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Elizabeth Frankenberg
Jed Friedman
Thomas Gillespie
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Robert Pynoos
lip Umar Rifai
Bondan Sikoki
Alan Steinberg
Cecep Sumantri
Wayan Suriastini
Duncan Thomas

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Mental Health in Sumatra After the Tsunami

Elizabeth Frankenberg, PhD, MPA, Jed Friedman, PhD, Thomas Gillespie, PhD, Nicholas Ingwersen, BA, Robert Pynoos, MD, MPH, Iip Umar Rifai, AMa, Bondan Sikoki, MA, Alan Steinberg, PhD, Cecep Sumantri, MPH, Wayan Suriastini, MA, and Duncan Thomas, PhD

Objectives. We assessed the levels and correlates of posttraumatic stress reactivity (PTSR) of more than 20 000 adult tsunami survivors by analyzing survey data from coastal Aceh and North Sumatra, Indonesia.

Methods. A population-representative sample of individuals interviewed before the tsunami was traced in 2005 to 2006. We constructed 2 scales measuring PTSR by using 7 symptom items from the Post Traumatic Stress Disorder (PTSD) Checklist–Civilian Version. One scale measured PTSR at the time of interview, and the other measured PTSR at the point of maximum intensity since the disaster.

Results. PTSR scores were highest for respondents from heavily damaged areas. In all areas, scores declined over time. Gender and age were significant predictors of PTSR; markers of socioeconomic status before the tsunami were not. Exposure to traumatic events, loss of kin, and property damage were significantly associated with higher PTSR scores.

Conclusions. The tsunami produced posttraumatic stress reactions across a wide region of Aceh and North Sumatra. Which factors emerged as the most important varied by the degree of damage in the community. (*Am J Public Health.* 2008;98:XXX–XXX. doi:10.2105/AJPH.2007.120915)

The tsunami associated with the December 26, 2004, Sumatra–Andaman earthquake killed some 250 000 people along the coastlines of the Indian Ocean. Indonesia was the country most devastated by the tsunami. Some 130 000 Indonesians died, and more than 500 000 were displaced.[1] Survivors experienced stresses known to adversely affect mental health, including fear of dying, exposure to dead bodies, loss of loved ones, community disruption, and physical and economic hardship.[2,3] We evaluated posttraumatic stress reactivity (PTSR) among adult tsunami survivors in Aceh and North Sumatra, the Indonesian provinces where damage was concentrated.

Our study sample, unlike most studies of mental health after a disaster, was representative of the predisaster population living in areas directly affected by the tsunami, as well as those living in similar areas not directly affected. Respondents had been interviewed in February 2004 before the tsunami as part of the National Socioeconomic Survey (SUSENAS), an annual population-based cross-sectional survey conducted by Statistics Indonesia. The SUSENAS survey was representative at the district level and based on a stratified multistage cluster design.

With assistance from Statistics Indonesia, we fielded the first wave of the Study of the Tsunami Aftermath and Recovery (STAR) between May 2005 and July 2006. We sought to recontact 39 500 individuals originally interviewed in 2004 in 585 survey communities.

We focused on PTSR, the most commonly identified psychological problem among adult survivors of disasters.[2] We had 3 primary objectives: (1) to describe the course of reactions over time, (2) to examine variation associated with degree of damage in the community in which the respondent was living before the tsunami, and (3) to assess the correlation of PTSR to pretsunami characteristics, with exposure to traumatic events, loss of family and friends, and property damage as a result of the tsunami.

Because our sample included respondents from communities spanning a continuum of damage, the results provided a comparison of mental health after a disaster in heavily damaged areas against mental health in areas that were not directly affected by the tsunami. We used high-resolution remotely sensed imagery to quantify destruction in the aftermath of a disaster and thereby illustrate the potential value of combining remotely sensed imagery with survey data in public health research. Because we will be collecting several additional waves of data from the same respondents, the results presented here introduce a longitudinal study that will track the evolution of mental health during disaster recovery and rebuilding. This is important because there is very little scientific evidence on mental health trajectories after such events.[4]

METHODS

We attempted to contact all SUSENAS respondents who had been living in coastal areas of Aceh and North Sumatra before the tsunami. Although we attempted to contact all ages, for purposes of this study we analyzed only those 15 years and older. Of the 25 778 age-eligible (15 years and older) target respondents, we traced 25 004 (97%). Among them, 6.3% had died, 0.6% refused to participate in our follow-up survey, and 16% had moved to new locations (three quarters of whom were interviewed in their new location). We completed face-to-face individual interviews with 98% of those who were recontacted, yielding a sample of more than 20 500 adults. Interviews took place 5 to 17 months after the tsunami, after obtaining oral informed consent from all study participants.

