Mortality rates immediately after severe hurricanes in Cuba have decreased over the past three decades

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Abstract

Objectives: Understanding how countries respond to extreme weather events can help identify and disseminate good public health practice.

Study design: Observational study using routinely collected mortality data.

Methods: National daily mortality counts after severe hurricanes arrived on the Cuba landmass since 1990 were compared to baseline values. Incidence rate ratios of mortality during the hurricane and for the four weeks afterwards were calculated for four eligible hurricanes: Georges (1998), Dennis (2005), Ike (2008) and Irma (2017).

Results: Mortality rates decreased over time ($p<0.001$ for interaction), and no excess mortality counts were observed after Hurricane Irma in 2017.

Discussion: Mortality rates for severe hurricanes that have made landfall in Cuba have decreased over three decades, despite the most recent hurricane (Irma) being one of the strongest observed in recent decades. This suggests that the Cuban public health preparations and responses to recent severe hurricanes are probably contributing to this mitigation in national mortality rates during these periods.

Key words: hurricanes, Cuba, mortality

The frequency of extreme weather events is increasing globally as a consequence of climate change. In the Caribbean this results in an increased risk of hurricanes which can be devastating. [1] This was evident when Hurricane Maria made landfall at Puerto Rico, resulting in estimates of mortality ranging from 1139 to 4645 deaths [2-4] and economic costs of approximately $90 billion. [5] This has led to the awareness that there is a public health need to improve national responses to hurricanes. [6]

Cuba is the largest country in the Caribbean, and as a consequence the public health authorities have extensive experience dealing with hurricanes. The country's government has made planning for hurricanes and responding to them a national priority [7], with a number of strategies including educating individuals how to respond during and after a hurricane and also ensuring that vulnerable individuals are protected. [7, 8] The country systemically collects data on health outcomes regardless of the societal circumstances. Cuban national mortality statistics were used to explore the impact of a hurricane on mortality during both the period of extreme weather and the recovery period afterwards.

The hurricanes were selected as they made landfall in large parts of Cuba since 1990, and were known for the substantial devastation caused. The hurricanes were Hurricane Georges (24-26th September 1998), Hurricane Dennis (7-9th July 2005), Hurricane Ike (7-9th September 2008) and Hurricane Irma (7-9th September 2017) as defined by the National Hurricane Center and Central Pacific Hurricane Center (https://wwwnhcnoaagov/outreach/history/). The daily national mortality data were obtained from the Office of National Statistics in Havana, Cuba (http://www.one.cu).

The data were analysed by Poisson regression. As there is marked seasonal variation in mortality rates, daily mortality data were analysed for four weeks before the first date of landfall of the hurricane, and for four weeks after the hurricane had left the Cuban landmass. As mortality may increase after the hurricane has dissipated as a consequence of the devastation caused, the periods of analysis consisted of five categories: the dates when each hurricane was recorded as being on the landmass of Cuba, and the subsequent four individual weeks coded as categorical variables. The time period of four weeks before the hurricane made landfall on Cuba period was used to define the baseline mortality rate. Mortality in the baseline period before the hurricane was compared to the period during and after the hurricane for each subsequent week. A likelihood ratio test was used to determine the presence of an interaction of the risk of mortality in these periods during and after the hurricane compared to baseline between individual hurricanes.

Over the past three decades, there were four eligible severe hurricanes that made landfall on the Cuban landmass. The daily mortality rates are presented in Figure 1 and the mortality rate ratios compared to baseline in Table 1. There was a strong interaction between the risk of death during and after the hurricane compared to baseline between the four hurricanes ($p<0.001$, likelihood ratio test), with lower mortality for the most recent event (Hurricane Irma in 2017) when mortality rates after the hurricane were lower than the baseline values.

Hurricane Georges (1998)

An increase in the mortality rate was observed during the period when the hurricane made landfall in Cuba (mortality rate ratio MRR 1.10; 95% confidence intervals CI: 1.01 to 1.20), but there was no significant increase in the short-term period afterwards.

Hurricane Dennis (2005)

The mortality rate when Hurricane Dennis was over the Cuban landmass was increased (MRR 1.16; 95% CI: 1.08 to 1.25) and remained increased for the next three weeks with an MRR in the fourth week after the hurricane of 1.24 (95%CI: 1.18 to 1.30). Examining the numbers of deaths for the whole of 2005, there was a clear increase in the mortality rates in July, August and September that is apparent in Figure 2, and the death rates remained elevated for the rest of the year.

