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**Psychiatric Disorders and Suicide Attempts in Swedish Tsunami Survivors:  
A 5-Year Matched Cohort Study**

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## **Abstract**

### **Background**

We aimed to determine whether Swedish survivors from the 2004 tsunami experienced increased risks of psychiatric disorders and suicide attempts five years after repatriation.

### **Methods**

Survivors repatriated from Southeast Asia (8762 adults and 3742 children) were matched with 864,088 unexposed adults and 320,828 unexposed children on sex, age, and socioeconomic status. Exposure severity was ascertained in a mail survey of 3534 survivors and used in a dose-response analysis. Psychiatric diagnoses and suicide attempts were retrieved from the National Patient Register. Hazard ratios (HRs) and their 95% confidence intervals (CIs) were estimated, adjusted for pre-tsunami psychiatric disorders, and, for children, for parental pre-tsunami disorders.

### **Findings**

Exposed adults were more likely than unexposed adults to receive any psychiatric diagnosis (6.2 vs. 5.5%; HR=1.21, 95%CI: 1.11-1.32), particularly stress-related disorders (2.1 vs. 1.0%; HR=2.27, 95%CI: 1.96-2.62) and suicide attempts (0.43 vs. 0.32%; HR=1.54, 95%CI: 1.11-2.13), but not mood or anxiety disorders. The risk of stress-related disorders was pronounced among survivors with severe exposure and during the first year after the tsunami. There was no difference in overall risk of psychiatric diagnoses between exposed and unexposed children (6.6 vs. 6.9%; HR=0.98, 95%CI: 0.86-1.11), although exposed children had a higher risk for suicide attempts with uncertain intent

(HR=1.43; 95%CI: 1.01-2.02) and stress-related disorders (HR=1.79; 95%CI: 1.30-2.46), primarily during the first three months after the tsunami.

### **Interpretation**

A disaster such as the tsunami can, independently of previous psychiatric morbidity, increase the risk of severe psychopathology; mainly stress-related disorders and suicide attempts, in children and adults.

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## Introduction

In the last decade, natural disasters afflicted more than 200 million people each year,<sup>1</sup> resulting in loss of lives, property destruction, and psychological suffering worldwide. Literature reviews suggest that survivors are at increased risk of psychiatric disorders, particularly posttraumatic stress disorder (PTSD).<sup>2-5</sup> As noted previously,<sup>6-8</sup> however, due to the limitations of past studies uncertainties remain about the effect of disaster exposure on the risk of PTSD,<sup>3-5</sup> other psychiatric diagnoses,<sup>9,10</sup> and suicide attempts.<sup>11</sup> Given the well-known lasting nature of severe stress-related disorders,<sup>12</sup> surprisingly few studies have followed survivors beyond the first three years post-disaster,<sup>6-8</sup> and existing long-term studies often suffer from attrition or small samples.<sup>13</sup> Furthermore, the majority of investigations rely on self-reported outcomes without a clinical assessment.<sup>13,14</sup> Similarly, researchers have largely relied on retrospective self-reports on pre-disaster psychopathology.<sup>6,7</sup> There are a few exceptions,<sup>15-17</sup> and they generally show that pre-existing psychopathology influences post-disaster mental health. Thus, it awaits to be firmly established the extent to which disasters induce lasting risks of severe psychiatric disorders independently of underlying vulnerabilities.

With complete population registries of healthcare utilization and medical diagnoses of every inhabitant, Sweden provides an excellent setting for such investigations. On December 26, 2004, a massive earthquake caused a series of tsunamis that inundated coastal areas around the Indian Ocean<sup>18</sup> and took more than 200,000 lives.<sup>19</sup> The Swedish government estimated that 20,000 Swedish

