Impact of the 2004 Tsunami on Self-Reported Physical Health in Thailand for the Subsequent 2 Years

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Objectives. We examined self-reported physical health during the first 2 years following the 2004 tsunami in Thailand.

Methods. We assessed physical health with the revised Short Form Health Survey. We evaluated 6 types of tsunami exposure: personal injury, personal loss of home, personal loss of business, loss of family member, family member's injury, and family's loss of business. We examined the relationship between tsunami exposure and physical health with multivariate linear regression.

Results. One year post-tsunami, we interviewed 1931 participants (97.2% response rate), and followed up with 1855 participants 2 years after the tsunami (96.1% follow-up rate). Participants with personal injury or loss of business reported poorer physical health than those unaffected ($P < .001$), and greater health impacts were found for women and older individuals.

Conclusions. Exposure to the tsunami disaster adversely affected physical health, and its impact may last for longer than 1 year, which is the typical time when most public and private relief programs withdraw. (*Am J Public Health.* 2013;103:2063–2070. doi:10.2105/AJPH.2013.301248)

At the end of Boxing Day in 2004, more than 5 million people were affected by one of the world's worst natural disasters.[1–3] An earthquake triggered a tsunami that affected 14 countries. In Thailand, the geographical focus of this study, more than 60 000 people in 6 southern provinces (Phuket, Phang Nga, Krabi, Ranong, Trang, and Satun) were directly affected.[2,3] There were 3980 deaths and 6065 injuries.[3,4]

Studies of the impact of a tsunami have focused primarily on mental health of those affected,[5–10] with limited information on health service utilization[11–13] and physical health.[8,14] Previous investigations of physical health have focused on general physical health status, mortality, and nutritional status.[14–19] Of those, there were 2 studies conducted in post-tsunami settings of Thailand.[14,15] Two months after the tsunami, one study found that displaced individuals (those whose homes were affected by the disaster) reported significantly poorer physical health than unaffected individuals.[14] The other study focused on Scandinavian tourists (from Norway, Denmark, and Sweden) who were in Thailand during the tsunami.[15] The results indicated that, 14 months post-tsunami, being directly affected by the tsunami led to increased risk of musculoskeletal, cardiorespiratory, neurologic, and gastrointestinal health problems.

The longer-term impact of the tsunami on Thai residents has not been previously examined. Hence, it is unclear whether the impacts of the tsunami on health are similar for those living in Thailand as for those who visited, and how long such physical impacts last. We report, here, the findings of a comparative study of self-reported physical health of those directly affected and those unaffected 1 and 2 years following the 2004 tsunami. Our findings could help public health officials in Thailand as well as add to the limited literature on the impacts of a disaster more than 1 year after it occurred.[8,20–22]

METHODS

The study population comprised Thai citizens who were living in the study provinces at the time of the tsunami and were aged 14 years or older. We chose this age criterion on the basis of the age threshold of the SF-36 Short Form Health Survey (QualityMetric, Lincoln, RI). The study sample was drawn from 4 Thai provinces (Phuket, Phang Nga, Krabi, and Ranong), where more than 90% of tsunami victims were residing.[4] The 4 provinces also accounted for approximately 60% of the population of 6 provinces that were exposed to the tsunami.[23] We excluded the remaining 2 affected provinces, Trang and Satun.

Within each province, we stratified the population on the basis of tsunami-affected status to form 2 mutually exclusive sampling frames. Affected individuals were sampled from households that were registered with Department of Disaster Prevention and Mitigation (DDPM) of Thailand as being directly affected by the 2004 tsunami. The DDPM included 8891 households in Phuket, 6769 in Phang Nga, 4074 in Krabi, and 2219 in Ranong province. To interview only 1 individual per household, we conducted a 2-stage sampling within each province: simple random sampling of households from the DDPM registry, and random selection of a person within each household, using the Kish procedure performed by public health officers.[24]

We identified unaffected individuals from the National Household Registry of the Bureau of Registration Administration of Thailand (BORA), which included all Thai citizens.[23] For the purpose of the study, we removed tsunami-affected households (included in the DDPM registry) from the BORA registry. The BORA registry selected 1000 individuals from each province by using a systematic sampling to create the unaffected sampling frame. As all sampling procedures were performed within offices of BORA and public health, researchers were kept blind to data or statistics that were required for estimating sample weights.