Our survey instrument covered multiple dimensions of health, socioeconomic status, consequences of the tsunami, and experience of posttraumatic stress reactivity. Questions regarding traumatic exposure asked about experiences during and immediately after the tsunami with yes/no items ranging from whether the respondent had felt the earthquake to whether the respondent had seen or been caught in the tsunami wave, saw family or friends disappear, or sustained injuries. Respondents were asked if they had had a living spouse, mother, father, daughter, son, or sibling at the time of the tsunami and whether any of these specific relatives or other family and friends had died. Other questions focused on property damage.

Information Collected From Each Respondent Aged 15 Years and Older Regarding 7 Items From the Post Traumatic Stress Disorder (PTSD) Checklist–Civilian Version

For each item (A) through (G):
Q1: Since the tsunami, have you ever experienced (item)?
If yes,
Q2. During the time, you experienced (item) most strongly, did it occur (1) Rarely (2) Sometimes (3) Often?
Q3. When did (. . .) start?
Q4. Do you still experience (item)? (1) No (2) Sometimes (3) Often?
If not still experiencing
Q5. How long did it last?
Items
(A) Repeated, disturbing memories, thoughts, dreams, or experiences of tsunami
(B) Feeling very upset when something reminded you of tsunami
(C) Avoiding activities or situations because they reminded you of a stressful experience
(D) Feeling as if your future will somehow be cut short
(E) Trouble falling or staying asleep
(F) Feeling irritable or having angry outbursts
(G) Being "super alert," watchful, or on guard

We assessed PTSR by using 7 symptom items from the 17-item PTSD Checklist–Civilian Version.[5] This instrument has been validated with veterans, victims of accidents and sexual assault, and survivors of bone marrow transplants.[6,7] The items listed in the box on this page were asked of all respondents aged 15 years and older in our survey. For each item, respondents provided information on whether they had experienced the reaction since the tsunami and if so, when it began, how frequently they had experienced it at its maximum intensity, whether they continued to experience it, and with what frequency.

We used these data to construct PTSR scales consistent with empirical evidence of a stress-response continuum.[8,9] To measure posttsunami levels of PTSR, responses to the questions regarding whether the respondents had ever experienced the symptom were scored from 0 (no occurrence) to 3 (occurred often when it was experienced most intensely) and summed across the symptoms. The resulting scale ranged from 0 to 21 (Cronbach's $\alpha=0.70$). We created an equivalently constructed scale for PTSR at the time of the interview (Cronbach's $\alpha=0.67$) using information on current symptom intensity.

Symptoms of posttraumatic stress are known to be strongly linked to the degree of exposure to trauma.[2,10–12] Some research shows that beyond individual experiences, the degree of destruction to one's community as a whole may matter as well.[13] Although the earthquake rocked all the survey communities, the destructive power of the subsequent tsunami varied greatly. Generally, the tsunami diminished in force and magnitude with distance from the earthquake epicenter.[14] On a more localized scale, the height of water from the tsunami on shore varied with slope, water depth, and topography.[15]

We constructed a community-level measure of destruction by using remotely sensed data from the National Aeronautics and Space Administration's (NASA's) Moderate Resolution Imaging Spectroradiometer (MODIS) sensor (Goddard Flight Center, Greenbelt, MD). Images from December 17, 2004, and December 29, 2004, were geographically linked using the MODIS reprojection tool. Measurements of latitude and longitude were used to locate the study sites on the grid. For each of the 585 survey communities, an area of 0.6 km^2 was defined with the study site at the center. Within this area, we assessed the degree to which the pretsunami ground cover visible in the first image had been replaced by bare earth in the second image. Communities were stratified into 3 zones based on the extent of damage. Approximately 15% of the areas were classified as heavily damaged (at least 20% of pretsunami ground cover replaced by bare earth). Approximately 35% were classified as undamaged by the tsunami (no change in ground cover). The remaining communities were classified as moderately damaged. Although this classification is perhaps imperfect, it corresponds well with other evidence gathered independently by our interviewers during their visits to survey communities.

First, there were strong and statistically significant correlations between the remotely sensed measures of damage and community leaders' retrospective reports as well as field supervisors' observations of the degree of damage in each of the survey communities (polychoric correlations were 0.84 and 0.79, respectively). Second, mortality for primary adults in the period between the SUSENAS and STAR surveys were much higher in areas that were more heavily damaged relative to rates in areas that were either moderately damaged or that were not damaged.