tourists were in Southeast Asia at the time of the event; 543 Swedish lives were lost, making Sweden the hardest hit country after the countries in Southeast Asia.<sup>20</sup> The Swedish authorities organized an airlift to evacuate survivors and within 20 days approximately 16,000 citizens were repatriated to their intact homes and communities.<sup>20</sup> Traumatic experiences and self-reported distress have been reported among the Swedish survivors<sup>21,22</sup> while it remains unexplored whether this population suffers lasting risks of psychiatric disorders as diagnosed in healthcare services. The aim of this study was to understand whether tsunami survivors, independently of their pre-tsunami psychiatric history, had elevated risks of receiving psychiatric diagnoses and committing suicide attempts during five years after the tsunami. We also planned a dose-response analysis in a subgroup of survivors with available data on disaster exposure severity, expecting that more severe exposure was related to increasing risk of a psychiatric diagnosis.

## **Methods**

### **Study population and design**

We undertook a matched cohort study of the Swedish inhabitants who arrived at Swedish airports from destinations in Southeast Asia between December 26, 2004, and January 15, 2005, and were confirmed alive through the register of the State Police Services (N=16,068). The exposed and matched cohorts were followed from December 26, 2004 until emigration, death, or end of follow-up, January 31, 2010, whatever came first. The socioeconomic characteristics of the group returning from

Southeast Asia were considerably different from those of the general population (Table 1).<sup>23</sup> We therefore matched exposed individuals to similar unexposed individuals. To draw from national register data in the matching process, we selected native Swedes (N=14,002), comprising adults (N=10,248; age $\geq$ 18 years in 2004, mean age=42.1) and children and adolescents (N=3,754; age<18 years in 2004, mean age=12.2). We then included only those with permanent residence in Sweden at the time of the event. Each exposed individual was matched with approximately 100 unexposed individuals to ascertain a sufficient number of incident cases in the unexposed group. The final cohort included 8762 exposed and 864,088 unexposed adults and 3742 exposed and 320,828 unexposed children and adolescents.

The comparison group was matched to the exposed group through the Swedish Total Population Register on the following variables: sex, birth year, cohabitation (yes/no), educational attainment (primary and lower secondary, upper secondary, post-secondary, postgraduate), employment status (blue or white collar), and annual income in 2004 (<20/20-79/ $\geq$ 80 percentile). Children were matched on sex, birth year, parental cohabitation status, disposable family income, education and employment of both parents as defined above.

### **Record linkage and outcome ascertainment**

The individuals returning from Southeast Asia were registered in a database, and could therefore be linked to the Swedish Patient Register<sup>24</sup> for ascertainment of psychiatric diagnoses by using their unique personal identification numbers.<sup>25</sup>

The Swedish Patient Register includes all primary and secondary diagnoses

according to the International Classification of Diseases and Related Health Problems<sup>26</sup> made in psychiatric inpatient care in Sweden since 1973 and in psychiatric outpatient visits at private and public caregivers since 2001.<sup>27</sup> The coverage of the Swedish Patient Register was reported in 2010 to be as high as 97% of all psychiatric diagnoses requiring inpatient care.<sup>27</sup> The coverage for outpatient visits was 72-75% in 2004-2010. For these visits, a diagnosis was registered in 42% of the visits in 2004 and had increased to 91% in 2010.<sup>24</sup>

The outcomes were the first presentation of a psychiatric disorder (diagnostic codes F00-F99), a definite suicide attempt based on a diagnosis of intentional self-harm (X60-X84), or an uncertain suicide attempt based on a diagnosis of events of undetermined intent (Y10-Y34). For the sake of precision we primarily report diagnoses in the category of disorders related to stress and adjustment disorders (F43; henceforth labeled stress-related disorders), and diagnoses with  $\geq 20$  events in the tsunami cohort during the observation period. We include all diagnoses in the supplemental tables.

### **Exposure severity**

Exposure severity is an important risk modifier for post-traumatic psychopathology,<sup>28,29</sup> and a diagnosis of PTSD is conditional on traumatic exposure.<sup>26</sup> Therefore, we performed an analysis in tsunami survivors with available data on their exposure severity. Exposure data were collected in a postal survey sent 14 months after the event to 10,501 tsunami survivors who were  $\geq 16$  years of age, and where 4932 (47%) responded.<sup>22</sup> We included 3534 respondents who were also included in the main analysis.