Hurricane Ike (2008)

There was no significant increase in the mortality rate observed during the period when the hurricane affected Cuba, but there was an increase in the first week afterwards (MRR 1.14; 95% CI 1.08 to 1.20) that did not persist into the second week.

Hurricane Irma (2017)

No significant increase in mortality rates was observed with regard to Hurricane Irma, either during the period when the hurricanes made landfall in Cuba or in the following four weeks. The mortality rate after Hurricane Irma made landfall decreased in the third (MRR 0.93: 95%CI: 0.88 to 0.97) and fourth week (MRR 0.94: 95% CI: 0.89 to 0.98) afterwards compared to baseline.

This is the first analysis that has used national mortality data to explore the impact of four severe hurricanes on mortality in the same country over a three-decade period. The results demonstrate that their impact on national mortality rates diminished with time, with relatively small or no increase in mortality rates following the two most recent hurricanes.

The strengths of these data are that they are routinely collected throughout extreme weather conditions, and are probably one of the best available data sources to study the impact of hurricanes on mortality. Cuba is an island with secure borders and has an excellent health data surveillance system, [9] and as a consequence it is unlikely that any deaths have been missed.

One limitation of these data is that they represent the country as a whole, and not the specific geographical location where the hurricanes made landfall. Hence it is not possible to observe how the daily mortality rates increased in the precise region where the weather was the most extreme. However, hurricanes of interest were selected on the basis of having been defined as severe, based on the Cuban authors' awareness of the devastation that was caused locally, and their paths affecting large proportions of the Cuban landmass. A second limitation of these data is that while the analysis can identify temporal association between the impact of a hurricane and the daily mortality rates, this type of observational epidemiological study design cannot prove a causal association. Analyses using cause of death data would be important to further understand this prolonged increase in mortality rates. A further limitation is that while the analysis demonstrates how mortality rates are modified during and after experiencing a severe hurricane, they provide no insights into the relative effectiveness of public health interventions. Nonetheless, comparison of the Cuban public health hurricane preparations [8] with other countries such as Puerto Rico where the mortality rate increased substantially after Hurricane Maria [2-4] would be one approach that may help inform future planning for extreme weather events.

As the analysis used simple aggregated summary data, there was no facility to explore the changes in the age or sex structure of deaths that occurred during the periods when hurricanes impacted on the Cuban landmass. This may confound an analysis of mortality as demographic transition is resulting in Cuba having an aging population over time [10]. However, relative mortality in the same population was compared to the baseline comparison period just before the hurricane arrived and an aging population would be expected to be more susceptible to the extreme conditions experienced during a hurricane. There was no excess mortality during the more recent hurricane (Irma). One possible explanation is that some of the excess mortality observed during the earlier hurricanes was due to cardiovascular disease provoked by the cold weather, and better treatment of this also contributed to lower mortality from hurricanes over time.

Mortality after experiencing a hurricane can occur by a variety of causes. During the period when the hurricane is directly over the landmass, the experience of the Cuban authors is that there is an increased risk of trauma and suffocation due to strong winds, electric shock by infrastructure damage, as well as limited availability of electricity, water and provisions. After the extreme weather has passed, damage may occur because of adverse impacts on the provision of utilities such as transportation, energy power, sanitation and medical supplies for a variable period of time. [11] The highest cause of mortality after Hurricane Maria went over the landmass of Puerto Rico was the interruption of medical care, as a consequence of damage to the health care system. [4] Without public health services planning for hurricanes, these events can be catastrophic.

