Impact of the December 2004 Tsunami on Birth Outcomes in Aceh, Indonesia

Amar Hamoudi, Elizabeth Frankenberg, Cecep Sumantri, & Duncan Thomas

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Abstract

On December 26, 2004, a massive undersea earthquake sent a trillion tons of water crashing into the coasts of south and southeast Asia, Africa, and Australia. The Indonesian province of Aceh, being closest to the epicenter, was especially hard hit. We use retrospective birth histories collected as part of a unique longitudinal survey conducted in the aftermath of the tsunami to explore the impact of the disaster on birth outcomes to surviving women. Preliminary results suggest the disaster had no appreciable impact on birthweights, attendance at birth, reported non-live terminations, or sex ratios. These results are surprising in light of previous work by others indicating substantial impacts on outcomes like these from disasters of similar or smaller magnitude. We explore these surprising null results in some detail. Our results may point to a remarkable resilience of evolutionary adaptations to forestall transmission of deleterious conditions to the next generation.

On December 26, 2004, a massive earthquake centered off the coast of Aceh, Indonesia sent a trillion tons of water crashing into the coasts of south and southeast Asia, Africa, and Australia. The province of Aceh, being closest to the epicenter, was especially hard hit. In many coastal communities, over a quarter of the population died; the disaster also displaced tens of thousands of survivors, and destroyed billions of dollars in assets. The magnitude of the disaster in human and economic terms has been outlined in greater detail elsewhere [Frankenberg, Gillespie, Preston, Sikoki, and Thomas, 2011]; in terms of standard seismic metrics, it was the third most powerful earthquake in recorded history [USGS, 2011].

We draw on retrospective birth histories collected as part of a unique ongoing longitudinal survey conducted in Aceh and the neighboring province of North Sumatra. This survey– the Study of the Tsunami Aftermath and Recovery (STAR)– has been described in detail elsewhere [Frankenberg, Gillespie, et al, 2011]. The baseline sample are residents of respondent households to the 2004 Indonesian National Socioeconomic Survey (SUSENAS), which was conducted before the disaster. STAR field teams painstakingly tracked everyone enumerated by the baseline survey– including those who had been displaced– ultimately accounting for about 95 percent of the sample, and successfully interviewing over 90 percent of survivors. The geographic coverage of the survey includes communities that were directly impacted by the earthquake and tsunami, as well as communities that were not directly hit.

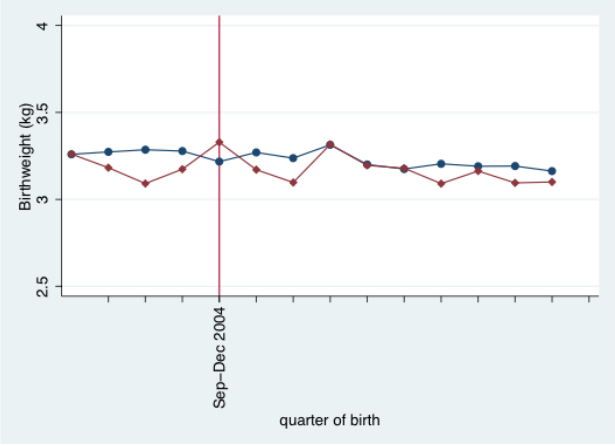
We use these retrospective histories to explore the impact of the disaster on birth outcomes to surviving women in Aceh. All respondent women of reproductive age provided a birth history, including details on prenatal conditions and neonatal outcomes for births that occurred within the five years immediately preceding. We exploit geographic variation in the magnitude of the disaster– which was primarily driven by arguably exogenous factors like coastal topography– as well as the timing of births before and after the disaster. Specifically, we assign surviving women an "exposure status" on the basis of the magnitude of damage suffered in the community in which they were living at the time of the disaster, and then use a semi-parametric regression specification to compare the time paths of birth outcomes in heavily damaged communities among more and less "exposed" women. By comparing differences in these time paths, we aim to isolate the impact of the disaster on these outcomes.

Our hypotheses are motivated by evidence that has emerged in the public health and social science literatures in recent years, that adverse events during a pregnancy– especially those occurring during the first trimester– have substantial negative impact on fetal health. Several biological mechanisms could play a role in driving these effects, including physiological consequences of maternal stress.

