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Community Destruction and Traumatic Stress in Post-Tsunami Indonesia

Elizabeth Frankenberg¹, Jenna Nobles², and Cecep Sumantri³

¹Duke University, Durham, NC, USA

²University of Wisconsin, Madison, WI, USA

³SurveyMETER, Yogyakarta, Indonesia

Abstract

How are individuals affected when the communities they live in change for the worse? This question is central to understanding neighborhood effects, but few study designs generate estimates that can be interpreted causally. We address issues of inference through a natural experiment, examining post-traumatic stress at multiple time points in a population differentially exposed to the 2004 Indian Ocean tsunami. The data, from the Study of the Tsunami Aftermath and Recovery, include interviews with over 16,000 Indonesian adults before and after the event. These data are combined with satellite imagery, direct observation, and informant interviews to examine the consequences of community destruction for post-traumatic stress. Using multilevel linear mixed models, we show that community destruction worsens post-traumatic stress, net of rigorous controls for individual experiences of trauma and loss. Furthermore, the effect of community destruction persists over time and extends across a wide range of community types.

Keywords

community; disaster; health; neighborhood; survey methodology

The impact of community on individual well-being is of long-standing interest to social scientists. In the past two decades, the spotlight has turned to defining and measuring disorder at the neighborhood level and linking these measures to well-being (Hill, Ross, and Angel 2005; Sampson and Raudenbush 1999; Wheaton and Clark 2003). Such research encompasses many outcomes, though interest in mental health is perhaps the most enduring (Coleman 1961; Durkheim [1887] 1951; Erikson 1976; Leventhal and Brooks-Gunn 2003; Ross, Reynolds and Geis 2000; Shaw and McKay 1942).

Measuring the causal effects of communities on individuals requires overcoming the difficulty that variation in neighborhood characteristics is rarely exogenous to the individual outcomes of interest. Although understudied, disasters provide a powerful strategy for examining neighborhood effects because they can suddenly alter the functions of communities, giving rise to a natural experiment. Since Samuel Prince (1920) studied the Halifax explosion, sociologists have used disasters to observe features of social life made visible when social systems are strained (Browning et al. 2006; Clarke 2004; Dynes, Tierney, and Fritz, 1994:15; Klinenberg 2002; Quarantelli 1989; Tierney 2007). In fact,

several of the seminal sociological writings on the meaning of community life center on disasters. Kai Erikson (1976), for example, used the 1972 Buffalo Creek flood to develop the concept of collective trauma: the idea that community demise exerts its own independent impact on the psychological well-being of individuals, net of individual loss.

Relatively few subsequent studies have focused on disasters as sources of community disruption, despite their potential for elucidating the value of community functioning and the origins of spatial variation in mental health. Indeed, reviews have called for a more systematic examination of the role that community plays in postdisaster mental health (Galea, Nandi, and Vlahov 2005; Norris, Friedman, and Watson 2002a).

We assess the impact of community destruction on post-traumatic stress after a large-scale disaster: the 2004 Indian Ocean tsunami. Our design harnesses the power of a natural experiment, drawing on data collected before and after the disaster in heavily damaged and undamaged communities. The design extends the literature on neighborhoods by using an exogenous source of community change: a community-level shock to the physical and social environment that varies in magnitude across the hundreds of communities in our study. We demonstrate that tsunami-induced community destruction affects post-traumatic stress. These effects exist above and beyond experiences of individual trauma, and they hold across different types of communities.

Our results provide strong evidence regarding the causal impact of community change on individual welfare. Disasters alter physical spaces and damage social and economic functions of communities in ways that can inform our understanding of more chronic community decay: the disorder generated by neighborhood poverty and violence. In this sense, we follow Erikson (1976), Klinenberg (2002), and other scholars in harnessing a shock to illuminate the value of community functions for health outcomes.

BACKGROUND

Post-Traumatic Stress after a Disaster

Disasters affect multiple dimensions of mental health. We focus on post-traumatic stress reactivity (PTSR), defined as the presence of symptoms that include reexperiencing the event, avoiding reminders of it, and hyperarousal (American Psychiatric Association 1994).

The biological underpinnings of PTSR are complex. Recent theories posit that relative to ordinary events, the processes of memory storage and retrieval differ markedly for experiences that create extreme stress, involving dysregulation within multiple biological systems (Brewin and Holmes 2003; Hageman, Andersen, and Jorgenson 2001). Disasters may cause dysregulation in these systems if they create intense fear, horror, or feelings of helplessness, or if disasters challenge fundamental assumptions about the world and one's sense of safety within it (Dalglish 1999; Ehlers, Maercker, and Boos 2000:45; Reynolds and Turner 2008).

High-mortality disasters may expose individuals to extreme stress, even without posing a direct threat to one's own survival. Disasters may create an atmosphere from which escape seems impossible, generating feelings of complete helplessness (Kalayjian 1999; Zinner and Williams 1999). Events involving multiple deaths can create intense feelings of horror, loss, and complicated grief (Walsh 2007; Zinner and Williams 1999). Additionally, threats to the integrity of social and economic resources create extreme stress by challenging fundamental assumptions about the world (Hobfoll 1988).

Sociological and Psychological Studies of the Role of Community in Postdisaster Mental Health

Early sociological work on disasters focused on understanding collective behavior under high-stress conditions. Researchers were dispatched to stricken communities to observe postdisaster dynamics as they unfolded (Fritz and Marks 1954). Work in this vein documented the symptoms of postdisaster numbness and dazed shock that now characterize PTSD. Describing a tornado's aftermath, Wallace (1956) linked this state explicitly to the experience of viewing one's community in tatters, even in the absence of significant personal loss.

