



Commentary

Estimating Mortality Displacement During and After Heat Waves

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The proportion of excess deaths occurring as a result of hot weather that are brought forward by only a short time (“displaced”) is important but not easy to estimate. A recent proposal by Saha et al. (*Am J Epidemiol.* 2014; 179(4):467–474) was to estimate this using a “displacement ratio” equal to the sum of deficits of daily deaths below an expected baseline divided by the sum of excesses over all days during and up to 15 days after a heat wave. Unfortunately, this method results in important artifacts due to natural Poisson variation in deaths by which deficits, and hence displacement ratios above zero, will occur even when there is no real short-term displacement. Simulations confirm this and further show spurious patterns, such as the displacement ratio diminishing with more severe waves. This displacement ratio cannot be relied upon for interpretation. Quantifying mortality displacement remains an incompletely resolved problem.

Abbreviation: MDR, mortality displacement ratio.

Editor’s note: Armstrong et al. originally wrote this piece as a letter to the editor. However, because it presented original data, we asked that it be reformatted as a research letter, a new category of publication in the Journal. Dr. Saha et al. were then asked to respond. The exchange is presented here as a commentary and response (see page 1407) because that was thought to better fit with the Journal’s publication policy. Research letters in the Journal will not have a response.

Quantification of the extent to which excess deaths that occur during or just after hot weather are brought forward by only a short time (“displaced”) is an important unresolved issue for public health policy. One approach that is attractive in its simplicity is to compare such excesses with deficits in the days after the excesses. In a recent article, Saha et al. (1) used a version of this approach that we believe gives rise to severe bias.

The approach compared daily death counts from the start of a heat wave until 15 days after with “baseline” counts estimated using a time series regression model. The mortality displacement ratio (MDR) was then defined as the sum over all such 15-day periods of daily mortality deficits (number of deaths lower than the baseline) divided by the sum of

the excesses (number of deaths higher than the baseline), no matter when the excesses or deficits occurred. The main problem in this approach arises from natural (typically Poisson) variation in daily death counts, whereby there will be deficits that occur even in the absence of short-term displacement of deaths. By simulating data, we found that even when there is no short-term displacement, this method shows an artificial displacement. We also found that the displacement appears to lessen as the threshold temperature used to define a heat wave increases, as was found by Saha et al.

The scenario for our simulation is based on 1987–2000 National Morbidity Mortality Air Pollution Study (2) data for Atlanta, Georgia, which was the first of the cities included in the article by Saha et al. For simplicity, we used dry-bulb temperature rather than mean apparent temperature and natural splines rather than penalized splines. We first fit the model described in model 2 of Saha et al. using real death counts. To obtain data that we knew had no short-term displacement, we simulated new death counts to follow a Poisson distribution around the model-predicted daily counts (given the actual lag 0 temperatures and the seasonal spline). We then applied the method described by Saha et al. to estimate the daily numbers of excess and deficit deaths relative to a baseline count for all days in the heat-wave and after, and hence the MDR. Core R (R Foundation for Statistical Computing, Vienna, Austria)

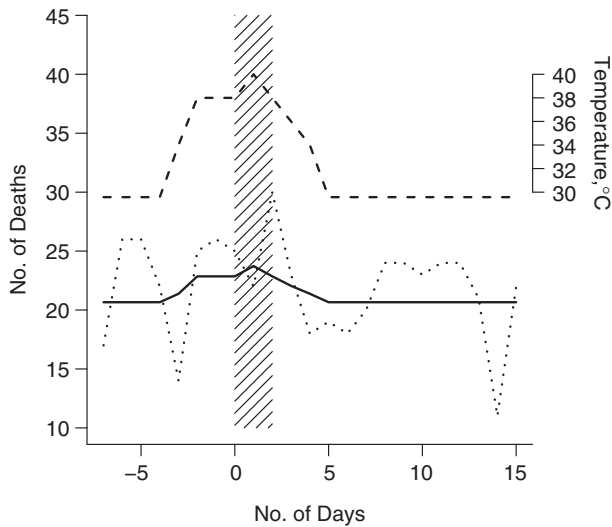


Figure 1. Top, hypothetical temperatures (dashed line) around a heat wave (3 or more days at 38°C or hotter; cross-hatched area). Bottom, a model-predicted death count (solid line) assuming no short-term displacement and a new death count simulated to follow a Poisson distribution (dotted line) around this. Data are based on 1987–2000 National Morbidity Mortality Air Pollution Study data for Atlanta, Georgia.

code is provided in the Web Appendix (available at <http://aje.oxfordjournals.org/>). The same simulation around a hypothetical heat wave (Figure 1) illustrates how below-baseline death counts over the 15-day window could occur by chance alone.

The simulation showed a MDR of 0.89 with heat wave threshold at the 80th percentile, and the MDR declined as the heat wave threshold increased despite there being no real short-term displacement (Figure 2). These results are largely similar to those of Saha et al. (1), suggesting that those patterns are due in substantial part to artefacts. Simulations from the other cities in the article by Saha et al. showed broadly similar patterns, although there were variations in the size of the MDRs and in the strength of associations between MDR and heat wave threshold across cities.

The artificial association of the displacement ratio with heat wave threshold is due to 2 things. First, the numbers of excess deaths are higher in heat waves with higher thresholds because of the high temperatures (Figure 1)—a real effect of heat. Thus, the sum of excesses (denominators of MDR) will be higher and the MDR consequently lower in hotter heat waves, even if post-heat wave deficits remained the same. Second (and artificially), the days during and after a heat wave that has a hotter threshold are likely to also be hotter, so deficits due to Poisson variation are less likely.

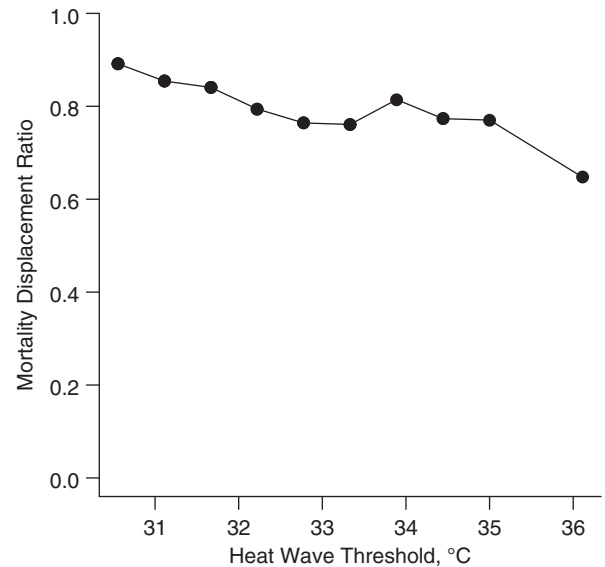


Figure 2. Mortality displacement ratio by heat wave threshold with deaths simulated to have no real short-term displacement, Atlanta, Georgia, 1987–2000.

If real short-term displacement were present, it does seem likely that it would contribute to a high displacement ratio. However, the presence of these powerful artifacts makes it very difficult to separate its presence, extent, or determinants from the displacement ratios proposed by Saha et al.

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Conflict of interest: none declared.

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