Tsunami exposures, or affected status, can be broadly classified as direct and indirect. Direct exposure referred to cases when a traumatic event (e.g., being affected by the tsunami) happened directly to individuals themselves, whereas an indirect exposure indicated when

the event occurred to people close to the individuals, such as spouse or children (e.g., the study participant reported having a family member who was affected). Direct exposures to the tsunami may show more severe health effects than indirect exposures.[5,25–30]

Public health officers collected data through face-to-face interviews 1 year (October 2005) and 2 years (September 2006) following the tsunami. The 217 interviewers completed a training program, provided by the research team. With 90% power, a total sample of 1280 (i.e., 160 from each study group in each province) was required to detect a 20% change in the health status measure (i.e., effect size of 0.2).

Variables and Measurements

Physical health. We measured physical health, the dependent variable, with the SF-36.[31–33] The Thai versions have been used and found to be reliable and valid in various patient groups, such as patients with stroke or low back pain and the general population.[34–37] Studies have addressed content, construct, criterion, and predictive validity of the SF-36 and reported the reliability statistics to exceed the minimum standard of 0.70.[31–33,38] The SF-36 provides a physical component summary (PCS) score, which reflects physical health status during the past 4 weeks before the interview.[31,39–41] In this study, the PCS score had a Cronbach α reliability of 0.75. The PCS score was easy to estimate statistically, and its use has been previously evaluated in 23 subgroups of patients with different medical conditions.[39,40]

In addition to the PCS score, the SF-36 consists of 4 physical health dimensions.[31,39,41] Physical functioning captures both the presence and extent of physical limitations. Role functioning represents the degree of limitations in social activities attributable to physical health problems (an example of a question that addresses role functioning would be "During the past 4 weeks, have you cut down the amount of time you spent on work or other activities as a result of your physical health?"). The bodily pain dimension reflects the intensity of bodily pain or discomfort as well as the extent of interference with normal activities because of pain (a sample question would be "How much bodily pain have you had during the past 4 weeks?"). Lastly, general health refers to the current health status of the participants (here, participants would be asked, for example, "In general, would you say your health is excellent, very good, good, fair, or poor?"). Cronbach α reliability for the 4 subscales ranged from 0.83 to 0.89.

Most studies, including this one, used the method of summated ratings and standardized scoring algorithms, which have been validated in several countries.[39] Here, we standardized the raw scores and calculated the norm-based scores for the summary score and each dimension, with a mean of 50 and a standard deviation of 10. A final score ranged from 0 (the worst possible health state) to 100 (the best health state). Thus, if a score was below 50, health status was considered to be below the average.[39]

Exposure status. The independent variable was tsunami exposure or affected status. We assessed 6 types of tsunami-affected status: (1) personal injury, (2) personal loss of home, (3) personal loss of business, (4) loss (death or missing) of family member, (5) injured family member, and (6) family member's business loss. The first 4 categories refer to events that affected participants directly (direct exposure), whereas the last other 2 refer to events that affected family members (indirect exposure). On each variable, participants were coded with a "1" if they were affected in that specific manner.

Correlates of physical health. The correlates of physical health we considered in the analysis included age, gender, marital status, religious affiliation, education, employment status, household size, health insurance, residing province, household income, and distance to health facilities. We obtained this information 1 year post-tsunami from the Demographic Data Form.[11] We measured age in years of chronological age. We used binary variables to identify participants younger than 21 years (vs ≥ 21 years); males (vs females); those currently married (vs never or previously married); non-Buddhists (vs Buddhists); those that attained higher than elementary school education (vs ≤ elementary school); those currently unemployed (vs employed); individuals living in a small-sized household (1 or 2 members vs ≥ 3); and those with no health insurance (vs insured). We identified residing province by 3 binary dummy variables of Phuket, Phang Nga, and Ranong, with Krabi as the reference category.