The recent severe hurricane was Irma in 2017 and no increase in mortality rates were observed at this time. Hurricane Irma was the Atlantic basin's strongest tropical cyclone in recent decades that tracked Cuba's northern coastline, causing widespread damage and effecting 20% of the Cuban population, [8] and hence provided a stern test of the Cuban emergency preparations for hurricanes. Analysis of the government's response to Hurricane Irma identified five components that contributed to the successful Cuban public health response. 1. Active learning from past events. 2. Integrating healthcare and public health responders. 3. Proactively preparing the public for hurricanes. 4. Use of technology such as decentralising the national electricity system. 5. Using science for anticipating and mitigating extreme weather events.[8] This is co-ordinated by the Cuban civil defense system which is directly accountable to the government. [7]

These data demonstrate that there were small or no increases in national mortality rates in Cuba during and after experiencing severe hurricanes in recent years. Despite climate change resulting in higher sea surface temperatures and a higher risk of tropical cyclones, [1] the Cuban public health preparations and responses to recent severe hurricanes are probably contributing to this mitigation of excess national mortality during these events.

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Ethical approval: Not required as using routinely collected mortality data.

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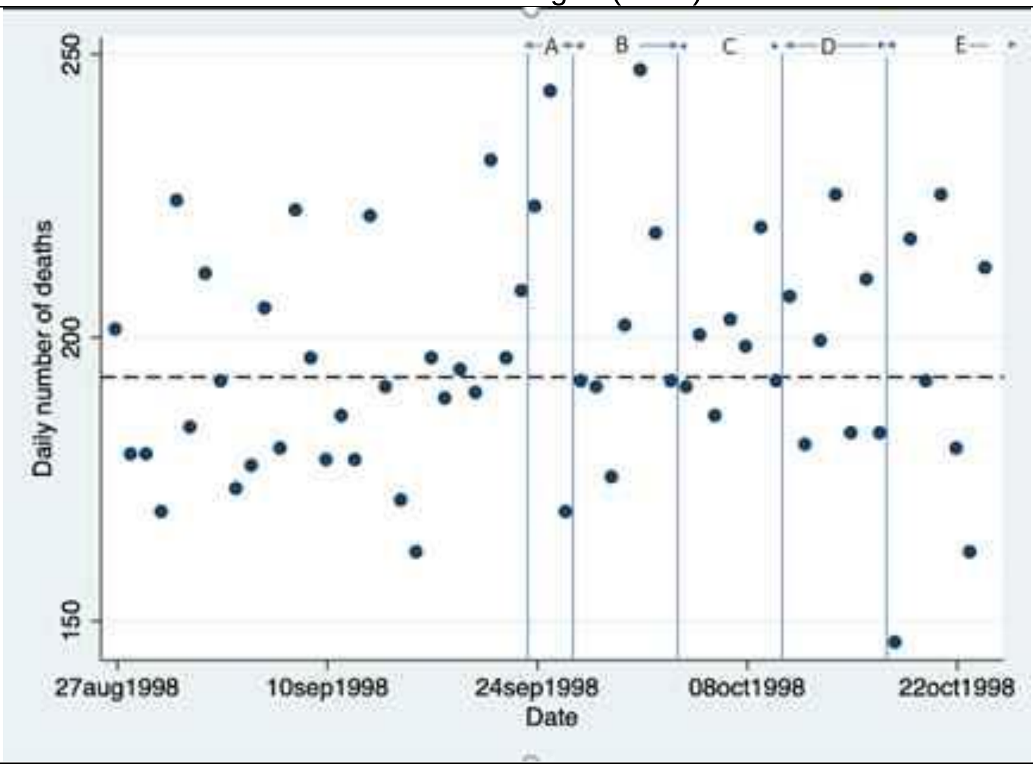
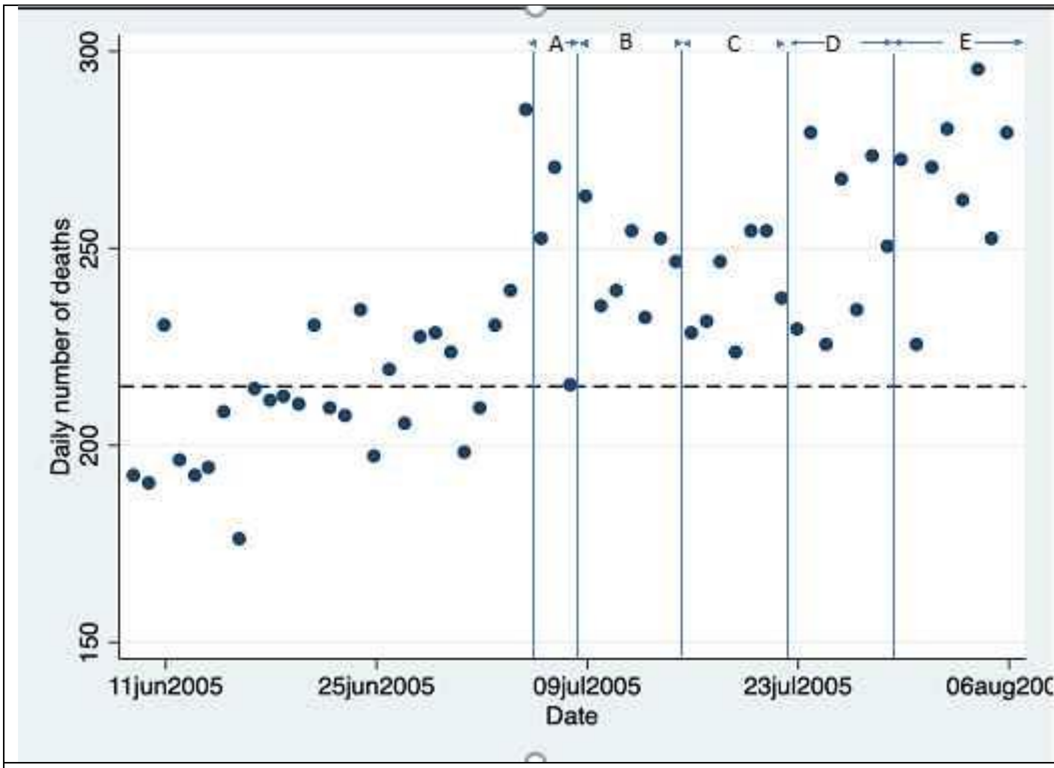
Figure 1. Daily numbers of deaths for the selected hurricanes in Cuba.