Descriptive statistics for the analytic sample are presented in Table 1. Tables 2 and 3 report results from multivariate ordinary least squares regressions that relate the PTSR scales to geographic characteristics of the respondent's residence in 2004, demographic characteristics and markers of socioeconomic status (measured before the tsunami), and measures of exposure, loss of family and friends, and property damage as a result of the tsunami. Variance–covariance estimates took into account heteroscedasticity and clustering of respondents within survey communities.[16] Analyses were conducted with Stata version 9 (StataCorp LP, College Station, TX).

RESULTS

Summary Statistics

Our analytic sample consisted of tsunami survivors who were first interviewed in February 2004. Across the sample as a whole, respondents lived an average of 17.6 km from the coast and just over half were female. Respondents were on average aged 36 years with 8 years of schooling. At the time of the tsunami, approximately 60% were married and nearly 75% had a living parent. Household monthly spending (per capita), an indicator of resource availability, averaged about US$45.

Approximately 33% of the respondents experienced the trauma of either hearing the

TABLE 1—Sample Characteristics, by Zone: Aceh and North Sumatra, Indonesia, May 2005 to July 2006

Characteristics	Overall (n = 20 539)	Heavily Damaged (n = 2802)	Moderately Damaged (n = 10 437)	Undamaged (n = 7300)
Demographic characteristics				
Distance from the coast, km, mean (SD)	17.61 (22.18)	2.58 (2.20)	10.10 (12.98)	34.11 (26.50)
Women, no. (%)	10 643 (52)	1 388 (49)	5 425 (52)	3 830 (52)
Age, y, mean (SD)	35.63 (14.92)	35.72 (14.81)	35.78 (14.87)	35.38 (15.02)
Education, y, mean (SD)	7.93 (4.23)	8.94 (4.44)	7.80 (4.37)	7.73 (3.89)
Married at tsunami, no. (%)	12 405 (60)	1 627 (58)	6 367 (61)	4 411 (60)
Parent(s) alive at tsunami, no. (%)	15 078 (73)	2 123 (76)	7 647 (73)	5 310 (73)
Own a house or household goods, no. (%)	20 178 (98)	2 737 (98)	10 276 (98)	7 165 (98)
Own land livestock or equipment	16 963 (83)	2 461 (88)	8 684 (83)	5 818 (80)
Per capita monthly expenditures, US $, mean (SD)	45.45 (92.97)	52.30 (50.47)	46.31 (122.35)	41.59 (43.68)
Tsunami-related traumatic events				
Heard tsunami wave or heard screams about tsunami wave, no. (%)	7 001 (34)	2 314 (83)	4 266 (41)	421 (6)
Saw family or friends struggle or disappear, no. (%)	1 332 (6)	701 (25)	599 (6)	32 (0)
Sustained injuries, no. (%)	691 (3)	372 (13)	309 (3)	10 (0)
Spouse died, no. (% among those married)	382 (3)	146 (9)	160 (2)	76 (2)
Child or parent died, no. (%)	921 (4)	509 (18)	373 (4)	39 (1)
Other family member or friend died, no. (%)	4 817 (23)	1 694 (60)	2 744 (27)	349 (5)
Home or household goods damaged, no. (%)	5 160 (25)	1 680 (60)	3 094 (30)	386 (5)
Land, livestock, or equipment damaged, no. (%)	3 084 (15)	1 319 (47)	1 653 (16)	112 (2)
PTSR scale (0–21)				
At time of interview, mean (SD)	4.24 (3.58)	5.77 (3.62)	4.71 (3.61)	2.98 (3.10)
Point of maximum intensity since tsunami, mean (SD)	6.58 (4.55)	8.80 (4.88)	6.95 (4.43)	5.21 (4.13)

Note. PTSR = posttraumatic stress reactivity.

tsunami wave or screams about it, and 6% watched family or friends struggle or disappear. Only 3% of the respondents sustained injuries. Overall, 3% lost a spouse, 5% lost a parent or child, and nearly 25% of respondents lost other family or friends. Damage or loss of a home or household goods affected 25% of the respondents, and 15% suffered damage or loss of land, livestock, or equipment.

The statistics for the overall sample mask substantial differences across the damage zones. Respondents were assigned to the community in which they were living before the tsunami. Almost 85% of respondents who were living in the heavy-damage zone heard the tsunami wave or screams about it, 25% watched friends or family struggle, 61% lost a family member or friend, and a similar proportion suffered property damage. Such experiences were extremely rare among respondents from the undamaged zone.