We measured income by the average monthly household income in the year 2005. With the middle-range income (5001 to 15 000 baht per month) as the reference category, we used 3 binary variables to identify 3 income categories; lower income (≤ 5000 baht), upper income (> 15 000 baht), and those with missing data on income. In 2005, 35 Thai baht was equivalent to approximately 1 US dollar. The lower-income category represented household income that was lower than that earned by a person earning the minimum wage, and the upper-income category represented average income for an individual with a bachelor's degree.[42] Distance to health facility referred to the distance between the participants' residence and their registered health care facilities—public health center and hospital. Both variables were continuous, measured in kilometers. We collected data on distance to a health facility during the research fieldwork, where the research team traveled 14 000 kilometers to collect coordinate data because geocoding was not available in the study provinces. With coordinate data, we calculated distance to a health facility by using a Network Analyst Extension in ArcGIS version 9.3 (ESRI, Redlands, CA).

We obtained permission to use the Thai version of SF-36. All instruments, except SF-36, were constructed in English, and then translated into Thai language by bilingual researchers from Thailand and Canada. The translated instruments were then evaluated in 2 focus groups, and modified by local health care professionals, to ensure that the instruments measured what they were supposed to, and were culturally appropriate and easy to understand.

Statistical Analyses

We conducted analyses with the SAS version 9.3 (SAS Institute, Cary, NC). We used Student *t* test and Pearson χ^2 test for continuous variables and categorical variables, respectively, to examine unadjusted differences of baseline characteristics between the affected and unaffected groups. To examine

within-subject changes in physical health over time, we used a repeated measure analysis of variance. We examined 2 models by using multivariate linear regression. Model 1 examined the impact of 6 different types of affected status on overall physical health status, which was represented by the PCS score. Model 2 examined the impact of 6 types of affected status on each of 4 physical health dimensions. We controlled all analyses for correlates of physical health (i.e., age, gender, marital status, religious affiliation, education, employment status, household size, health insurance, residing province, household income, and distance to health facilities). We conducted separate analyses on the data collected 1 and 2 years post-tsunami. We examined the model assumptions and found that the final models were reasonable. We tested interactions to examine whether the impact of the tsunami varied by age, gender, residing province, or religious affiliation in separate models.

RESULTS

The total sample size comprised 1931 (1077 affected and 854 unaffected) participants with a response rate of 97.2%. Two years post-tsunami, 1855 participants (1031 affected and 824 unaffected) completed the second wave (wave 2) interview, thereby yielding a follow-up rate of 96.1%.

Baseline characteristics of the study participants shown in Table 1 indicate that males and females were equally represented. The mean age was 39.4 years. The majority of participants were married (69.3%), employed (70.8%), Buddhists (60.7%), reported having health insurance (94.7%), and completed primary school education (59.6%). On average, participants were living 4.1 kilometers and 12.7 kilometers away from a public health center or hospital, respectively. We categorized average monthly household income in 2005 (the year after the tsunami) into 4 groups—lower income (22.7%), medium income (38.1%), upper income (15.7%), and missing data on income (23.5%). Affected participants were more likely to be married, poorly educated, non-Buddhists, and living farther from hospitals than were unaffected participants.

TABLE 1—Baseline Characteristics of the Sample 1 Year Post-Tsunami: Thailand, 2005