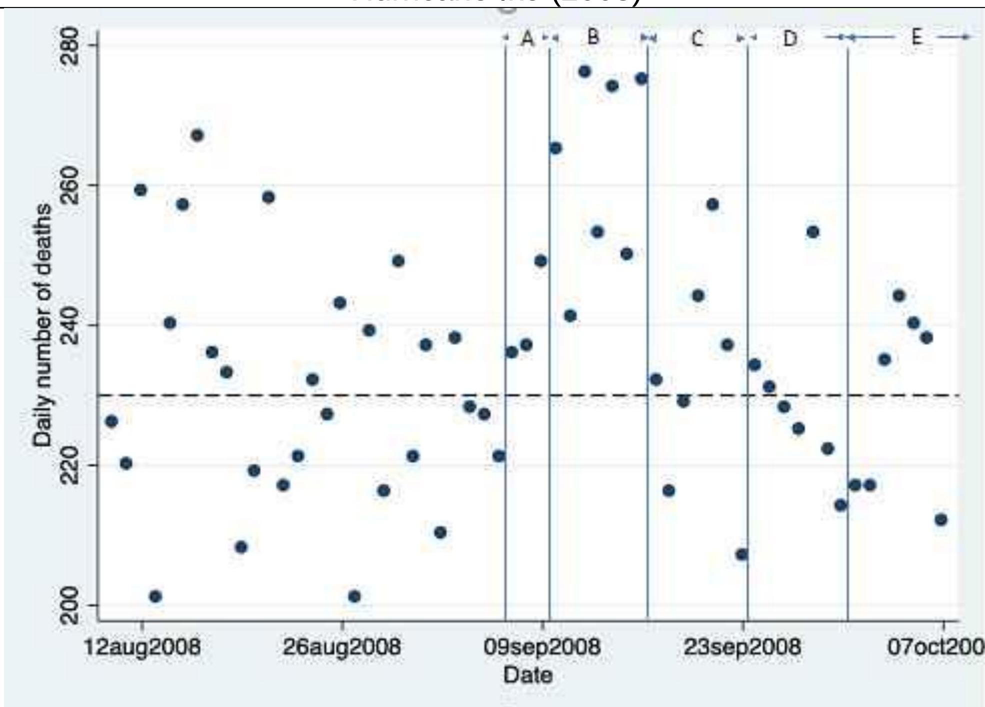
Hurricane Georges (1998)