Categorizations of exposure severity usually differentiate between being subjected to life threat and indirect exposure.<sup>22,28,29</sup> The survey participants were categorized accordingly based on 30 survey items that asked about their disaster experiences.<sup>22</sup> Participants were included in the *direct exposure group* (n=1660) if they indicated that they had been caught in or chased by the tsunamis, had felt that their life was threatened, or suffered injuries requiring immediate inpatient care. The *indirect exposure group* (n=903) included participants who reported none of the above but indicated bereavement of relatives, minor physical injuries to themselves or their loved ones, or being witness to distressing disaster scenes (e.g., dead bodies, wounded survivors). These experiences, including bereavement, were also frequently reported by the direct exposure group. In particular, 231 participants in the direct and 111 in the indirect exposure group indicated bereavement of family members, relatives, or friends. The remaining 971 participants comprised the *low exposure group*. They did not endorse any of the 30 exposure survey items but were likely to have been in areas proximal to the afflicted ones and have met/travelled with people in distress.

### **Statistical Analysis**

We used Cox regression models conditioned on the matching variables to calculate the hazard ratios (HRs) contrasting the hazards of any psychiatric disorder as well as specific diagnostic groups between the tsunami survivors and the unexposed cohorts. The cohorts were individually matched on age, gender and socio-economic characteristics and so these factors were inherently controlled for. We performed analyses with and without adjustment for pre-

tsunami psychiatric diagnoses (i.e., any outcome documented in the Swedish Patient Register from 1973 to December 25, 2004). We performed similar analyses on children while also adjusting for previous psychiatric diagnoses of their parents. Furthermore, we compared each exposure group against their respective unexposed controls with and without adjusting for bereavement. To further clarify the role of bereavement, we conducted an analysis on the survey subsample stratified on bereavement. Lastly, we compared overall survival curves with the Log-rank test between groups and we calculated the HRs of psychiatric disorders among the tsunami survivors at different times of follow-up (categorized *a priori* as 0-3/4-11/12-23/ $\geq$ 24 months post-disaster) as compared to the unexposed cohorts. Statistical analyses were undertaken with SAS software (version 9.3; Cary, NC, USA).

### **Role of the funding source**

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

### **Results**

During the five years post-tsunami (median observation time=62.1 mo.) the total number of new psychiatric diagnoses made in the adult tsunami cohort and the matched unexposed cohort was 547 (6.2%) and 47,734 (5.5%), respectively.

The corresponding numbers of pre-tsunami diagnoses among adults were 427(4.9%) and 47,329 (5.5%).

We found an overall increased risk of psychiatric disorders in the tsunami cohort, particularly of PTSD (Table 2 and eTable 1 in Supplement). There was a seven-fold risk of PTSD among survivors whereas the risks of anxiety disorders and depression were not elevated. The risk of suicide attempt was increased among exposed women but not men, whereas the risk of alcohol disorders was increased among exposed men but not women. The HRs increased slightly when adjusting for pre-tsunami psychiatric disorders.

### **Children and adolescents**

For children and adolescents the number of pre-tsunami diagnoses was 88 (2.4%) in the tsunami cohort and 10,096 (3.2%) in the unexposed cohort. The overall risk of a post-tsunami disorder was not increased in the tsunami cohort. There were elevated risks of stress-related disorders and suicide attempts with uncertain intent. In contrast, exposure to the tsunami was linked to a lower risk of anxiety disorders and unipolar depression. (Table 3 and eTable 2 in Supplement). A post-hoc analysis indicated that an increased risk was found among both boys and girls for stress-related disorders, HR=2.26 (95%CI: 1.33-3.86) for boys and HR=1.59 (95%CI: 1.06-2.39) for girls. There was an increased risk of unclear suicide attempts among boys, HR=2.26 (95%CI: 1.33-3.89) but not among girls, HR=1.19 (95%CI: 0.67-2.10).