With respect to the PTSR index, respondents averaged a score of 4.24 (out of 21) at the time of our interview. This represented a decline of approximately 33% from a mean value of 6.58 for the index computed using the retrospective information on symptom intensity at any point since the tsunami. Differences in mean scores across the damage zones tracked variation in exposure. At the time of the interview, the mean scores were 5.77, 4.71, and 2.98 for those from heavily, moderately, and undamaged areas, respectively. For the score measuring PTSR since the tsunami, the relative differences across regions were similar: 8.80, 6.95, and 5.21 for those from heavily damaged, moderately damaged, and undamaged areas, respectively.

In 2004, a 10% subset of SUSENAS respondents had been asked about difficulty sleeping. The questions were asked again in our survey. Analysis of these data revealed that before the tsunami there were no reported differences in sleeping difficulties across damage zones. Sleeping difficulties were reported in all 3 zones in 2005, and differences across zones were statistically significant. The largest before–after increase occurred in the most heavily damaged areas, suggesting that the tsunami affected mental health and that posttsunami comparisons of PTSR across damage zones are a fruitful means of assessing the effect of the tsunami.

Multivariate Regression Analyses

Table 2 reports the results from multivariate ordinary least squares regressions for the 2 indicators of PTSR for the sample overall, as well as the F statistics for joint significance of each covariate group. Each regression controls the characteristics included in Table 1, the interview month, and the district of residence at the time of the 2004 interview (results not shown). Overall, each model explains just over 20% of the variance in PTSR.

For both PTSR measures, as the distance of the respondent's pretsunami residence from the coast increased, his or her PTSR score decreased, indicating relatively better mental health. When controlling for distance from the coast, the indicators for damage zone are not statistically significant. PTSR scores were significantly higher for females than for males. With respect to age, which is specified as a linear spline with knots at 30 and 50 years, scores rose among respondents younger than 30 years and, for PTSR since the tsunami, fell among respondents 50 years and older. As a group, these demographic attributes were highly significant.

The PTSR scores at the time of the interview were lower among respondents with a parent alive before the tsunami. Being married before the tsunami was unrelated to the PTSR score. The measures of education and economic resources were not significantly associated with PTSR, nor were these factors statistically significant as a group.

Most factors associated with the direct consequences of the tsunami for survivors exhibited positive and statistically significant associations with PTSR scores, indicating poorer mental health. In combination, hearing the tsunami wave or screams about it,

TABLE 2—Variables Used in Multivariate Analysis of PTSR Scales: Aceh and North Sumatra, Indonesia, May 2005 to July 2006

Variable	PTSR Maximum Since Tsunami, b (95% CI) or F (*P*)	PTSR at Interview, b (95% CI) or F (*P*)
Distance from coast, km	–0.02 (–0.03, –0.01)	–0.02 (–0.03, –0.01)
Heavily damaged zone	0.02 (–0.47, 0.51)	0.03 (–0.38, 0.44)
Moderately damaged zone	0.10 (–0.09, 0.43)	0.17 (–0.09, 0.43)
Female	0.69 (0.57, 0.81)	0.54 (0.45, 0.63)
Age, y (spline)		
15–29	0.44 (0.25, 0.63)	0.51 (0.37, 0.66)
30–49	0.01 (–0.11, 0.13)	0.04 (–0.05, 0.14)
≥50	–0.22 (–0.36, –0.07)	–0.09 (–0.21, 0.03)
Married at the time of the tsunami	0.12 (–0.06, 0.31)	–0.01 (–0.16, 0.12)
Parents alive at the time of the tsunami	–0.08 (–0.26, 0.08)	–0.17 (–0.30, –0.04)
Years of education	0.00 (–0.02, 0.02)	–0.01 (–0.27, 0.00)
Monthly per capita expenditure level (natural log)	0.06 (–0.09, 0.21)	0.05 (–0.06, 0.17)
Owned house or household goods	–0.16 (–0.71, 0.39)	–0.25 (–0.65, 0.14)
Owned land, livestock, or equipment	0.09 (–0.11, 0.29)	0.03 (–0.13, 0.19)
Heard tsunami wave or screams about the tsunami wave	1.22 (0.92, 1.51)	0.73 (0.51, 0.96)
Sustained injury	1.07 (0.64, 1.51)	0.88 (0.49, 1.26)
Saw family or friends struggle or disappear	0.70 (0.35, 1.06)	0.69 (0.38, 1.00)
Spouse died	0.41 (–0.03, 0.86)	0.52 (0.15, 0.88)
Child or parent died	1.06 (0.74, 1.39)	0.96 (0.69, 1.22)
Friend or other family	1.17 (0.92, 1.41)	0.51 (0.32, 0.71)
House or household goods damaged	0.67 (0.40, 0.93)	0.38 (0.16, 0.59)
Land, livestock, or equipment damaged	0.68 (0.35, 1.00)	0.49 (0.23, 0.75)
Constant	3.88 (1.82, 5.93)	0.70 (–0.83, 2.23)
Geographic attributes	5.55 (.001)	11.28 (.001)
Demographic attributes	41.10 (.001)	55.09 (.001)
Kinship network	1.30 (.27)	3.20 (.04)
Education and economic resources	0.48 (.74)	1.02 (.40)
Exposure to trauma	45.61 (.001)	42.65 (.001)
Death of loved ones	52.23 (.001)	33.67 (.001)
Property damage	24.48 (.001)	16.81 (.001)

