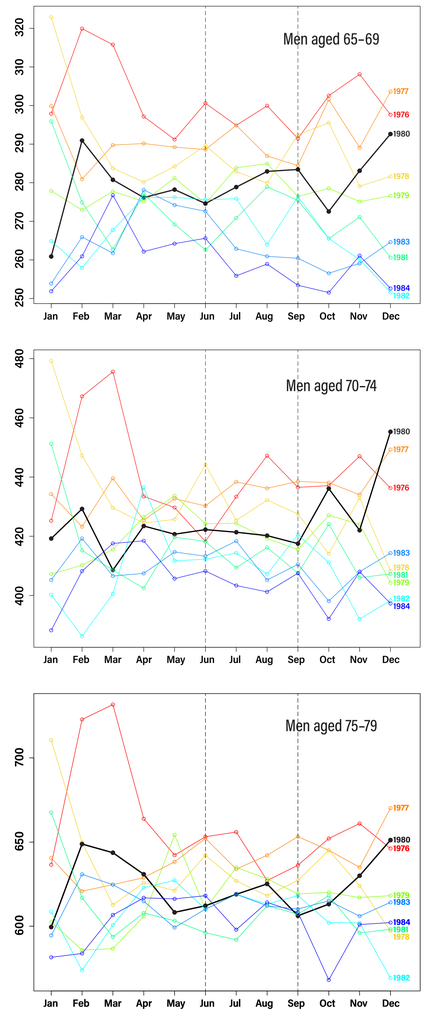
Substituting spline-interpolated values for ASDRs and counts results in lower rates and counts across all age groups in the DMF and USMDB. Differences in proportion to actual values are minor, ranging from 1.1 to 2.9%, with the largest differences for the 75–79 age group and the smallest for the 70–74 group. Plot ❸ shows the estimated number of excess deaths (deaths above the interpolated estimates). Within the 65–79 age range, I estimate 8,375, 9,099, and 10,479 excess male deaths in 1980 using DMF counts, DMF rates, and USMDB rates, respectively.

❸ **Estimated excess deaths for 1980**



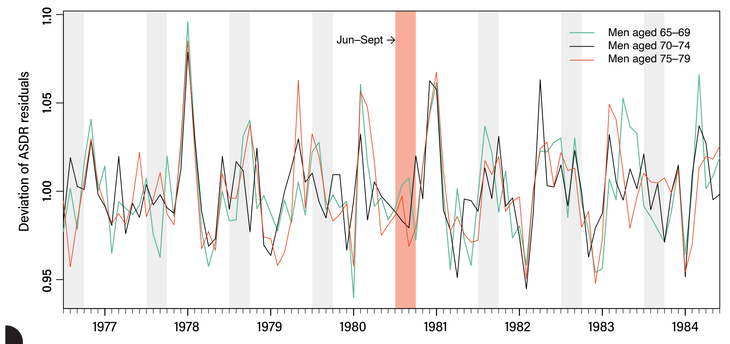
The absence of an isolated heat wave effect is also evident in the random component of the DMF ASDR time series data in plot ❺, which shows no distinct outlier pattern during the Jun–Sept 1980 period (marked in color). This outcome directly contrasts with the Dec 1980–Jan 1981 period, which shows singularly higher mortality compared to the same period in almost all years before or after.

❹ **Seasonal plots of DMF ASDRs (per 100,000)**



To the extent these excess deaths are coincident with the heat wave, the seasonal plots ❹ should show abnormally elevated ASDRs during any or all of the months of June through September 1980 relative to other years. Instead, we see unusual ASDR increases in December 1980 and mostly typical mortality outcomes during the summer.

❺ **Random component from the decomposed DMF ASDR time series**



DISCUSSION & IMPLICATIONS

The failure of this exploratory analysis to discern conspicuous mortality spikes in 1980 during or immediately after the summer heat wave should be interpreted with caution. Robustness checks using alternate interpolation or decomposition methods will help validate these results. Nonetheless, the present findings suggest that even unusually severe or prolonged heat waves may not be sufficient to induce the same number of excess deaths as other causes. The December 1980 spike, for example, coincides with a cold snap and flu epidemic during the winter of 1980–81, both of which were instantiations of an annual mortality burden that is typically several times greater than the death burden by heat [14–15].

More fine-grained analyses are warranted, particularly regarding identfication of excess deaths spatiotemporally. While the 1980 heat wave was nearly continent-wide, different regions experienced extreme heat at different times during the summer and for various durations [1], and the national level of the analysis potentially masks this heterogeneity. While extreme heat waves are unquestionably deadly, their lethality may express at a lower magnitude than other hazardous events. One implication of this research is that the hazard of a heat wave may not be in the overall *volume* of deaths that it precipitates nationwide, but instead in the short period that a relatively small number of excess deaths occur within a localized area—a period short enough that even measuring aggregated deaths at a monthly level cannot qualitatively capture it.

The 1980 heat wave's value as an analog to future extreme heat events therefore may not be in its impact across a heterogeneous area where heat exposure, which even at the high range of its estimated toll represented only a small fraction of total deaths in the U.S. that year, but in its toll in specific areas where the impact of extreme heat was uniform.

NEXT STEPS

Several ways exist to carry this research forward. At the least, it would be necessary to conduct these analyses for older women, as well as men and women in younger age groups, to complete the basic picture of excess mortality at a national level. This can easily be achieved using the USMDB, but is presently more difficult in the CenSoc-DMF, which is among the very few sources of publicly available individual-level death records that allow the monthly disaggregation of mortality. I intend, for example, to investigate some of the new approaches in administrative record linkage being developed by the Census Linking Project [16] that could allow deaths of women to be quantified at proportions closer to those of men. Notwithstanding this step, however, it may behoove us to consider alternate research contexts where the interpolation of excess mortality using aggregated data may be more conclusive.

References: See ancillary handout for list of references [1]–[16].

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