### **Time to diagnosis**

Because of the dissimilar findings for stress-related vs. other psychiatric disorders, and to preserve precision for meaningful comparisons, we used these two large diagnostic groups in these analyses. For adults, exposure to the tsunami was associated with a shorter average time to a diagnosis of stress-

related disorders, Log-rank test=0.93,  $P<0.001$  (Figure 1). The tsunami cohort had a higher risk of stress-related disorders at each individual time period, peaking at the first 3 months post-disaster (Table 4). For children, exposure was associated with a shorter time with elevated risks of stress-related disorders, Log-rank test=0.0983,  $P<0.001$  (Figure 1). We found an increased risk among exposed children during the first 3 months but not thereafter (Table 4). For neither adults nor children were tsunami exposure associated with a shorter time to diagnosis of non-stress-related disorders and there were no indications of a higher risk of these disorders at any specific time interval (Table 4).

### **Exposure severity**

The proportions of pre- and post-tsunami psychiatric disorders among survey respondents were: 4.5% and 7.2% for the direct, 5.4% and 5.4% for the indirect, 3.8% and 3.3% for the low exposure groups, and 5.4% both pre- and post-tsunami in the unexposed groups. A dose-response relationship between increasing severity of exposure and risk of psychiatric disorders was suggested, although not statistically significant (Figure 2 and eTable 3 in Supplement). Direct exposure was related to an increased risk of any psychiatric disorder, HR=1.51 (95%CI: 1.25-1.83); mainly stress-related disorders, HR=3.18 (95%CI: 2.40-4.22) and particularly PTSD, HR=14.6 (95%CI: 8.60-24.9). Direct exposure was also related to a higher risk of alcohol abuse, HR=1.65 (95%CI: 1.08-2.53). Indirect exposure was only related to a higher risk of PTSD, HR=3.48 (95%CI: 1.02-11.9). Low exposure was related to an overall lower risk of any psychiatric diagnosis compared with the unexposed group, HR=0.69 (95%CI: 0.48-0.98),

whereas no difference was found for individual diagnostic categories (lowest  $P=0.22$ ).

When adjusting for bereavement status (yes/no) the relative risks among directly exposed remained but were attenuated for stress-related disorders, HR=1.97 (95%CI: 1.36-2.87) and PTSD, HR=6.31 (95%CI: 2.71-14.67) whereas the risk of alcohol abuse was essentially unchanged, HR=1.71 (95%CI: 1.10-2.66). For the indirect exposure group, the elevated risk of PTSD was no longer significant.

Comparing the bereaved survivors to their matched controls, there were elevated risks of any disorder (14.0% vs. 5.4%), HR=3.47 (95%CI: 2.59-4.64), mainly driven by stress-related disorders (7.6% vs. 1.1%), HR=7.92 (95%CI: 5.26-11.91). For those not bereaved ( $n=3192$ ), there was an elevated risk only of stress-related disorders (1.4% vs. 1.0%), HR=1.42 (95%CI: 1.05-1.91), see also eTable 4.

## **Comment**

Our study represents a complete five-year follow-up of Swedish citizens repatriated after the 2004 Indian Ocean tsunami and provides evidence for an increased risk of post-tsunami psychiatric disorders, essentially for stress-related disorders, among adults and also among children in the short-term. The risk elevation was restricted to first 3 months post-disaster among children whereas the risk peaked initially but a notable long-term risk for stress-related disorders was seen among adults. In this cohort of individuals predominantly

from higher socioeconomic strata we further found increased risks of suicidal attempts among adult women and alcohol abuse among men. This study is the first to provide complete data on the effect of a large-scale disaster on psychiatric morbidity in a civilian population while accounting for pre-disaster psychiatric morbidity and using a socio-demographically matched unexposed cohort.