Erikson (1976) developed these ideas in his evocative study of the Buffalo Creek flood, arguing that community disruption affects psychological well-being net of individual trauma. He posited that the impact of community change on individuals may emerge slowly. Although the destruction in the community is immediate, the realization that the event has disrupted communal life is gradual. Erikson described the intertwining of ecological destruction with destruction of the network of social relationships in place before the disaster, so that Buffalo Creek looked and felt like a very different place. For Erikson's informants, the loss of community was the loss of people and loss of place. He wrote,

People are grieving for their lost friends and lost homes, but they are grieving too for their lost cultural surround; and they feel dazed at least in part because they are not sure what to do in the absence of that familiar setting. They have lost their navigational equipment, as it were, both their inner compasses and their outer maps. (p. 200)

More recently, work on post-Katrina New Orleans emphasized how destruction of the built environment and emergence of a "disaster landscape" complicated the recovery of individuals and communities (Miller and Riviera 2008:9).

Studies of chronic community disorder—Studies of disasters complement sociological research on chronic disorder in communities, as characterized by weak community ties, poverty, and decaying physical infrastructure. Neighborhood research informs predictions about the effects of disaster-induced destruction at the community level and why predisaster attributes of communities may condition these effects.

Research on chronic disorder emerges from an older line of scholarship relating community attributes and social problems. Scholars theorized that high-functioning communities leverage economic, political, and social capital to navigate threats to community welfare (Coleman 1961). Poverty, residential instability, and population density and heterogeneity were thought to impede leveraging of these resources, resulting in negative social outcomes. Empirical work documented a spatial correlation between community composition and crime, deviance, and mental illness (e.g., Shaw and McKay 1942).

More recent research has emphasized the social and physical components of chronic disorder (Ross and Mirowsky 1999). Ross et al. (2000) found a significant correlation between residential stability, poverty, and psychological distress in the United States, which was largely explained by a scale measure of disorder capturing perceptions of neighborhood safety and sociality. Studying Los Angeles, Aneshensel and Sucoff (1996) found that poor socioeconomic status and low residential mobility predicted a neighborhood scale of "ambient hazards" that correlated with depression, anxiety, and behavior disorders among adolescents. Neighborhood studies now regularly include measurements of physical decay, termed "visible disorder" by Sampson and Raudenbush (1999).

An important issue discussed throughout neighborhood research is that individuals choose where to live, complicating isolation of the impact of neighborhood-level disorder from the impact of other choices that affect health.

Some analyses address this problem by considering the effects of neighborhood disorder on mental health using differenced estimates from longitudinal data (Hill et al. 2005). Others use experimental approaches. The Moving to Opportunity study, for example, recruited families from poor neighborhoods to participate in an experiment in which a randomly selected subsample were offered the chance to move to a better neighborhood. Mental health outcomes were better for adult women to whom housing vouchers were offered than for controls to whom vouchers were not offered (Kling, Liebman, and Katz 2007). Considerable debate has emerged over these results (e.g., Ludwig et al. 2008). Sampson (2008) elucidated many of the issues, noting that the Moving to Opportunity study did not change characteristics within neighborhoods and so could not inform discussions of how individuals fare when their neighborhood changes around them, a critical question for establishing policy implications (Thoits 2010).

Concern about selection highlights the value of an unexpected change for understanding the meaning and importance of community attributes, much as Erikson (1976) proposed nearly three decades ago. A disaster functions as an acute, unexpected, and external shock to communities. And though disasters reflect extreme experiences, several important links to the neighborhood literature are clear. The changes after a disaster constitute acute shifts in elements central to neighborhood research: residential instability, disruption of social networks, and decay of infrastructure. If these attributes are causal antecedents of mental health, an acute shift should produce a measurable impact on mental health.

Disasters also provide a window into the value of preexisting neighborhood-level attributes for individuals' abilities to navigate community change. Early scholarship on neighborhoods suggests that communities with attributes predicting greater cohesion among residents should fare better after a disaster (e.g., Coleman 1961). Some empirical work supports this prediction. Browning et al. (2006) showed that in the 1995 Chicago heat wave, mortality rates were higher in communities with alcohol-oriented businesses and dilapidated commercial buildings. However, with respect to traumatic stress specifically, Erikson (1976) suggested the opposite relationship: Community destruction is more traumatic in places with highly interdependent residents because they mourn the loss of decades of context-specific social capital.

In the present study, we consider these relationships in Indonesia, where poverty and inadequate physical infrastructure are known impediments to good health and where a large-scale disaster abruptly shifted the social and physical terrain of many communities.

Indonesia and the Sumatra-Andaman Earthquake and Tsunami

Our study draws on data from the Indonesian provinces of Aceh and North Sumatra. For several decades a conflict occurred in Aceh between the Indonesian government and guerrillas struggling for greater provincial autonomy, but a peace agreement ended the conflict nine months after the tsunami.

In both provinces, the village (*desa*) is the smallest of set of nested administrative subdivisions. Villages are salient, well-defined physical and social spaces. Every village has an elected leader, whose roles include supporting community activities and facilitating the implementation of government social safety net programs. The importance of the village as a social and economic unit is long standing. In Aceh, Hurgonje (1906) observed the communal functions of the village, noting that "sundry family matters such as marriage,

divorce, the bringing up of orphans, or changes in residence are treated in Aceh as matters affecting the whole *gampong* [village]" (p. 65). Traditional institutions of the community remain important components of daily life in Aceh and North Sumatra (Reid 2001:9; Singarimbun 1967:128).

On December 26, 2004, the Sumatra-Andaman earthquake struck, generating a 1,200-km rupture in the seafloor and displacing a trillion tons of water. The displacement generated a series of tsunami waves that slammed into the island of Sumatra shortly afterward, killing some 160,000 people (Lay et al. 2005; Rofi, Doocy, and Robinson 2006).