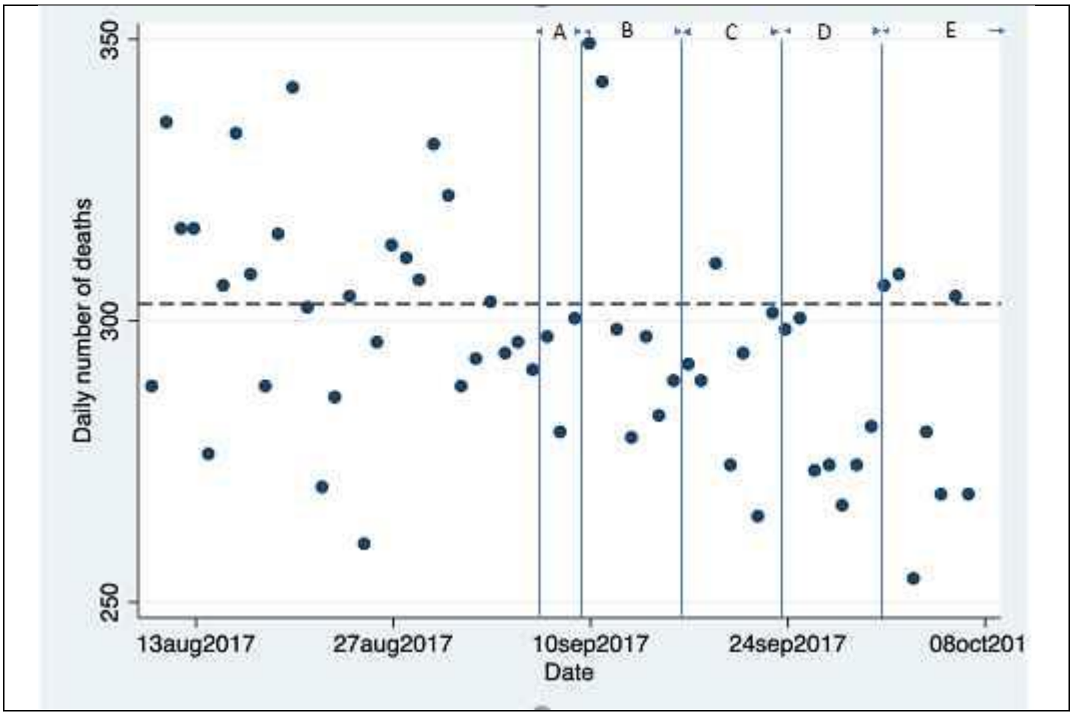
Hurricane Dennis (2005)



Hurricane Ike (2008)



Hurricane Irma (2017)



Dashed line indicates baseline daily number of deaths in the four weeks before the hurricane of interested made landfall in Cuba
Time periods: A= Hurricane made landfall, B=1st week after, C = 2nd week after, C=3rd week after, D=4th week after
Total population of Cuba was 11 333 482 individuals in 2019 (World Bank)

Table. Rate ratios of daily mortality rates during the period before and after the category five hurricanes made landfall in Cuba.

Hurricane	MRR	95% confidence intervals
George (1998)		
During hurricane	1.10	1.01 to 1.20
+ 1 week	1.05	0.99 to 1.12
+ 2 weeks	1.03	0.97 to 1.09
+ 3 weeks	1.03	0.97 to 1.09
+ 4 weeks	0.99	0.93 to 1.05
Dennis (2005)		
During hurricane	1.16	1.08 to 1.25
+ 1 week	1.12	1.06 to 1.18
+ 2 weeks	1.11	1.05 to 1.17
+ 3 weeks	1.20	1.14 to 1.26
+ 4 weeks	1.24	1.18 to 1.30
Ike (2008)		
During hurricane	1.04	0.97 to 1.13
+ 1 week	1.14	1.08 to 1.20
+ 2 weeks	1.01	0.95 to 1.06
+ 3 weeks	1.00	0.94 to 1.05
+ 4 weeks	1.00	0.94 to 1.05
Irma (2017)		
During hurricane	0.96	0.90 to 1.03
+ 1 week	1.01	0.96 to 1.06
+ 2 weeks	0.95	0.91 to 1.00
+ 3 weeks	0.93	0.88 to 0.97
+ 4 weeks	0.94	0.89 to 0.98

MRR = Incidence rate ratio