The increased risk of psychopathology among both adult and children survivors was mainly represented by PTSD and other stress-related disorders, which concurs with findings from previous studies on various traumatic events.<sup>3,4</sup> The link between trauma exposure and stress-related disorders is strengthened by the indication of a dose-response effect of exposure severity among adults, and retained elevated risks among directly exposed after adjusting for bereavement. Notably, only direct exposure was related to elevated risks after this adjustment, and this group probably contributed to the elevated risk of stress-related disorders seen in those that were not bereaved. In addition, our data confirm the strong impact of bereavement associated with traumatic events on future risk of psychopathology.<sup>8</sup>

Adult survivors suffered protracted stress-related disorders diagnosed across several years after the event, extending previous studies that have found prolonged effects but without adjusting for pre-event disorders, for example, after the World Trade Centre terrorist attacks.<sup>13</sup> However, the elevated risk in children was limited to the first three months post-disaster suggesting general resiliency, although smaller studies have yielded ambiguous findings on the long-

term effects in children.<sup>4</sup> Adverse post-disaster events are associated with PTSD symptom maintenance in children,<sup>30</sup> which may explain the absence of any increased long-term risk herein.

We found an elevated risk of suicide attempts among adults, and of suicide attempts with uncertain intent among boys. The latter diagnostic category includes injuries from accidents, self-inflicted injuries, and assaults. These behaviors implicate impulsivity and risk-taking behavior, which increase among youngsters in response to trauma<sup>31</sup> and is being increasingly recognized as a symptom of PTSD in adolescents.<sup>32</sup> Among psychiatric disorders, PTSD is one of the strongest predictors, and has been associated with a seven-fold increased risk, of suicide attempts in adults.<sup>33</sup> Taken together, it seems that the effects of the tsunami independent of prior psychopathology were largely related to stress-related disorders.

There was, however, an increased risk of alcohol-related disorders among men whereas it has been suggested that post-disaster alcohol disorders reflect pre-disaster misuse.<sup>9</sup> In contrast, our data indicate that disaster exposure may exacerbate pre-existing alcohol problems or lead to new cases. The different methods among studies necessitate further well-controlled research to test the consistency of this finding.

The benign post-tsunami circumstances for the survivors, returning to an intact home environment and support networks, may have averted increased risks of mood and anxiety disorders.<sup>34</sup> This is in line with previous findings linking the

occurrence of these disorders among adults after a disaster to secondary stressors and adverse life circumstances.<sup>14,29</sup> For children, disaster exposure severity has previously been linked to more severe PTSD symptoms but not depression or anxiety.<sup>15,35</sup> In this sample we found lower risks of mood and anxiety disorders, possibly because of a resiliency not accounted for by the matching variables. Overall, the risk estimates increased when adjusting for pre-existing diagnoses, relating to the slightly lower prevalence of pre-tsunami diagnoses in the exposed cohort than in the matched controls.

### **Strengths and limitations**

The Swedish nationwide complete registries provide prospective information on clinically confirmed psychiatric disorders. Thus, our outcome ascertainment is nearly complete and do not rely on retrospective self-reports, which diminish risks of selection bias and various sources of information bias. Leveraging these resources allowed us to adjust for prospective data on pre-tsunami psychopathology. Second, whereas the effect of a disaster itself usually is confounded with the effects of post-disaster stressors,<sup>10,34</sup> in this study the survivors returned to a context relatively unaffected by the disaster and experienced very few other post-disaster stressful events during the follow up.<sup>21,22,36</sup> Third, we were able to show a dose-response pattern, increasing our confidence in the direct link between the tsunami and later psychopathology.

There are also limitations to this study. Importantly, healthcare-seeking behaviors may differ between the exposed and unexposed groups because the survivors might have been encouraged to seek and receive care for ill health,



although it is unclear if this is the case in the context of the tsunami.<sup>37</sup> Also, doctors may have been biased towards stress-related diagnoses because of anchoring and availability heuristics, which would magnify the differences observed herein. Regarding the latter, however, the survival curves do not indicate an inflated number of stress-related diagnoses, as it would be reflected by a corresponding decrease in other diagnoses. In addition, the findings on suicide attempts are less, if not at all, susceptible to this bias, lending particular weight to this outcome.