Note. PTSR = post traumatic stress reactivity; CI = confidence interval. Controls for month of interview and district of residence at the time of the tsunami are included. Standard errors adjust for clustering at the level of the survey community. R^2 for PTSR maximum since tsunami was 0.22, for PTSR at interview it was 0.21.

sustaining an injury, and watching friends or family struggle or disappear in the wave added about 3 points to PTSR scores since the tsunami and added about 2.3 points to PTSR scores at interview. Relative to exposure to traumatic events, the combined effects of death of friends and family were smaller in magnitude both for PTSR since the tsunami and at the time of the interview. Property damage was also positively and significantly associated with higher PTSR scores for both measures.

The correlates of the 2 measures of PTSR were very similar. For the exposure measures, the parameter estimates were typically smaller in magnitude in the model of PTSR at interview than in the model of PTSR since the tsunami, with 2 exceptions. The parameter estimate associated with seeing friends or family struggle or disappear remained the same across the 2 specifications, indicating persistence in the effect over time. The parameter estimate for losing a spouse actually increased in size and became statistically significant at conventional levels for PTSR at interview.

Table 3 reports the regressions stratified by damage zone for PTSR scores at interview and the F statistics for joint significance of each covariate group. Some important differences emerged across zones. With respect to demographic characteristics, the negative implications for PTSR of being female were considerably stronger for women from the heavily damaged zone than for those from the moderately damaged zone. Age, on the other hand, was unrelated to PTSR for those from the heavy damage zone but strongly related to PTSR for those from the moderately damaged and no-damage zones.

The measures of tsunami consequences were important predictors of PTSR score. For those from the moderately damaged zone, the parameter estimates associated with being injured or watching family or friends struggle were 2 to 3 times larger than they were for those from the heavily damaged zone. The measures of loss of loved ones were strong predictors for respondents from both zones, but their importance relative to the indicators of traumatic exposure was greater for respondents from the heavily damaged zone. Finally, the PTSR scores of the respondents in the heavily damaged zone were unaffected by damage to home or household goods; however, damage to land, livestock, or equipment had a strong positive effect on the score. For respondents from the moderately damaged zone, the indicators of damage to both types of property were statistically significant.

In the undamaged zone, the measures of tsunami consequences were specified differently because their occurrence was rare. We combined the 3 measures of exposure to traumatic events into 1 indicator, which equaled 1 if the respondent experienced any of the traumatic occurrences (and 0 otherwise). Likewise, we combined the 3 measures of death into 1 indicator, which equaled 1 if the respondent lost any family or friends, and 0 otherwise. For those from the no-damage zone, the indicator of traumatic experiences was large, positive, and statistically significant. The indicators of loss of family and friends and damage to

TABLE 3—Multivariate Analysis of PTSR Scale at Interview, Stratified by Damage Zone: Aceh and North Sumatra, Indonesia, May 2005 to July 2006