Variable	Total Sample, % or Mean (SD)	Unaffected, % or Mean (SD)	Affected, % or Mean (SD)
Affected status, % (no.)	100 (1931)	44.2 (854)	55.8 (1077)
Age, y			
Average	39.4 (15.3)	40.0 (16.6)	38.9 (14.2)
< 21	11.4	12.8	10.2
Gender			
Male	49.2	47.6	50.5
Female	50.8	52.4	49.5
Residing province			
Phuket**	25.8	22.8	28.1
Phang Nga	23.6	21.8	25.0
Ranong*	26.2	29.0	23.9
Krabi	24.4	26.4	23.0
Marital status**			
Not married	30.7	33.8	28.3
Married	69.3	66.2	71.7
Religious affiliation***			
Muslim or others	39.3	20.4	54.3
Buddhist	60.7	79.6	45.7
Education level*			
≥ middle school	40.4	43.5	37.9
≤ primary school	59.6	56.5	62.1
Monthly income, baht			
Lower income*** (≤ 5000)	22.7	16.9	27.3
Medium income (5001–15 000)	38.1	37.0	38.7
Upper income*** (> 15 000)	15.7	19.2	13.2
Missing data on income**	23.5	26.9	20.8
Employment status			
Unemployed	23.6	25.2	22.3
Employed	70.8	68.8	72.3
Missing data	5.6	6.0	5.4
Household size			
1–2	13.0	14.0	12.2
≥ 3	87.0	86.0	87.8
Health insurance			
Uninsured	5.3	4.9	5.5
Insured	94.7	95.1	94.5
Distance to a public health center, km	4.1 (4.2)	4.0 (3.8)	4.2 (4.6)
Distance to a hospital,*** km	12.7 (9.9)	10.4 (8.6)	14.5 (10.5)
Type of affected status,[a] % (no.)			
Direct: personal injury	9.4 (181)		16.8 (181)
Direct: loss of home	16.9 (327)		30.4 (327)
Direct: loss of business	38.0 (733)		68.1 (733)
Direct: loss of family member	5.6 (109)		10.1 (109)
Indirect: family member injured	7.7 (148)		13.7 (148)
Indirect: family member lost business	24.9 (481)		44.7 (481)

Note. Distributions of affected and unaffected samples are significantly different.
[a]Multiple responses.
*$P < .05$; **$P < .01$; ***$P < .001$ (2-sided).

TABLE 2—Physical Component Summary Score and 4 Physical Health Dimensions: 1 and 2 Years Post-tsunami: Thailand, 2005–2006

Physical Health Outcomes	Total, Sample Mean (95% CI)	Unaffected, Sample Mean (95% CI)	Affected, Sample Mean (95% CI)	*P*
1 year post-tsunami (wave 1)				
Physical component summary score**	51.7 (51.3, 52.1)	52.5 (51.8, 53.1)	51.1 (50.5, 51.6)	<.01
Four physical health dimensions				
Physical functioning	55.7 (55.2, 56.1)	55.9 (55.3, 56.6)	55.4 (54.9, 56.0)	.22
Role physical activities***	49.0 (48.4, 49.6)	50.9 (50.0, 51.7)	47.6 (46.7, 48.5)	<.001
Bodily pain***	52.3 (51.9, 52.8)	53.6 (52.9, 54.3)	51.4 (50.7, 52.0)	<.001
General health**	38.5 (38.2, 38.7)	38.9 (38.5, 39.3)	38.1 (37.8, 38.4)	<.01
2 years post-tsunami (wave 2)				
Physical component summary score	48.6 (48.2, 49.0)	49.0 (48.5, 49.6)	48.3 (47.8, 48.8)	.07
Four physical health dimensions				
Physical functioning	54.2 (53.7, 54.6)	54.4 (53.7, 55.0)	54.0 (53.4, 54.6)	.39
Role physical activities	48.4 (47.8, 49.0)	48.9 (48.0, 49.8)	48.0 (47.1, 48.8)	.14
Bodily pain*	45.9 (45.5, 46.3)	46.4 (45.8, 47.0)	45.5 (44.9, 46.0)	.03
General health	38.6 (38.4, 38.9)	38.9 (38.5, 39.2)	38.4 (38.1, 38.8)	.06

Note. CI = confidence interval. *P* values are for the comparisons of the physical health outcomes between unaffected and affected participants.
*$P < .05$; **$P < .01$; ***$P < .001$ (2-sided).

One year post-tsunami, means of all health dimensions were significantly lower for affected participants than for unaffected participants, with an exception of the physical functioning dimension (Table 2). Two years post-tsunami, affected individuals reported a significantly lower score in the bodily pain dimension than those unaffected ($P = .03$). Between 1 and 2 years post-tsunami (i.e., between waves 1 and 2), the PCS score declined significantly ($P < .001$). In fact, we found deterioration over the 12 months in all health dimensions ($P < .001$), except for general health.