Second, despite the large sample size and several years of follow up, there were few incident cases for several diagnoses, yielding inconclusive findings for several outcomes. This is particularly noticeable in the survey sample. As this was the first study to investigate out- and inpatient psychiatric diagnoses after a disaster we opted to analyze all diagnosis groups. Third, the high socioeconomic status of the exposed cohort required a careful matching process: Nonetheless, the pre-tsunami psychiatric morbidity was slightly lower in the tsunami cohort than in the unexposed cohort, which points to the possibility of unmeasured confounders, and suggests that the tsunami group was generally more predisposed against psychopathology. This also diminishes the probability of potential bias due to the fact that we were not able to match on urban/rural dwelling as a proxy for access to specialized mental health services. The lower risk of post-disaster psychopathology in the low exposure group might also reflect that low exposure was insufficient to produce severe psychopathology<sup>28</sup> while the event at the same time resulted in an influx of beneficial factors such as social support.

Finally, the data collection was set to start on the day of the disaster in order not to omit any potential cases. However, during the first days most exposed individuals were still abroad and could not seek healthcare while those unexposed provided outcome data from day one. Given that the repatriation took place within three weeks and the average time to diagnosis was more than two years we assume that the potential bias would be small and, if anything, result in conservative estimates. Further conservative bias is also likely in the large tsunami cohort due to slight oversampling at the airports, since practical circumstances prevented a thorough verification of the repatriated individuals exposure to the tsunami.

The outcomes in this study concern severe symptoms with functional impairment suffice for the survivors or their parents to seek professional help and then be referred to specialist care within a public healthcare system.

Disaster survivors with significant distress seem to be reluctant to seek healthcare services,<sup>38,39</sup> and several tsunami survivors received interventions from services that do not provide data to the Swedish Patient Register (e.g., support centers, primary care services).<sup>40</sup> Thus, we emphasize that the absolute risks do not reflect the true prevalence of post-trauma psychiatric disorders.

## **Conclusions**

Swedish survivors from this major yet transient natural disaster suffered an increased risk of severe psychopathology, predominantly stress-related disorders. In a population and context that otherwise bear a low risk of

psychiatric illnesses, it is reasonable to assume that the disaster itself, with its enormity and distinct duration, was the causal agent for the elevated risk. The increased risk of suicide attempts in particular highlights the capacity of one single threatening experience, even in the most benign circumstances, to lead to major consequences. The elevated long-term risk among exposed adults underscore the need for research using prolonged observation periods. Taken together, these findings emphasize the importance of timely efforts to provide effective early interventions and active follow up so as to prevent, detect, and alleviate dire health consequences among both adult and child survivors of inevitable future major natural disasters.

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## **Declaration of interests**

The authors declare no conflicts of interest.

## **Author contributions**

FKA, RG, AB, FF, PL, CMH, and UAV conceived and designed the study. FKA, PL, CMH, and UAV acquired the data. AB and FF analyzed the data. FKA, RG, AB, FF, PL, CMH, and UAV interpreted the data. FKA, FF, and UAV drafted the work and RG, AB, FF, PL, and CMH revised it critically for important intellectual content.

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## Figure Legends

Figure 1. Time to a Diagnosis of Psychiatric Disorders in Tsunami Survivors as Compared with Matched Unexposed Individuals.

Log-rank test  $P_s < 0.001$  for stress-related disorders in both adults and in children and adolescents.

Figure 2. Risk of Any Psychiatric Diagnosis, Stress-Related Disorders, and Posttraumatic Stress Disorder (PTSD) in Tsunami Survivors.

Survivors were stratified by disaster exposure and compared with matched unexposed individuals. Follow-up time was 5 years post-disaster. Error bars indicate 95% confidence intervals. Adjusted for pre-disaster psychiatric diagnoses. There were no PTSD cases in the low exposure group.