Variable	Heavily Damaged, b (95% CI) or F (*P*)	Moderately Damaged, b (95% CI) or F (*P*)	Undamaged, b (95% CI) or F (*P*)
Female	0.82 (0.55, 1.10)	0.47 (0.35, 0.60)	0.52 (0.39, 0.66)
Age, y (spline)			
15–29	0.05 (–0.31, 0.40)	0.74 (0.53, 0.95)	0.42 (0.20, 0.64)
30–49	0.09 (–0.16, 0.35)	–0.02 (–0.16, 0.12)	0.13 (–0.01, 0.27)
≥50	–0.10 (–0.44, 0.24)	–0.09 (–0.27, 0.09)	–0.1 (–0.27, 0.07)
Married at the time of the tsunami	0.30 (–0.10, 0.69)	–0.17 (–0.37, 0.03)	0.06 (–0.16, 0.28)
Parents alive at the time of the tsunami	–0.41 (–0.83, 0.01)	–0.12 (–0.31, 0.07)	–0.13 (–0.32, 0.06)
Years of education	0.0 (–0.04, 0.04)	–0.03 (–0.05, 0.00)	0.02 (–0.01, 0.04)
Monthly per capita expenditure level (natural log)	0.07 (–0.20, 0.34)	0.09 (–0.07, 0.25)	–0.01 (–0.18, 0.16)
Owned house or household goods	–0.33 (–1.43, 0.76)	–0.53 (–1.11, 0.06)	0.28 (–0.26, 0.82)
Owned land, livestock, or equipment	–0.65 (–1.14, –0.15)	0.30 (0.06, 0.53)	–0.11 (–0.34, 0.11)
Heard tsunami wave or screams about the tsunami wave	0.69 (0.18, 1.20)	0.63 (0.38, 0.89)	. . .
Sustained injury	0.43 (–0.06, 0.91)	1.23 (0.60, 1.85)	. . .
Saw family or friends struggle or disappear	0.36 (–0.07, 0.80)	1.16 (0.76, 1.57)	. . .
Heard tsunami wave or screams about the tsunami wave or were injured or saw struggle	. . .	. . .	1.14 (0.80, 1.48)
Spouse died	0.97 (0.30, 1.63)	0.67 (0.11, 1.23)	. . .
Child or parent died	1.09 (0.66, 1.51)	0.99 (0.60, 1.38)	. . .
Friend or other family member died	0.51 (0.10, 0.92)	0.53 (0.28, 0.79)	. . .
Any family member or friend died	. . .	. . .	0.27 (–0.18, 0.72)
Damage, house or household goods	0.32 (–0.10, 0.73)	0.47 (0.19, 0.75)	0.19 (–0.24, 0.61)
Damage, land, livestock, or equipment	0.59 (0.13, 1.06)	0.54 (0.20, 0.89)	1.11 (0.29, 1.93)
Constant	5.36 (1.08, 9.64)	–0.86 (–3.26, 1.53)	1.11 (–1.11, 3.32)
Demographic attributes	9.18 (.001)	28.36 (.001)	22.32 (.001)
Kinship network	3.15 (.04)	2.20 (.11)	1.03 (.36)
Education and economic resources	2.14 (.08)	3.38 (.01)	0.77 (.54)
Exposure to trauma	7.29 (.001)	41.83 (.001)	43.62 (.001)
Death of loved ones	16.56 (.001)	18.57 (.001)	1.38 (.24)
Property damage	4.81 (.01)	12.48 (.001)	4.84 (.001)

Note. PTSR = post traumatic stress reactivity; CI = confidence interval. R^2 for heavily damaged was 0.16, moderately damamged was 0.17, and undamaged was 0.14.

home or household goods were not significant, although the indicator for damage to land, livestock, and equipment was statistically significant and large.

DISCUSSION

Our findings represent the first wave of a long-term prospective longitudinal follow-up study examining the nature and course of mental health consequences and mediating and moderating influences among a population in Indonesia affected by the 2004 Indian Ocean tsunami. We employed a dose-of-exposure design focusing on adults in Aceh and North Sumatra. Our study was anchored to large-scale population-based survey data that were representative of the pretsunami population as of February 2004. These survey data were integrated with innovative use of remotely sensed data from NASA's MODIS sensor to establish graded zones of the disaster's effect. This design allowed for examination of potentially differential contributions of sociodemographic factors and tsunami-related trauma exposure, loss, and property damage to posttsunami distress across 3 objectively defined zones of damage.

Predictors of Post Traumatic Stress Reactivity

Levels of PTSR for both maximum intensity since the tsunami and at the time of interview followed a clear dose-of-exposure pattern. The measures of proximity to the coastline (a good proxy for experiencing the tsunami), exposure to traumatic events, loss of family and friends, and loss or damage of property were strongly related to PTSR. These results are consistent with the literature, which generally shows that among adults, more-severe exposure to a trauma increases the likelihood of adverse outcomes and that factors operating during or after the trauma are somewhat stronger predictors than pretrauma factors.[2] Similar dose-of-exposure findings have been demonstrated in prospective longitudinal studies among adolescents over the course of 5 years postdisaster.[17]

The findings suggest that in the heavily damaged zone, loss of family or friends appears to interfere with the resolution of PTSR, whereas in the undamaged zone, loss does not appear to do so. This issue will be explored more fully as data become available from the next follow-up wave, which includes a complete posttraumatic stress disorder scale, a scale directed at grief reactions, and a scale for depression.