Table 3 reports the results from multivariate regression models of the PCS score on 6 types of affected status, with control for the effects of physical health correlates. One year post-tsunami, individuals with personal injury or business loss reported poorer physical health than unaffected individuals ($P \leq .01$). The PCS score declined significantly as age increased ($P < .001$). Participants from Krabi reported poorer health than those living in other provinces ($P < .01$). Moreover, those in the low-income group reported poorer health than those in the medium-income group ($P = .04$). Two years post-tsunami, participants from Krabi continued to report poor physical health ($P < .01$). Finally, the PCS score declined as age increased ($P < .001$).

In 4 separate models, there was no interaction with respect to residing province and religious affiliation. However, the impact of the tsunami on physical health varied across gender and age. One year post-tsunami, affected males with personal injury reported better physical health than affected females ($P < .01$). With respect to age, 1 year post-tsunami, the impact of having a family member with injury was significantly greater among younger participants ($P = .02$), and the influence of having a family member that suffered business loss was significantly higher for older individuals ($P = .01$).

Table 4 shows the association between the 6 types of affected status and the 4 dimensions of SF-36. One year post-tsunami, the exposure to personal injury was significantly associated with lower levels of physical health for all dimensions ($P < .05$). Business loss (because of the tsunami) was related to poor health in the physical functioning and role functioning dimensions ($P = .02$ and $P < .001$, respectively). Having a family member who was injured as a result of the tsunami significantly lowered individuals' physical functioning ($P = .05$). Two years post-tsunami, impacts of the tsunami on physical health were limited to the loss of business and loss of family member with respect to reduced levels in the bodily pain ($P = .03$) and general health ($P = .01$) dimensions. In other words, the effects of the loss of a business found in wave 1 persisted in wave 2 data.

DISCUSSION

We investigated the negative impact of the tsunami on self-reported physical health 1 and 2 years postdisaster. We found a substantial impact on overall self-reported physical health, and on specific dimensions of health, within the first year. Two years post-tsunami, the impact was reduced but still had lasting effect on 2 specific physical health dimensions, bodily pain and general health. Therefore, it seems that although people's physical functioning and activities may have recovered, the tsunami continues to influence individual health through specific dimensions, namely residual bodily pain and perceived general health.

Our findings supported those reported in the literature, in that physical health problems are most significant during the first year postdisaster.[6,43–45] Nevertheless, the physical health consequences remain, even in their less severe form, 2 years after the disaster, suggesting that affected individuals will remain in need of support services in the years following the disaster. The negative consequence of the tsunami on physical health persisted even after we controlled for mental

TABLE 3—Multivariate Regression Model of Physical Component Summary Score on Types of Tsunami-Affected Status: Thailand, 2005–2006