## Tables

**Table 1. Demographic characteristics and psychiatric history in the tsunami cohort as compared to the Swedish population**

	General population (N=7285292)		Tsunami cohort (N=12734)	
	No.	%	No.	%
Age, years				
16–29	1 505 365	20.7	3 638	28.6
30–49	2 457 821	33.7	5 651	44.4
>49	3 322 106	45.6	3 445	27.1
Female	3 704 955	50.9	6 152	48.3
Born in Sweden	6 272 329	86.1	11 383	89.4
Post-secondary education <sup>a,b</sup>	1 869 820	29.3	4 887	38.9
Married or cohabiting <sup>a</sup>	3 084 784	42.3	5 041	39.6
Yearly income in population top 20% <sup>a</sup>	1 445 547	19.8	4 273	33.6
Unskilled or blue-collar occupation <sup>a,c</sup>	1 519 287	29.4	2 011	19.7
Pre-event psychiatric disorders <sup>a</sup>	637 632	8.8	697	5.5
Psychiatric disorders among fathers <sup>d</sup>	350 350	4.8	750	5.9
Psychiatric disorders among mothers <sup>d</sup>	398 733	5.5	832	6.5

The table includes individuals included in the Longitudinal Integration Database for Health Insurance and Labour Market Studies in 2004.<sup>23</sup>  $P < 0.001$  for all comparisons between groups according to two-tailed  $\chi^2$ -tests.

<sup>a</sup> Data only for adults.

<sup>b</sup> Highest level of education is missing for 14% and 1.4% of the general population and the tsunami cohort, respectively.

<sup>c</sup> Occupation was unknown for 29% and 20% of the general population and the tsunami cohort, respectively.

<sup>d</sup> Data only for children.

Table 2. Relative risks of psychiatric disorders and attempted suicide in adults during 5 years after the tsunami

Outcome	Total				Men			Women		
	No. (%)		HR (95% CI)		No. (%)		HR (95% CI)	No. (%)		HR (95% CI)
	Exposed n=8762	Unexposed n=864088	Crude	Adjusted <sup>a</sup>	Exposed n=4544	Unexposed n=448057	Adjusted <sup>a</sup>	Exposed n=4218	Unexposed n=416031	Adjusted <sup>a</sup>
Any psychiatric disorder	547 (6.2)	47734 (5.5)	<b>1.14 (1.04-1.24)</b>	<b>1.21 (1.11-1.32)</b>	246 (5.4)	21519 (4.8)	<b>1.17 (1.02-1.33)</b>	301 (7.1)	26215 (6.3)	<b>1.25 (1.11-1.40)</b>
Suicide attempt, definite	38 (0.43)	2752 (0.32)	1.36 (0.99-1.87)	<b>1.54 (1.11-2.13)</b>	16 (0.35)	1205 (0.27)	1.41 (0.85-2.34)	22 (0.52)	1547 (0.37)	<b>1.65 (1.08-2.53)</b>
Suicide attempt, uncertain	43 (0.49)	3438 (0.40)	1.24 (0.92-1.68)	1.27 (0.94-1.71)	27 (0.59)	2035 (0.45)	1.32 (0.91-1.92)	16 (0.38)	1403 (0.34)	1.19 (0.73-1.94)
Unipolar depression	176 (2.0)	18130 (2.1)	0.96 (0.83-1.11)	1.03 (0.88-1.19)	56 (1.2)	7208 (1.6)	0.79 (0.61-1.04)	120 (2.8)	10922 (2.6)	1.19 (0.99-1.43)
Alcohol abuse/dependence	102 (1.2)	8467 (0.98)	1.17 (0.97-1.43)	<b>1.27 (1.04-1.54)</b>	72 (1.6)	5775 (1.3)	<b>1.30 (1.03-1.64)</b>	30 (0.71)	2692 (0.65)	1.20 (0.84-1.72)
Substance abuse/dependence	42 (0.48)	4073 (0.47)	1.01 (0.75-1.37)	1.11 (0.82-1.50)	29 (0.64)	2392 (0.53)	1.27 (0.88-1.83)	13 (0.31)	1681 (0.40)	0.87 (0.50-1.50)
Anxiety disorders	148 (1.7)	16434 (1.9)	0.89 (0.76-1.04)	0.95 (0.81-1.12)	62 (1.4)	6386 (1.4)	1.00 (0.78-1.29)	86 (2.0)	10048 (2.4)	0.92 (0.75-1.14)
Stress-related disorders	187 (2.1)	8831 (1.0)	<b>2.10 (1.82-2.43)</b>	<b>2.27 (1.96-2.62)</b>	71 (1.6)	3211 (0.72)	<b>2.30 (1.81-2.90)</b>	116 (2.8)	5620 (1.4)	<b>2.25 (1.87-2.71)</b>
Acute stress reaction	75 (0.86)	3636 (0.42)	<b>2.03 (1.62-2.54)</b>	<b>2.16 (1.72-2.71)</b>	29 (0.64)	1492 (0.33)	<b>1.96 (1.36-2.83)</b>	46 (1.09)	2144 (0.52)	<b>2.30 (1.72-3.08)</b>
Post-traumatic stress disorder	46 (0.52)	692 (0.08)	<b>6.61 (4.95-8.83)</b>	<b>7.51 (5.47-10.3)</b>	16 (0.35)	168 (0.04)	<b>11.5 (6.77-19.5)</b>	30 (0.71)	524 (0.13)	<b>6.30 (4.25-9.34)</b>
Reaction to severe stress NOS	46 (0.52)	2000 (0.23)	<b>2.26 (1.69-3.01)</b>	<b>2.44 (1.82-3.27)</b>	19 (0.42)	718 (0.16)	<b>2.78 (1.78-4.34)</b>	27 (0.64)	1282 (0.31)	<b>2.26 (1.53-3.32)</b>