Our measures of PTSR reflect reactions at their points of greatest intensity since the tsunami and at the time of the interview. Levels of PTSR were significantly lower at the time of the interview than at their point of maximum intensity, suggesting that within exposure groups these symptoms have diminished over time. In addition to the general decrease in reactivity with time, the pattern of response over time underscores the traumatogenic effect of witnessing the drowning of a family member or friend and potentially a different time course for distress resulting from loss of a spouse rather than loss of other family members and friends. The results suggest the importance for assessment and postdisaster intervention programs to attend to trauma-specific exposures as well as actual loss.

Women had significantly higher PTSR scores than did men. This finding is consonant with other findings in the disaster literature; however, trauma-salient features may

also be operative, especially gender differences in the ability to swim or in efforts to protect children. The finding that PTSR scores rose between ages 15 and 29 years suggests vulnerability in young adulthood. Whether it persists over time will be examined with additional waves of data.

In the moderately damaged zone, one sees the combined effect of damage to home and to livelihood, whereas in the undamaged zone, the singular effect of damage to land, livestock, and equipment plays a significant role in measures of distress. However, standard indicators of socioeconomic status such as education and pretsunami levels of economic resources were not associated with PTSR, indicating that the tsunami's negative effects on mental health were not disproportionately concentrated on those at either end of the spectrum of socioeconomic status. Whether vulnerability is greater in the long run for those with fewer resources will be determined as future waves of the STAR survey are collected.

Comparisons to Evidence From Other Settings

The methodology employed in this study provides a lens through which to evaluate and interpret other posttsunami studies. Consistent with our findings, a study of adult tsunami survivors in southern Thailand concluded that among the correlates of mental health outcomes after the tsunami, loss of economic livelihood (as reported by the respondent) poses the most consistent threat to mental health outcomes.[18] A study based on data from one village in India reported a similar finding.[19] Demographic characteristics and standard measures of socioeconomic status were not statistically significant predictors of PTSD in the study of Thailand. In India, however, the odds of PTSD were higher for women and those injured by the tsunami. In another study of Thai tsunami survivors, low exposure to the event appeared to be correlated with relatively stable emotional functioning.[20] Across these 3 studies, loss of livelihood appears to be strongly associated with mental health outcomes. However, if in our study we were to consider only results for respondents for the undamaged zone, we might reach a similar conclusion on the grounds that the parameter estimates associated with the indicators of damage to home and business assets are large and highly significant. Conversely, in the zones in which damage was moderate or heavy, we found that property damage pales as a correlate of PTSR in comparison to other measures of exposure and loss. This highlights the importance of evidence based on a population-representative sample.

Consistent with our results, van Griensven et al.[18] reported a decrease over time in the prevalence of posttraumatic stress reactions. STAR's prospective longitudinal dose-of-exposure design will allow for a more detailed investigation of differential rates of recovery across exposure groups.

The next wave of this study will build upon the results presented here and improve on several study limitations (this wave is already in the process of being conducted). It will include a full battery of validated PTSR-related questions, validated measures of depression, and questions on pretsunami trauma. Our analysis of subsequent rounds of the STAR data will consider more comprehensively the recovery ecology and its potential moderating influence on mental health outcomes, as well as the extent to which mental health recovery may shape the process of recovery on other dimensions. We will also examine the course of mental health problems over time. We expect that this 5-year study will provide important knowledge about long-term mental health outcomes after catastrophic disaster and a rationale for attention by international health organizations to sustain interventions beyond the immediate postcrisis period, and will guide the use of stratified public mental health postdisaster programs.[7,21–23] ■

About the Authors

Elizabeth Frankenberg and Duncan Thomas are with Duke University, Durham, NC. Jed Friedman and Nicholas Ingwersen are with the World Bank, Washington, DC. Thomas Gillespie, Robert Pynoos, and Alan Steinberg are with University of California, Los Angeles. Iip Umar Rifai, Bondan Sikoki, Cecep Sumantri, and Wayan Suriastini are with SurveyMETER, Yogyakarta, Indonesia.

Requests for reprints should be sent to Elizabeth Frankenberg, Duke University, Sanford Institute of Public Policy, 286 Rubenstein Hall, 302 Towerview Dr, Durham, NC 27708-0239 (e-mail: e.frankenberg@duke.edu).

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Contributors

E. Frankenberg and D. Thomas developed the survey and study, conducted data analyses and drafted the article. J. Friedman, N. Ingwersen, I.U. Rifai, B. Sikoki, C. Sumantri, and W. Suriastini designed and implemented the survey. T. Gillespie developed the indicator of tsunami damage. R. Pynoos and A. Steinberg helped conceptualize the measures of posttraumatic stress reactivity. All of the authors contributed to the interpretation of results and to article revisions.