Overviews of the event mask considerable local variation in impact. At the beachfront in the city of Banda Aceh, water depths were 9 m but rarely exceeded the height of a two-story building farther inland (Borrero 2005). In some areas, the water scoured the earth's surface, obliterating buildings and vegetation. In other areas, the water deposited mud, sand, corpses, and debris but left structures intact. After the waves subsided, low-lying areas remained waterlogged (McAdoo, Richardson, and Borrero 2007).

DATA AND METHODS

Our study investigates several related questions. We examine evidence for (1) effects of community destruction on post-traumatic stress, (2) temporal patterns in the influences of community destruction and individual exposure to trauma, (3) heterogeneity in the effects of community destruction by pretsunami community characteristics, and (4) an interaction between individual- and community-level experiences of the disaster with respect to the emergence of posttraumatic stress reactions.

Data

The data come from the Study of the Tsunami Aftermath and Recovery (STAR), a longitudinal survey of some 27,000 adults in the tsunami-affected areas of Aceh and in nearby comparison areas inland and in North Sumatra. These individuals were living in households from which baseline data were collected in February 2004 by Statistics Indonesia as part of its annual cross-sectional Socioeconomic Survey (SUSENAS). SUSENAS serves as the baseline for our study (referred to as STAR0), providing a representative sample of the population before the disaster and allowing us to control for predisaster attributes.

With assistance from Statistics Indonesia, we fielded the first follow-up wave (STAR1) between May 2005 and July 2006. We targeted SUSENAS respondents from 11 *kabupaten* (districts) in Aceh and 8 *kabupaten* in North Sumatra, which together yielded 585 enumeration areas in 526 villages.

We sought to recontact all members of the original households. Here we include STAR0 respondents who would have been 15 years or older at the STAR1 interview ($n = 27,624$). We determined survival status for 99 percent of these individuals. Individuals whose survival status is unknown tended to be relatively better educated, from smaller households, and to reside, before the tsunami, in communities that sustained light damage.

Almost 7 percent of individuals whose survival status is known were killed in the tsunami. Of survivors, 91 percent were members of interviewed households, 1 percent refused, and 8 percent could not be located, despite intensive tracking. Failure to relocate survivors at STAR1 was positively associated with younger age, higher levels of education, and pretsunami residence in a heavily damaged zone and was negatively associated with being female or married.

Each wave contains information on socioeconomic and demographic characteristics. In STAR1 and STAR2, these modules were expanded, and data were collected from community leaders and enumerator direct observation.

Individual face-to-face reinterview rates were 93 percent in STAR1 and 90 percent in STAR2. We have individual data from two post-tsunami waves for 16,709 people. Few studies attempt to locate a large predisaster population after enormous devastation or to follow respondents for multiple years (Norris et al. 2002a). Security issues before the September 2005 peace treaty compounded the difficult field conditions of the first wave. Given the environment, we believe that attrition is low, but no other comparable study exists against which to benchmark our retention rates.

A central element of the research design is that survey communities vary in degree of exposure to the tsunami. We stratify communities into three groups that range in the extent to which the disaster damaged the community, from none to heavy (Figure 1).

Our classification scheme combines information from multiple sources. In each community, the leader was interviewed about damage to houses, roads, bridges, land, aquaculture, community buildings, and the mosque. Survey supervisors conducted independent observations of visible damage to these entities, which parallel observation-based measures of visible disorder in the literature on neighborhood disorder. We developed indices of reported and observed physical damage from these data (the correlation between the two is .8).

We also incorporate measurements of water inundation from satellite images. Our project team developed one of these measures using images from NASA's Moderate Resolution Imaging Spectroradiometer sensor. Images from December 17 and December 29, 2004, were geographically linked, and study sites were located on the grid. For an area .6 km² surrounding each site, we measure the degree to which ground cover in the pretsunami image changes to bare earth in the post-tsunami image.

We also use satellite-based indicators of inundation constructed by the U.S. government and the German remote sensing data center (correlations among the satellite-based measures range from .69 to .74) and a model-based flooding indicator developed by the Dartmouth Flood Observatory (correlations between the indicator from the flooding model and the satellite-based measures are lower, ranging from .28 to .42).

We classify communities as undamaged if they have no indications of either inundation or physical damage. We classify communities with high values on one or both measures as heavily damaged and the remaining communities as moderately damaged. Our classification maps well to variation in mortality. In the communities with heavy damage, an average of 29 percent ($SD = .3$ percent) of respondents died by the first follow-up, versus 2.5 percent ($SD = .034$ percent) and 1.5 percent ($SD = .018$ percent) in communities with moderate and heavy damage, respectively.

Methods

Our statistical task is to relate individuals' PTSR to exposure to trauma and destruction at the individual and community levels. We control for other disaster-related experiences, individual characteristics, and interview month.

Because individuals are nested within survey clusters, we estimate multilevel linear mixed models with random intercepts and random slopes (Rabe-Hesketh and Skrondal 2008). We begin by estimating equation 1:

$$P_{ic}^m = \alpha + \beta I_{ict=0} + \phi' \mathbf{L}_{ict=0} + \lambda' \mathbf{X}_{ict=-1} + \gamma' \mathbf{M}_{ic} + \varepsilon_{ic}^m \quad (1)$$

$$\alpha = \eta + \xi_x$$

$$\beta = \eta + \zeta_c$$

The outcome of interest, P_{ic}^m , is post-traumatic stress for individual i from community c , for which there are $m = 3$ post-tsunami measurements. This specification highlights the impact of individual-level measures of exposure. $I_{ict=0}$ is a scale measuring, for individual i in community c , exposure to trauma at the time of the tsunami ($t = 0$), and $\mathbf{L}_{ict=0}$ is a vector of measures of loss of family and property. $\mathbf{X}_{ict=-1}$ is a vector of individual characteristics. $\mathbf{M}_{ic}$ is a vector of indicator variables for the number of months since the tsunami. We allow the intercept for each community to include a random error component, ε_c . We also allow the coefficient estimated on the individual exposure index to include a random error component, ε_x , relaxing the assumption that the effect of individual exposure is identical across communities. In this and all following specifications, we flexibly allow the random component of the intercept, ε_c , and of the coefficient on individual exposure, ε_x , to covary.