Predictors	1 Year Post-Tsunami (Wave 1; n = 1641) B (SE)	*P*	2 Years Post-Tsunami (Wave 2; n = 1590) B (SE)	*P*
Affected status				
Personal injury	−1.87 (0.76)	.01	0.90 (0.78)	.25
Loss of home	−1.03 (0.60)	.09	−0.12 (0.62)	.85
Loss of business	−1.37 (0.48)	<.01	−0.90 (0.50)	.07
Loss of family member	1.57 (0.95)	.1	0.05 (0.95)	.96
Family member injured	1.00 (0.82)	.23	0.42 (0.84)	.62
Family member lost business	−0.10 (0.51)	.84	−0.19 (0.53)	.72
Unaffected (Ref)	1.00		1.00	
Age, y				
Average	−0.24 (0.02)	<.001	−0.15 (0.02)	<.001
< 21	−0.89 (0.86)	.3	−0.67 (0.89)	.45
Gender				
Male	0.60 (0.42)	.15	0.74 (0.43)	.08
Female (Ref)	1.00		1.00	
Residing province				
Phuket	3.90 (0.63)	<.001	2.61 (0.66)	<.001
Phang Nga	1.92 (0.60)	<.01	2.31 (0.63)	<.01
Ranong	2.17 (0.58)	<.01	2.67 (0.60)	<.001
Krabi (Ref)	1.00		1.00	
Marital status				
Currently not married	0.56 (0.52)	.28	−0.75 (0.53)	.16
Married (Ref)	1.00		1.00	
Religious affiliation				
Other than Buddhism	−0.42 (0.46)	.36	−0.77 (0.48)	.11
Buddhism (Ref)	1.00		1.00	
Education level				
≥ middle school diploma	0.98 (0.49)	.05	0.04 (0.50)	.94
≤ primary school (Ref)	1.00		1.00	
Employment status				
Unemployed	−0.77 (0.56)	.18	−0.33 (0.58)	.57
Data missing	−2.22 (0.98)	.02	−1.49 (0.99)	.13
Employed (Ref)	1.00		1.00	
Household size				
1–2	0.63 (0.64)	.33	0.24 (0.65)	.71
≥ 3 (Ref)	1.00		1.00	
Household income in 2005				
Low income	−1.12 (0.54)	.04	−0.49 (0.55)	.38
High income	0.01 (0.59)	.98	1.14 (0.61)	.06
Data missing	−0.87 (0.58)	.13	−0.56 (0.59)	.34
Medium income (Ref)	1.00		1.00	
Health insurance				
No insurance	−0.03 (0.98)	.98	−1.26 (1.03)	.22
Insured (Ref)	1.00		1.00	

Continued

health status. Results on the impact of the tsunami on mental health are reported elsewhere (W. I., P. C. C., K. M., S. N., unpublished data, March 2013).

The study participants in both the affected and unaffected groups reported a deterioration in physical health between 1 and 2 years post-tsunami. This reduction in physical health status may partially reflect the loss of additional support services at the end of 1 year after the disaster. Often, service providers and governments fail to anticipate the lasting effect of a disaster and prematurely withdraw support services.[46,47]

The study results revealed a significant difference in the tsunami's impact between gender and age groups. Tsunami-affected men reported significantly better physical health (i.e., lesser impact of the tsunami) than their affected female counterparts. In general, men are less vulnerable to stressful life events than are women.[10,48] In addition, women may be more emotionally involved in the lives of others around them, making them more vulnerable to the impact of life events that occur to members of their informal networks.[28,49] The fact that the tsunami-related events included losses experienced by family members and relatives might explain why women may show greater vulnerability compared with men. We examined the alternative explanations based on gender differences in socioeconomic resources. However, we failed to observe significant differences in income and education between genders.

The role of age depended on the type of affected status (i.e., whether age lessened or increased the impact of a disaster depended on how individuals were affected). Older participants with an injured family member were able to manage the impact of the tsunami better, and subsequently reported lesser impact than the younger participants with an injured family member.[49,50] Having more experiences in life may help individuals handle stressful life events.[51] On the other hand, older participants with a family member who lost his or her business reported more negative physical health consequences than those who had the same experience at a younger age. As individuals become older, they may become more dependent on their family, both economically and physically, than when they

TABLE 3—*Continued*

Distance to public health center, km	0.05 (0.05)	.33	0.03 (0.05)	.54
Distance to hospital, km	0.01 (0.02)	.72	0.00 (0.02)	.87
Intercept	59.74 (1.06)	<.001	53.32 (1.09)	<.01
F ratio	20.07	<.001	8.23	<.01
Adjusted R^2	0.218		0.106	

were younger. Thus, the effect of their family member's property loss may directly affect their health. Further research is required to comprehensively understand the reasons behind these results.

With respect to correlates of physical health, personal income showed significant protective effect, as those with higher income were able to sustain the impact of the tsunami better than were those with limited economic resources. In this study, however, we found no protective influences of other factors, such as education, marital status, employment status, family size and composition, and resources, such as health insurance. The variation among study provinces could be attributed to the differences in the provincial health systems and health service accessibility among the study provinces. Further research should be aware of and take into account correlates of physical health.

