CORRESPONDENCE

Mortality in Puerto Rico after Hurricane Maria

TO THE EDITOR: Kishore et al. (July 12 issue)[1] used household surveys to estimate the number of excess deaths (4645; 95% confidence interval [CI], 793 to 8498) that occurred in Puerto Rico during the 102 days following Hurricane Maria in 2017. To test the robustness of their findings, we conducted time-series forecasting[2] with the use of monthly mortality data in Puerto Rico between January 2010 and September 2017 to forecast the number of expected deaths had Hurricane Maria not occurred (Fig. 1). We then compared the forecast estimates with the survey-based mortality estimates. Using an average of a state-space and autoregressive integrated moving average model with a mean absolute percent error of 3.8% on cross-validation, we estimated the number of excess deaths in the 102 days after Hurricane Maria to be 4970 (95% CI, 1117 to 8822).

Our findings, which were based on forecasting methods rather than on the authors' original comparison with historical death rates, support the conclusion that the authors' estimate of excess mortality is probably conservative. In the same spirit as that which informed the authors' decision to publish their data, we developed a tool to facilitate time-series forecasting and have shared this tool online.[3]

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No potential conflict of interest relevant to this letter was reported.

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TO THE EDITOR: The excess mortality estimates reported by Kishore et al. for the 102 days after Hurricane Maria depend on the quality of their data. I examined that quality by calculating mortality for the 263 days before Maria and then comparing that rate with those from other sources.

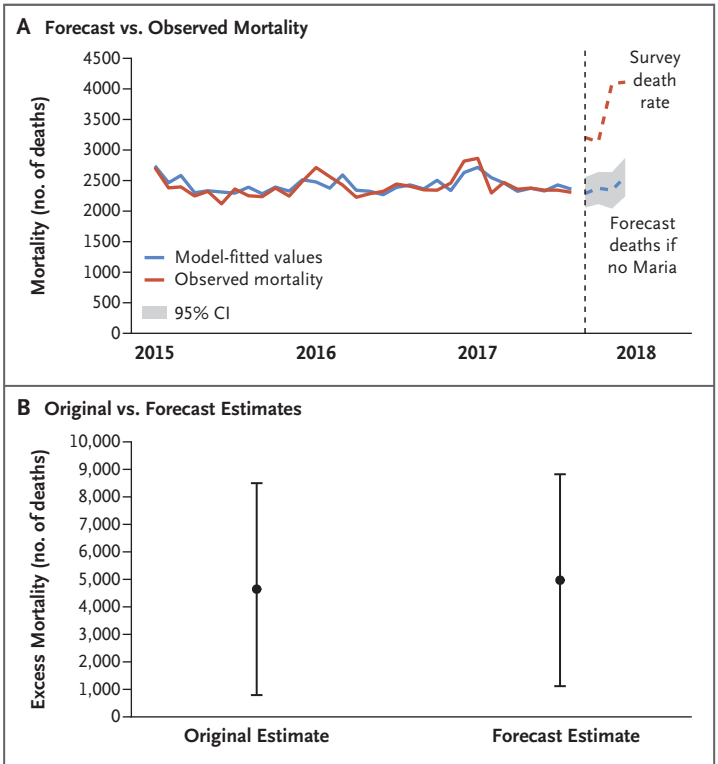

Figure 1. Estimates of Mortality Related to Hurricane Maria.

Panel A depicts mortality forecast on the basis of the average of a state-space and autoregressive integrated moving average (ARIMA) model. Model fit was calculated on the basis of mortality data before September 2017 with the use of cross-validation on a rolling 4-month horizon. The mean absolute percentage error was 3.8%. Forecast mortality is shown between September 20 and December 31, 2017. The best-fitting forecast model was used after comparison with the following models: simple exponential smoothing, Holt's linear method, Holt–Winters' additive method, ARIMA alone, and state-space model alone. Models were run with use of a Web-based tool developed and shared to enable time-series forecasting.[3] Panel B depicts the original estimate of excess mortality by Kishore et al.[1] and our estimate based on the forecasting model. I bars denote 95% confidence intervals.

Using the authors' methodology and data, I calculate the mortality as 2.6 deaths (95% CI, 1.4 to 3.8) per 1000 persons from January 1 through September 19, 2017. This rate is inconsistent with the rate calculated on the basis of the official monthly statistics for 2010 through 2017: 8.3 deaths (95% CI, 8.2 to 8.4) per 1000 persons. It is almost statistically impossible for there to have been only 18 deaths in the 3299 households before Maria. The problem remains even when the authors' later calculations, which adjusted for household size, are taken into account.

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THE AUTHORS REPLY: We thank Verma et al. for these additional analyses and for their commitment to public sharing of data and methods. We encourage other researchers to do the same.

A few days after the release of our study, the Puerto Rican government made the official death registry data available to researchers. Subsequent estimates of post-hurricane mortality have been made on the basis of this newly available information, and they confirm that excess mortality continued for several months.

It is important to note that our study shed light not only on excess deaths but also on the possibility of prolonged, indirect effects of the hurricane, as well as causes of death and infrastructure disruption. The limitations of the use of post-disaster surveys to calculate mortality or excess deaths are well articulated in the literature.[1] We attempted to address known challenges with sampling, stratification, and biases in the methods we adopted. As noted by Kane, the raw, prehurricane estimates of mortality from our survey were lower than historical averages. We have addressed this issue in detail, both in a Technical FAQ (https://github.com/c2-d2/pr_mort_official/blob/master/misc/technical-faq.pdf) and in a public discussion forum with Kane in June 2018 (https://github.com/c2-d2/pr_mort_official/issues/7). We were aware of this issue and did not use prehurricane data for any of the estimates reported in our article. We also note that when single-person households and age structure are included in the estimate, this low rate is brought within the range of the 2016 death rate for Puerto Rico. The code and data required for this analysis are available at the link to the public discussion forum, above.

The international humanitarian community has called for greater investment in post-disaster ascertainment of mortality.[2] Given the breakdown in regular prospective surveillance systems, as was witnessed in Puerto Rico, domestic disaster-response agencies would similarly benefit from dedicating resources to improving estimation methods for the calculation of mortality.

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Since publication of their article, the authors report no further potential conflict of interest.

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