In the second specification, we introduce $C_{ct=0}$, which is a scale measuring the level of tsunami-induced destruction to community c (in which individual i was living) at the time of the tsunami:

$$P_{ic}^m = \alpha + \beta I_{ict=0} + \delta C_{ct=0} + \phi' \mathbf{L}_{ict=0} + \lambda' \mathbf{X}_{ict=-1} + \gamma' \mathbf{M}_{ic} + \varepsilon_{ic}^m. \quad (2)$$

We then consider whether the effect of community destruction varies by community features in place before the disaster. We introduce a series of measures capturing community social and economic attributes in 2004, $D_{ct=-1}$, and assess whether these modify the effect of community destruction on post-traumatic stress (equation 3) by including interaction terms between the pretsunami community characteristics and the measure of community trauma ($D_{ct=-1} \times C_{ct=0}$):

$$P_{ic}^m = \alpha + \beta I_{ict=0} + \delta C_{ct=0} + \phi' \mathbf{L}_{ict=0} + \lambda' \mathbf{X}_{ict=-1} + \Psi' D_{ct=-1} + \pi' (D_{ct=-1} \times C_{ct=0}) + \gamma' \mathbf{M}_{ic} + \varepsilon_{ic}^m. \quad (3)$$

Finally we assess whether community destruction interacts with individual exposure by introducing a cross-level interaction ($I_{ict=0} \times C_{ct=0}$) between individual and community exposure:

$$P_{ic}^m = \alpha + \chi (I_{ict=0} \times C_{ct=0}) + \beta I_{ict=0} + \delta C_{ct=0} + \phi' \mathbf{L}_{ict=0} + \lambda' \mathbf{X}_{ict=-1} + \gamma' \mathbf{M}_{ic} + \varepsilon_{ic}^m. \quad (4)$$

Measures

Our stress measures are constructed from information on PTSR, assessed using 7 items from the 17-item PTSD Checklist Civilian Version (Weathers et al. 1993).

All respondents aged 15 years and older in the post-tsunami survey were asked about symptoms that cover the distinctive psychological domains of post-traumatic stress: hyperarousal, avoidance behaviors, and event reexperience. We asked about repeated disturbing memories, thoughts, dreams, or experiences of the tsunami; feeling very upset when reminded of the tsunami; avoiding activities or situations because they reminded the respondent of a stressful experience; feeling that one's future would be cut short; trouble falling or staying asleep; feeling irritable or having angry outbursts; and being supernalert or

on guard. In STAR1, respondents were asked whether each experience or feeling had occurred since the tsunami, its frequency when most intense, whether it was still occurring at the time of the interview, and how frequently. In STAR2, questions on current experience were repeated.

These data were used to construct PTSR scales, developed in Frankenberg et al. (2008). To measure the maximum level of PTSR an individual experienced between the tsunami and the STAR1 interview (which we refer to as maximum PTSR), responses to the questions on symptom frequency when most intense were scored from 0 (no occurrence) to 3 (occurred often) and summed across symptoms. The scale ranges from 0 to 21. Higher values reflect higher PTSR. Equivalent scales were constructed for PTSR at the time of the STAR1 and STAR2 interviews on the basis of current symptom intensity. The three scales measure PTSR at (1) its reported highest point after the tsunami but before the STAR1 interview (Cronbach's $\alpha = .70$); (2) at the STAR1 interview, on average 10 months after the tsunami ($\alpha = .67$); and (3) at the STAR2 interview, on average 22 months after the tsunami ($\alpha = .63$).

We present summary statistics for PTSR (Table 1, panel A) for the sample overall and by damage zone on the basis of the respondent's pretsunami residence. Overall, the mean reactivity, at 6.7, is highest for the measure based on symptom intensity between the tsunami and STAR1. By the time of the STAR1 interview, PTSR has fallen by about a third, to 4.3, where it remains at STAR2.

By damage zone, the measure of maximum PTSR between the tsunami and STAR1 exhibits a strong dose-response relationship. For the heavy-damage zone, PTSR, at 9.4, is 4 points higher than in the undamaged zone. By the time of the STAR1 interview, PTSR is lower in each zone, but the dose-response relationship remains. By STAR2, the scores in the heavily damaged and moderately damaged zones have fallen further, but in the zone without damage, scores have increased slightly, a pattern documented in the literature (Norris et al. 2002b).

We also build indices measuring individual-level traumatic experiences during the tsunami and the degree of destruction in the community.

The scale for tsunami-induced community destruction draws on five dichotomous indicators of dimensions emphasized in the literatures on disasters and neighborhood disorder: residential stability, visible disorder, and access to basic services. Two indicators relate to neighborhood stability: whether 20 or more people in the community were killed and whether five or more families relocated after the disaster (about 15 percent of communities meet these criteria). Another two indicators capture the tsunami's impact on visible disorder: whether property boundaries needed redrawing after the disaster (necessary in 27 percent of communities overall) and whether debris was a problem (an issue in 18 percent of communities overall). Finally, one indicator relates to basic sustenance: whether community water sources were contaminated by the tsunami (reported for 23 percent of communities).