Our preliminary analyses suggest that the disaster had no appreciable impact on birthweights, attendance at birth, reported non-live terminations, or sex ratios. These results are surprising in light of previous work by others indicating substantial impacts on outcomes like these from disasters of similar or smaller magnitude.

We explore these surprising null results in some detail, focusing in particular on birthweights. Figure 1 illustrates our main (preliminary) result for this outcome. The time path of average reported birthweights in the most heavily affected communities–where, in many cases, over a quarter of residents were killed in the disaster–mirrors the time path in less affected communities. (Visual inspection of the time paths may suggest differences between the two groups at a few points in time. However, analyses of the differences in a regression context fails to reject the null hypothesis that each of these differences, and also any differences-in-differences between groups over time, are anything more than random chance).

Figure 1: Time paths in average reported birthweights in heavily damaged and less-damaged communities in Aceh, Indonesia



Notes: Diamonds indicate the time path in heavily damaged communities; circles, in the less-damaged communities. Total sample size is 6500 births.

First, we explore whether the results may be driven by very prosaic mismeasurement or misreporting among STAR respondents. To that end, we compare reported birthweights in STAR against those reported across Indonesia in the 2002 and 2007 Demographic and Health Surveys. The distributions do not differ substantially, implying that the birthweights reported in STAR match those reported in other, independent high-quality data sources.

Next, we explore whether average reported birthweights after the disaster are likely to be inflated in the most heavily damaged communities. If the lowest weight births in these communities were

more likely to have occurred away from a health facility after the disaster, or to have mismeasured or unmeasured weights for some other reason, this would likely bias results against finding an effect of the disaster even if such an effect existed. We find no evidence of any systematic relationship between the availability of birthweight information for a reported birth, and the timing/location of that birth. We also find no evidence of a systematic relationship between timing/location and the likelihood that a birth was attended by a health professional, or that it occurred in a home rather than a health facility. This suggests that our null results are unlikely to be driven by systematic selection in the availability of outcome data.

More difficult to assess are the dynamics arising from the retrospective nature of our data. This retrospective character implies for example that if a mother died or was lost to followup, then *all* her children– whether they were born before or after the event– are missing from the data. It is difficult to assess *a priori* how this selection process may be expected to impact our results. On the one hand, if the mothers whose gestational outcomes that were most likely to have been affected by the disaster were also more likely to have died or been lost to followup, this would bias us against finding an effect, even if one existed. On the other hand, if those who were lost to followup had some *constant* differential propensity to higher or lower birthweights, then their missingness from the data would affect estimated differences between the heavily damaged and less damaged communities at each point in time, but it may not affect our ability to detect differences in the time *paths* of the two types of communities.

In order to explore the types of births that are likely to be missing from the data, we will compare characteristics of reporting mothers in the 2007 Demographic and Health Survey (DHS) to those in STAR. Since the sample for the 2007 DHS was drawn after the event, it represents the surviving (and post 2004 in-migrant) population. By contrast, the STAR sample is based on the population in Aceh in 2004, and also includes those who have come to coreside with members of the original sample. By comparing the distribution of maternal and offspring characteristics in these three samples– the baseline STAR sample, those who joined the STAR sample by moving into STAR households, and the DHS sample– we can look for evidence of "missing mothers."

Most of our preliminary analyses have been focused on the impact of the disaster on the mean of the measured outcomes we have examined (and, relately, its impact on the likelihood of several dichotomous outcomes). There remains the important consideration, however, that the disaster may have had substantial impacts on the population that would be only very weakly reflected in the mean. It may have severely affected those in the least advantaged or most vulnerable part of the population distribution, for example, but had only a smaller impact on the rest. Such an impact

would be difficult to detect merely by analyzing the mean, but may be of very great social scientific and policy importance. We will use a quantile regression approach to explore the impact of the disaster at several points in the distribution, in order to explore these potential impacts.

If our preliminary results hold, however, they will suggest an important caveat to previous work on the fetal health impact of distress and disruption. There are important evolutionary adaptations in the physiology of gestation that have been observed in animal models to mitigate these health impacts substantially. In humans, the placenta has been observed to block the transmission of stress hormones and other potentially deleterious proteins from mother to fetus. The emerging evidence in the social science and public health literature has highlighted some potential weaknesses in these adaptations; but our results, if they hold, may point to a remarkable resilience as well.