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Human Participant Protection

This study was approved by the University of California, Los Angeles, North General institutional review board. Oral informed consent was obtained from all study participants.

References

1. Doocy S, Gorokhovich Y, Burnham G, Balk D, Robinson C. Tsunami mortality estimates and vulnerability mapping in Aceh, Indonesia. *Am J Public Health.* 2007;97:S146–S151.

2. Norris FH, Friedman MJ, Watson PJ, Byrne CM, Diaz E, Kaniasty K. 60,000 disaster victims speak: part I: an empirical review of the empirical literature, 1981–2001. *Psychiatry.* 2002;65:207–239.

3. Bhugra D, Van Ommeren M. Mental health, psychosocial support, and the tsunami. *Int Rev Psychiatry.* 2006;18(3):213–216.

4. Hampton T. Mental trauma lingers in tsunami's wake. *JAMA.* 2005;293:663–664.

5. Weathers FW, Litz BT, Herman DS, Huska JA, Keane TM. The PTSD checklist: reliability, validity, and diagnostic utility. Paper presented at: 9th Annual Meeting of the International Society for Traumatic Stress Studies; October 24–27, 1993; San Antonio, TX.

6. Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD checklist (PCL). *Beh Res Ther.* 1996;34:669–673.

7. Smith MY, Redd W, DuHamel K, Vickberg S, Ricketts P. Validation of the PTSD Checklist-Civilian Version in survivors of bone marrow transplantation. *J Trauma Stress.* 1999;12:485–493.

8. Ruscio AJ, Ruscio J, Keane TM. The latent structure of posttraumatic stress disorder: a taxometric investigation of reactions to extreme stress. *J Abnorm Psychol.* 2002;3:290–301.

9. Forbes D, Haslam N, Williams BJ, Creamer M. Testing the latent structure of posttraumatic stress disorder: a taxometric study of combat veterans. *J Trauma Stress.* 2005;18:647–656.

10. Foa EB, Stein DJ, McFarlene AC. Symptomatology and psychopathology of mental health problems after disaster. *J Clin Psychiatry.* 2006;67(suppl 2):15–25.

11. Brewin CR, Andrews B, Valentine JD. Meta-analysis of risk factors for posttraumatic stress disorder in

trauma-exposed adults. *J Consult Clin Psychol.* 2000; 68:748–766.

12. Briere J, Elliott D. Prevalence, characteristics, and long-term sequelae of natural disaster exposure in the general population. *J Trauma Stress.* 2000;13: 661–779.

13. Davidson JRT, McFarlene AC. The extent and impact of mental health problems after disaster. *J Clin Psychiatry.* 2006;67(suppl 2):9–14.

14. Black R. Navy releases tsunami images. British Broadcasting Web Site. Available at http://news.bbc.co.uk/2/hi/science/nature/4247409.stm. Last updated February 9, 2005. Accessed March 30, 2006.

15. Ramakrishnan D, Ghosh S, Raja V, Chandran R, Jeyram A. Trails of the killer tsunami: a preliminary assessment using satellite remote sensing technique. *Cur Sci.* 2005;88:709–711.

16. Huber PJ. The behavior of maximum likelihood estimates under nonstandard conditions. In: *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability.* 1967;1: 221–33.

17. Goenjian AK, Najarian LM, Steinberg AM, Fairbanks LA, Tashjian M, Pynoos RS. A prospective study of posttraumatic stress, anxiety and depressive reactions after earthquake and violence. *Am J Psychiatry.* 2000;157:911–916.

18. van Griensven F, Chakkraband MLS, Thienkrua W, et al. Mental health problems among adults in tsunami-affected areas in southern Thailand. *JAMA.* 2006;296: 537–548.

19. Kumar M, Murhekar M, Subramanian T, Ramachandran V, Gupte M. Prevalence of posttraumatic stress disorder in a coastal fishing village in Tamil Nadu, India, after the December 2004 tsunami. *Am J Public Health.* 2007;97:99–101.

20. Tang CS. Trajectory of traumatic stress symptoms in the aftermath of extreme natural disaster: a study of adult Thai survivors of the 2004 Southeast Asian earthquake and tsunami. *J Nerv Ment Dis.* 2007;195: 54–59.

21. Silove D, Bryant R. Rapid Assessments of mental health needs after disasters. *JAMA.* 2006;576–578.

22. Ashraf H. Tsunami wreaks mental health havoc. *Bull World Health Organ.* June 2005;83(6):405–406.

23. Pynoos RS, Goenjian AK, Steinberg AM. A public mental health approach to the postdisaster treatment of children and adolescents. *Psychiatr Clin N Am.* 1998;7: 195–210.