The scale of community destruction, constructed by adding up the dichotomous indicators, ranges from 0 to 5. Mean levels by damage zone range from 3.1 in the heavily damaged area to 0.2 in the undamaged area (Table 1, panel B).

We develop a second scale measuring individual exposure to trauma. This scale is constructed by summing five dichotomous indicators of respondents' sensory experiences during the event that might produce extreme stress: hearing the water from the tsunami, seeing the water, being swept up in that water, sustaining an injury, and seeing people struggle in the water.

Approximately two thirds of respondents from communities in the heavily damaged zone heard the water, over half witnessed it, one third saw family or friends struggling in the water, almost one quarter were swept up in it, and 17 percent were injured as a result of it (Table 1, panel C). Such experiences are rare among those living in undamaged areas. Mean levels on the 5-point scale vary from 2 in the heavily damaged area to 0.1 in the undamaged area. The correlation between the community scale and the individual scale is .53.

Beyond community destruction and individual experiences, death of family and damage to property likely affect PTSR. We construct a dichotomous indicator of death of a spouse, parent, or child, which occurred for about a quarter of respondents in the heavy damage zone but for only 2 percent of those in the undamaged zone (Table 1, panel D). We measure property loss from information on whether assets were damaged. We include these measures so that our community-level measure will not simply reflect unmeasured individual experiences. Nevertheless we cannot categorically rule out this possibility.

We also control for respondent's age and sex, educational attainment, and economic well-being as measured by household per capita monthly expenditures. Age and education are specified using sets of dichotomous indicators (reference groups are ages 15 to 24 years and no education, respectively). We log-transform expenditures to adjust for skewness. These variables are all measured before the tsunami. Finally, we include month-of-interview fixed effects.

RESULTS

Individual- and Community-Level Exposure to the Tsunami

We begin by considering the relative contribution to PTSR of exposure to individual trauma and community destruction. The first three columns of Table 2 contain results from specifications that include the individual traumatic experiences scale. Column 1 presents the results for PTSR at its maximum between the disaster and the first follow-up interview, column 2 for PTSR at the first follow-up interview, and column 3 for PTSR at the second follow-up interview.

A clear pattern emerges. Individual exposure to trauma is strongly related to PTSR, regardless of the time point of measurement, but the effect attenuates over time. The magnitude of the individual exposure effect is greatest for the measure of PTSR at its maximum level between the tsunami and the first follow-up interview. Each 1-point increase in the scale is associated with a .81 increase in PTSR. The coefficient values are .57 and .29, respectively, for PTSR at the time of the STAR1 and STAR2 interviews. A similar pattern of decay over time emerges among the coefficients associated with losing a family member and with property damage.

We test whether community destruction exerts its own impact on PTSR independent of individual trauma in columns 4 to 6 of Table 2. The scale measuring extent of community destruction is a statistically significant predictor of PTSR at all measurement points. Each 1-unit increase in the community destruction scale increases the maximum level of PTSR by about .32 points. At the STAR1 and STAR2 interviews, the increase is .24 points.

The coefficients for individual exposure diminish as the time gap between the tsunami and the PTSR measurement increases. This diminution occurs for the measure of community destruction as well, but it is less marked. This result is consistent with the proposition that differences in the time frame over which effects of individual experiences emerge differs from that for the effects of community destruction. Our data suggest that the effects of

individual experiences are most extreme in the months after the event, whereas the effects of community destruction are more stable over the subsequent two years.

The remaining rows of Table 2 present the results for the other measures of individual loss and for background characteristics. PTSR is significantly higher for those who have lost a family member or whose assets were damaged, but the effect size diminishes by STAR2.

Women have higher PTSR scores than men. Scores for older adults are higher than for younger adults. With respect to individual characteristics, we find little to suggest that pretsunami socioeconomic resources are protective. Higher levels of household per capita expenditure are not significantly associated with levels of PTSR. Shortly after the tsunami, PTSR is higher among those with postsecondary schooling than for those with no schooling, but this relative elevation does not persist.

Our results provide strong evidence that mental health after a disaster is affected not only by individuals' own experiences but also by what happens in the community around them. Three possible issues threaten our interpretation of these results. First, differential attrition might introduce bias. Communities with higher levels of tsunami-induced destruction are communities in which more residents perished. If survivors are the least susceptible to PTSR, then our estimates of the effects of community trauma could be downwardly biased. Failure to reinterview certain respondents might also be selective. We assess this by comparing PTSR levels of those interviewed in only one versus both waves. PTSR levels are very similar, suggesting that failure to obtain multiple reinterviews is not correlated with PTSR (results available on request).

Another possible issue is that we do not control for the level of post-traumatic stress before the tsunami. Conceptually, post-traumatic stress is a reaction to a specific event, so before the event, the level of "baseline" PTSR in the population is assumed to be low, in this study and in the literature more generally. From a practical perspective, STAR0 does not include questions that support measurement of PTSR. We did test, for a small subsample that answered a special baseline module, whether the community trauma scale predicted any of four crude indicators of mental health before the tsunami. It did not, suggesting that our results do not reflect a correlation between pretsunami mental health and tsunami-induced community destruction (results available on request).

Third, our measures of individual exposure to trauma and loss may be inadequate, so that our estimate of the effect of community destruction simply reflects unmeasured individual exposures. We control rigorously for individual trauma and loss, but we cannot completely rule out this explanation. However, we have some analytical leverage in the form of duration of exposure to community destruction. If community destruction affects mental health, the impact should be stronger for those who stay in the community and experience daily exposure to its manifestations than for those who migrate away. On the other hand, if our community measure captures an unobserved element of individual trauma, the coefficient for community destruction should be similar or larger for those who move relative to the coefficient estimated for those who stay (because individual trauma is likely to be more intense among the displaced). We reestimate our models for PTSR at the STAR1 interview, stratifying by migration status since the time of the tsunami. Although the individual experiences of trauma are significant predictors of PTSR for both groups, the effect of community destruction is large and statistically significant only for the 12,014 people who remained in their communities after the tsunami ($\beta = .38$, $SE = .08$; full results available on request). This finding underscores our interpretation that it is the experience of living in a heavily damaged community that produces higher levels of post-traumatic stress.