Different types of tsunami-affected status resulted in different intensity of impacts on physical health. One year post-tsunami, personal injury and loss of business, as well as having a family member with a tsunami-related injury, were significantly related to lower physical health. The differences in physical health consequences among disaster exposures corresponded with the findings previously reported in literature stating that certain types of affected status have been shown to impose greater risks for physical health problems.[5,6,15] Two years post-tsunami, loss of business and loss of family member showed a lasting effect of the tsunami on the bodily pain and the general health dimensions of physical health. Literature on different types of affected status and physical health in post-tsunami settings has focused on specific populations, namely tourists who do not permanently reside in the affected regions.[15] Thus, this study adds to the extant body of knowledge in this field by reporting negative associations between certain affected status and physical health by reporting results derived from a sample of adult

TABLE 4—Multivariate Regression Model of 4 Physical Health Dimensions on Types of Tsunami-Affected Status: Thailand, 2005–2006

	SF-36 Physical Health Dimensions							
	Physical Functioning[a]		Role Functioning[b]		Bodily Pain[c]		General Health[d]	
Predictors	B (SE)	*P*	B (SE)	*P*	B (SE)	*P*	B (SE)	*P*
1 year post-tsunami (wave 1)								
Personal injury	−1.84 (0.78)	.02	−3.22 (1.18)	.01	−3.10 (0.91)	<.01	−1.25 (0.49)	.01
Loss of home	−0.68 (0.62)	.27	−0.03 (0.95)	.97	−0.75 (0.73)	.30	−0.22 (0.39)	.58
Loss of business	−1.31 (0.50)	.01	−3.15 (0.76)	<.001	−0.93 (0.58)	.11	−0.33 (0.31)	.29
Loss of family members	0.73 (0.97)	.45	2.17 (1.47)	.14	−0.83 (1.13)	.46	−0.84 (0.61)	.17
Family member injured	1.65 (0.84)	.05	−0.04 (1.28)	.98	0.54 (0.99)	.58	0.43 (0.53)	.42
Family member lost business	0.09 (0.53)	.86	0.22 (0.80)	.78	0.10 (0.62)	.87	−0.38 (0.33)	.25
Unaffected (Ref)	0 (0)		0 (0)		0 (0)		0 (0)	
Intercept	61.81 (1.09)	<.001	59.49 (1.66)	<.001	58.56 (1.27)	<.001	41.12 (0.69)	<.001
2 y post-tsunami (wave 2)								
Personal injury	0.68 (0.86)	.43	1.55 (1.26)	.22	0.12 (0.88)	.89	0.15 (0.51)	.21
Loss of home	−0.67 (0.68)	.33	−0.02 (1.01)	.98	−0.01 (0.70)	.99	0.27 (0.41)	.14
Loss of business	−0.82 (0.55)	.14	−0.97 (0.81)	.23	−1.19 (0.56)	.03	0.08 (0.33)	.41
Loss of family members	−0.11 (1.05)	.91	−1.46 (1.55)	.35	−1.80 (1.08)	.09	0.87 (0.63)	.01
Family member injured	0.45 (0.93)	.63	−0.56 (1.37)	.68	1.52 (0.95)	.11	0.22 (0.55)	.24
Family member lost business	−0.07 (0.58)	.91	0.86 (0.86)	.31	−0.82 (0.60)	.17	−1.03 (0.35)	.54
Unaffected (Ref)	0 (0)		0 (0)		0 (0)		0 (0)	
Intercept	58.28 (1.21)	<.001	53.35 (1.78)	<.001	48.07 (1.23)	<.001	42.22 (0.72)	<.001

Note. Coefficients were estimated in the models that included all the following predictors: average age in years, age < 21 years, gender, residing province, marital status, religious affiliation, education level, employment status, family size, income, health insurance, and distance to health facilities.
[a]The sample sizes were wave 1 = 1656; wave 2 = 1598.
[b]The sample sizes were wave 1 = 1658; wave 2 = 1596.
[c]The sample sizes were wave 1 = 1659; wave 2 = 1594.
[d]The sample sizes were wave 1 = 1654; wave 2 = 1598.

population residing permanently in the affected regions of Thailand. Our study is also the first to examine the impact of the 2004 tsunami on physical health in the Thai adult population. The majority of the tsunami literature in Thailand has focused on only the first year following the disaster or on mental health outcomes.