Interaction of Community Destruction with Preexisting Community Attributes

The results discussed above reflect the average effect of community destruction across all communities. However, the effects may differ across different types of communities. For example, Erikson's (1976) research suggests that community destruction's toll on mental health may be higher in places previously characterized by tightly knit communal relationships. Alternatively, higher levels of cohesiveness before the tsunami may protect residents from the effects of community destruction.

To examine these competing hypotheses, we construct indicators of community characteristics before the disaster and interact each indicator with our measure of community destruction. We emphasize characteristics that have historically been considered predictive of community cohesiveness and thus may condition the effect of community trauma for individuals (Browning and Cagney 2002; Coleman 1961; Sampson and Groves 1989; Shaw and McKay 1942). Using data from STAR0, we measure whether the community was urban (19 percent), ethnically heterogeneous (36 percent), or poor (lowest quintile as measured by community-level average per capita household expenditures). Additionally, to incorporate Aceh's history, we consider whether the community experienced any significant incidents related to political security in the five years before the tsunami (17 percent).

Results from models that include the main effects for these terms and their interactions with the scale of community destruction are presented in Table 3.

Postdisaster PTSR appears to be strongly influenced by the economic resources at the community level that were in place when the disaster occurred (column 1). Net of household resources, respondents from the most impoverished communities prior to the disaster exhibit PTSR levels half a point higher than respondents from better-off communities. Ethnic heterogeneity and urban residence are not correlated with postdisaster PTSR, but respondents from communities that experienced political security incidents within the five years before the disaster have higher PTSR levels (by .85 points) than respondents who lived in communities without such events.

To test whether these preexisting community features modify the effects of community destruction, we introduce an interaction between each of these measures and the community destruction scale (columns 2 to 5 in Table 3). Interestingly, the interaction terms are not statistically significant for the indicators of poverty, urban status, or ethnic heterogeneity.

The most notable modifier of community trauma is the indicator of previous political insecurity. Disaster-related community destruction has a smaller effect on the PTSR of residents of communities with previous security-related incidents than on residents of communities that did not report incidents. Possibly residents of these villages did not rely heavily on communal resources before the disaster and so were less affected by community destruction caused by the tsunami. Such a finding is consistent with Erikson's hypothesis and with psychological research contending that PTSR emerges as a response to the realization that relationships and institutions are susceptible to abrupt and significant disruptions (Brewin and Holmes 2003).

Interaction of Community-Level Destruction with Individual-Level Exposure to Trauma

Our last question concerns whether community destruction in conjunction with individual trauma worsens stress reactions beyond what they would be in the presence of either factor alone. To explore this question, we introduce an interaction between the scales for individual trauma and community destruction (Table 4). For the measure of maximum PTSR and for PTSR at time of the first interview, the interaction is negative and statistically significant,

and the main effects and the interaction term are jointly significant. The relationship between PTSR and individual exposure to trauma is flatter in communities where community trauma was high than in communities where community trauma was minimal. This result implies that the impact on stress reactions of additional traumatic experiences at the individual level is dampened when the community as a whole has been heavily damaged and likewise that the impact of more intensive community destruction is dampened for individuals who experienced high levels of individual trauma. By the second interview, the interaction is effectively zero and statistically insignificant (though the main effects and the interaction term are jointly significant).

DISCUSSION

Disasters provide an opportunity to observe how individuals and societies fare in the face of sudden change, but data are rarely available to consider how individuals are affected by the changes to their communities while accounting for variation in their individual experiences. We develop and implement tests of hypotheses that relate community destruction to individual stress reactions using data encompassing hundreds of villages that span the areas hardest hit by the tsunami and the areas left undamaged.

Our results show unequivocally that community destruction increases PTSR, independent of the effects of rigorous controls for individual exposure to trauma and loss. Moreover, although the effect of community destruction is smaller in magnitude than the effect of individual exposure to trauma, the community effect attenuates more gradually. This finding is consistent with the idea that destruction to the community affects individuals along a different time path than individual experience of trauma.

We find that community-level poverty and political insecurity before the disaster are important predictors of individuals' post-traumatic stress response in the disaster's wake. Our finding on poverty echoes research on mortality after the Chicago heat wave, which documents elevated mortality in communities with preexisting commercial decline (Browning et al. 2006). We further demonstrate that the effects exist net of individual experiences during the disaster, suggesting that they do not reflect spatial variation in individuals' ability to avoid the event.

Finally, we observe that in the short term, the impact on post-traumatic stress of increasing levels of individual trauma is less severe for individuals from communities where the destruction to physical and social infrastructure was extreme. This finding is consistent with the idea of the importance of shared experience: that individual loss may be easier to bear when others have had similar experiences (Dynes et al. 1994:15; Erikson 1994:231).

Our research builds on previous studies in both sociological disaster research and psychological trauma research by giving serious consideration to the role of destruction of community. Our study contributes to the neighborhood literature in sociology as well by using a sudden and exogenous source of variation in the level of disorder within the community (in this case induced by the tsunami) to predict individual well-being. The approach provides an unusual opportunity to measure the effects of community change without the concerns that distressed individuals select into neighborhoods with higher levels of disorder or that a third unmeasured characteristic causes both individual distress and community disorder. We demonstrate that community destruction has a profound and persistent causal effect on the mental health of residents.