Limitations

This study has limitations in terms of confounding and the measurement of exposure. Confounding effect occurs when the differences in outcomes between the 2 groups are attributable to factors other than the independent variable or tsunami-affected status.[52] To minimize confounding effect in this study, we included known and measurable confounders in a regression model, the most commonly used technique to reduce confounding in cohort studies.[53] Therefore, we used multivariate regression models to control for differences in baseline characteristics between affected and unaffected participants. Because of the nature of the study design, the results remain prone to unmeasured and unknown confounders. Moreover, we could not include a few important potential determinants of health (e.g., predisaster health status, coping repertoires, mastery, and social support) because the relevant data were unavailable. This is an important limitation of this study, as we were not able to address issues related to host resistance or personal resilience. Future research should attempt to explain why certain types of loss exert more adverse and lasting health consequences and how some affected tsunami victims manifested no or little changes in health. In addition, future research could benefit from expanding the conceptual model to include a wide range of protective or risk-reducing factors, as well as risk factors in this study.

Misclassification of the participants was also possible; for example, it is likely that some affected people did not register with the DDPM. To minimize this bias, study participants were asked whether and how they were affected by the tsunami in the Disaster Impact Questionnaire; and those misplaced (approximately 5%) were moved to an appropriate group in the analysis. Moreover, additional research on non–tsunami-related injuries or health conditions experienced after the tsunami could provide further insight into the impact of this catastrophic disaster. Although the number was minimal, it is possible that some affected individuals might have moved away from the affected areas. Future research thus may find it of interest to pursue this specific and special affected population. Finally, readers should be cautious in generalizing our findings beyond the study sample, because we based all analyses on unweighted data.

Conclusions

This study confirmed the impact of the tsunami on self-reported physical health 1 and 2 years after the disaster in Thailand, with a more significant effect within the first year. Furthermore, we established that different types of affected status could inflict different effects on physical health. Research in the area of natural disasters would benefit by continuing to examine the impact of different types of affected status on health status. Future research may also consider examining various dimensions of physical health to highlight areas in which physical health interventions could focus. The study results may help health providers understand how a tsunami disaster influences the physical health status of individuals (i.e., through which health status dimension). In addition, the results may provide insight to external organizations or other governments on areas where they could provide assistance (e.g., people with which types of affected status need more assistance or which physical health dimensions could be supported).[54] Information from this study may also assist in the development of guidelines on long-term disaster recovery planning. ■

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This article was accepted on January 9, 2013.

Contributors

W. Isaranuwatchai and P. C. Coyte contributed to the study design and conducted the data collection. W. Isaranuwatchai conducted the literature search. W. Isaranuwatchai and S. Noh developed the article, including research questions, data analyses, and interpretations, as well as the Discussion and "Conclusions" sections. All authors contributed to the data interpretation, and edited, reviewed, and approved the article before submission.

Acknowledgments

This study was partially supported by the Genesis Fellowship Award from the Canadian Health Services Research Foundation and Canadian Institute of Health Research Chair in Health Care Settings and Canadians.

We would like to acknowledge the following organizations and institutions: University of Toronto and McMaster University in Canada; Chulalongkorn University and Mahidol University, Thai Ministry of Public Health, Provincial Public Health Office (Phuket, Phang Nga, Krabi, and Ranong), Medical Council of Thailand, Department of Disaster Prevention and Mitigation, Thai Ministry of Interior, Department of Provincial Administration, Bureau of Registration Administration, Provincial Governor's Office (Phuket, Phang Nga, Krabi, and Ranong), and Krabi Post Office in Thailand.

Human Participant Protection

The study protocol was approved by the ethics review boards of the University of Toronto, Canada, and Chulalongkorn University, Thailand. Written informed consent forms were obtained from all participants.

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