Disasters undoubtedly represent a specific type of community trauma, but scholars have long argued that disasters change communities in ways that illuminate otherwise unobservable community functions. Our study's emphasis on trauma links research on

disasters to neighborhood research, in which post-traumatic stress is widely used as an outcome influenced by chronic poverty and violence (see Fowler et al. 2009; Wandersman and Nation 1998). One difference is that under conditions of long-term exposure, a process of habituation may occur. If so, the effect of a sudden change after a disaster may be larger than the sum of a series of ongoing acts of violence or negligence experienced in chronically dysfunctional neighborhoods. Indeed, our finding that community destruction matters less for residents of communities with previous incidents of political insecurity suggests this possibility.

The acute nature of our example does parallel other approaches to understanding the importance of community. In the Moving to Opportunity experiment, for example, community context shifted abruptly because of the movement of individuals into new neighborhoods; in the case of Indonesia, community context shifted abruptly when neighborhoods changed around individuals. Our approach is relevant for the study of neighborhood effects given that external sources of community change are relatively common. Public policy innovations, for example, frequently involve community-level interventions.

Disaster itself is not uncommon. In the past decade, more than 4,000 disasters with significant structural and mortality impacts have been documented worldwide (Vos et al. 2010). Although the 2004 tsunami was extreme, subsequent events in the United States, China, Pakistan, Haiti, and Japan have been similar in scope and in the spatial heterogeneity of their impacts.

Community destruction in the aftermath of a disaster can be characterized in many ways. We construct our measure with two goals in mind. First, we aim to capture both social and physical dimensions of destruction, because both dimensions are important in the literatures on why neighborhoods matter for individual well-being and on how disasters affect well-being. Second, we focus on the dimensions of community change that are sudden, unexpected, and beyond the control of individual community members. This second goal is critical to our argument that we are analyzing a natural experiment to establish the causal effect of community change on well-being.

By designing our study as a test of the exogenous effects of community change on mental health, we preclude ourselves from examining differences that emerge across communities after the disaster with respect to the restoration of communality. It may be that failure of a community to recover impairs individuals' abilities to recover from their own independent exposure to trauma, whereas individual recovery trajectories proceed more smoothly when community functions are quickly restored, as suggested in the literature on community resilience. At the same time, community function may return more promptly when residents' mental health recovers quickly. In this relationship, cause and effect likely run in both directions, making it difficult to isolate either effect.

We can harness the STAR data to describe community-level recovery after the disaster. Indeed, the pace varies across communities, both in terms of successful reconstruction of local infrastructure and with respect to residents' participation in the process. Among the communities most heavily damaged, for example, a handful were unable either to maintain or to resuscitate the community development programs in place before the tsunami, but a number of other communities did both. Addressing community restoration descriptively by identifying features associated with quicker recovery heeds the emphasis in ethnographies of disaster to remember both the importance of communal ways of life in general and the importance of restoring communal life after a disaster.

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Biographies

Elizabeth Frankenberg is a professor of public policy and sociology at Duke University. She studies health and development in low-income settings.

Jenna Nobles is an assistant professor of sociology at the University of Wisconsin. She studies health, development, and family change in low-income settings.

Cecep Sumantri is a senior project director at Survey-METER in Indonesia, working in health, education, and household surveys.

Figure 1.
Map of Northern End of Sumatra Island, with Survey Clusters Coded by Degree of Damage

Table 1**Summary Statistics**

Variable	Overall	Extent of Damage		
		Heavy	Some	None
A. Individual-level dependent variables				
Post-traumatic stress reactivity				
At maximum between tsunami and wave 1	6.7 (4.5)	9.4 (4.9)	7.1 (4.3)	5.5 (4.3)
At wave 1 interview	4.3 (3.6)	6.1 (3.7)	4.9 (3.6)	3.2 (3.2)
At wave 2 interview	4.4 (3.8)	5.5 (4.1)	4.4 (3.7)	4.0 (3.6)
B. Community-level indicators of tsunami-induced destruction				
20 people killed (percent)	13	52	5	4
5 families relocated (percent)	12	36	12	1
Property boundaries redrawn (percent)	27	61	25	13
Problems with debris (percent)	18	80	8	0
Water contaminated (percent)	23	84	17	1.4
Overall score (0–5)	.9 (1.3)	3.1 (1.3)	.7 (.8)	.2 (.4)
Number of communities	526	94	220	212
C. Individual-level indicators of traumatic experiences and loss				
Components of the scale of individual trauma				
Heard water (percent)	21	68	24	5
Saw water (percent)	14	54	14	2
Saw family/friends struggle (percent)	6	33	4	1
Swept up in water (percent)	4	22	2	.6
Injured in tsunami (percent)	3	17	3	.5
Overall score (0–5)	.5 (1.1)	2.0 (1.6)	.5 (.9)	.1 (.5)
D. Other controls for individual loss				
Death of a family member (percent)	6	25	4	2
Damage to household or business assets (percent)	28	82	32	8
Number of individuals (<i>n</i>)	16,709	2,022	7,244	7,443

Source: Study of Tsunami Aftermath and Recovery.

Note: Standard errors are reported in parentheses.

Table 2
Relationship between PTSR and Exposures to Individual and Community Trauma ($n = 16,709$)

Variable	Without Community Destruction			With Community Destruction		
	PTSR Maximum ^a	PTSR First Interview	PTSR Second Interview	PTSR Maximum ^a	PTSR First Interview	PTSR Second Interview
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to community destruction				.32** (.07)	.24** (.06)	.24** (.06)
Exposure to individual trauma	.81** (.05)	.57** (.04)	.29** (.04)	.74** (.05)	.51** (.04)	.26** (.04)
Death of any family member	1.11** (.15)	.86** (.12)	.37** (.14)	1.02** (.15)	.79** (.12)	.30* (.14)
Damage to assets	1.16** (.10)	.70** (.08)	.36** (.09)	1.07** (.10)	.64** (.08)	.28** (.09)
Female	.70** (.06)	.53** (.05)	.49** (.06)	.70** (.06)	.53** (.05)	.48** (.06)
Age (reference: 15–24 years)						
25–39 years	.51** (.08)	.53** (.06)	.39** (.07)	.51** (.08)	.53** (.06)	.39** (.07)
40–59 years	.55** (.09)	.66** (.07)	.61** (.08)	.56** (.09)	.66** (.07)	.62** (.08)
60 years	.39** (.14)	.64** (.11)	.61** (.12)	.39** (.14)	.64** (.11)	.61** (.12)
Education (reference: 0 years)						
1–6 years	.18 (.14)	-.15 (.11)	-.06 (.13)	.18 (.14)	-.15 (.11)	-.06 (.13)
7–12 years	.23 (.15)	-.18 (.12)	-.12 (.13)	.23 (.15)	-.18 (.12)	-.12 (.13)
13 years	.57** (.18)	.03 (.15)	-.28 (.16)	.56** (.18)	.02 (.15)	-.29 (.16)
Household per capita expenditure in 2004 (ln)	-.05 (.07)	-.05 (.05)	-.05 (.06)	-.06 (.07)	-.06 (.05)	-.06 (.06)
Constant	5.24** (.86)	3.05** (.69)	4.38** (.76)	5.16** (.86)	2.98** (.69)	4.33** (.76)
Log likelihood	-46,898	-43,114	-44,917	-46,887	-43,106	-44,909

Source: Study of Tsunami Aftermath and Recovery.

Note: PTSR = post-traumatic stress reactivity. Results from mixed linear effects models. Month-of-interview fixed effects are included. Robust standard errors are in parentheses.

^a Maximum value of post-traumatic stress experienced between the tsunami and the first post-tsunami interview.

* $p < .05$ and

** $p < .01$ (two-tailed tests of significance).

Table 3
Pretsunami Community Characteristics and Post-Traumatic Stress Reactivity at STAR1

Variable	(1)	(2)	(3)	(4)	(5)
Exposure to community destruction	.27** (.06)	.27** (.06)	.27** (.07)	.24** (.06)	.36** (.06)
Exposure to individual trauma	.50** (.04)	.50** (.04)	.50** (.04)	.50** (.04)	.50** (.04)
Death of any family member	.79** (.12)	.79** (.12)	.79** (.12)	.80** (.12)	.78** (.12)
Damage to assets	.64** (.08)	.64** (.08)	.64** (.08)	.64** (.08)	.65** (.08)
Household per capita expenditure in 2004 (ln)	-.00 (.05)	-.00 (.05)	-.00 (.05)	-.05 (.05)	-.00 (.05)
Community characteristics					
Less than 20th percentile per capita expenditures	.51** (.17)	.47* (.20)	.51** (.17)	.51** (.17)	.49** (.17)
Multiethnic	-.22 (.14)	-.22 (.14)	-.24 (.17)	-.21 (.14)	-.19 (.14)
Urban	-.25 (.17)	-.25 (.17)	-.25 (.17)	-.42* (.21)	-.29 (.17)
Political security event	.85** (.18)	.85** (.18)	.85** (.18)	.86** (.18)	1.25** (.21)
Community destruction × impoverished		.05 (.15)			
Community destruction × multiethnic			.02 (.11)		
Community destruction × urban				.16 (.12)	
Community destruction × security event					-.46** (.13)
Constant	2.13** (.72)	2.13** (.72)	2.14** (.72)	2.14** (.72)	2.02** (.72)
Pretsunami sociodemographic controls	Yes	Yes	Yes	Yes	Yes
<i>n</i>	16,709	16,709	16,709	16,709	16,709
Log likelihood	-43,085	-43,085	-43,085	-43,084	-43,079

Source: Study of Tsunami Aftermath and Recovery (STAR).

Note: Results from mixed linear effects models. Pretsunami measures of gender, age, and education are included in specifications but not shown. Month-of-interview fixed effects are included. Robust standard errors are in parentheses.

* $p < .05$ and

** $p < .01$ (two-tailed tests of significance).

Table 4

Effect on PTSR of Cross-level Interaction between Exposures to Individual Trauma and Community Destruction

Variable	PTSR Maximum between Tsunami and First Interview	PTSR at First Interview	PTSR at Second Interview
	(1)	(2)	(3)
Interaction: community destruction × individual trauma	-.13 ** (.03)	-.10 ** (.03)	-.02 (.02)
Exposure to community destruction	.47 ** (.08)	.36 ** (.07)	.26 ** (.06)
Exposure to individual trauma	.94 ** (.07)	.67 ** (.06)	.28 ** (.06)
Death of any family member	1.06 ** (.16)	.82 ** (.12)	.30 * (.14)
Damage to assets	1.04 ** (.10)	.62 ** (.08)	.27 ** (.09)
Constant	5.06 ** (.86)	2.92 ** (.69)	4.32 ** (.76)
Pretsunami sociodemographic controls	Yes	Yes	Yes
<i>n</i>	16,709	16,709	16,709
Log likelihood	-46,880	-43,099	-44,909

Source: Study of Tsunami Aftermath and Recovery.

Note: Results from mixed linear effects models. Pretsunami measures for gender, age, education, and per capita household expenditures are included in specifications but not shown. Month-of-interview fixed effects are also included. Robust standard errors are in parentheses.

*
 $p < .05$ and

**
 $p < .01$ (two-tailed tests of significance).