Individuals were matched for sex, year of birth, income, and marital, educational, and occupational status. Abbreviations: CI, confidence interval; HR, hazard ratio; NOS, not otherwise specified.

<sup>a</sup> Adjusted for any psychiatric disorder before the tsunami.

Table 3. Relative risks of psychiatric disorders and attempted suicide in children and adolescents

Outcome	Incidence, No. (%)		Hazard ratio (95% CI)	
	Exposed n=3742	Unexposed n=320828	Crude	Adjusted <sup>a</sup>
Any psychiatric disorder	248 (6.63)	22081 (6.88)	0.94 (0.83-1.06)	0.98 (0.86-1.11)
Suicide attempt, definite	18 (0.48)	1997 (0.62)	0.73 (0.46-1.15)	0.74 (0.47-1.17)
Suicide attempt, uncertain	32 (0.86)	1933 (0.60)	<b>1.42 (1.01-2.01)</b>	<b>1.43 (1.01-2.02)</b>
Unipolar depression	42 (1.12)	4825 (1.50)	<b>0.71 (0.53-0.96)</b>	<b>0.73 (0.54-0.98)</b>
Eating disorders	21 (0.56)	2082 (0.65)	0.87 (0.56-1.34)	0.90 (0.58-1.39)
Alcohol abuse/dependence	54 (1.44)	3633 (1.13)	1.24 (0.94-1.62)	1.25 (0.96-1.64)
Substance abuse/dependence	21 (0.56)	1346 (0.42)	1.27 (0.82-1.96)	1.35 (0.87-2.10)
Anxiety disorders	47 (1.26)	5637 (1.76)	<b>0.70 (0.53-0.94)</b>	<b>0.74 (0.55-0.98)</b>
Stress-related disorders	39 (1.04)	1827 (0.57)	<b>1.75 (1.28-2.39)</b>	<b>1.79 (1.30-2.46)</b>
Acute stress reaction	20 (0.53)	768 (0.24)	<b>2.13 (1.38-3.27)</b>	<b>2.14 (1.38-3.32)</b>
Post-traumatic stress disorder	9 (0.24)	270 (0.08)	<b>2.62 (1.36-5.01)</b>	<b>2.83 (1.44-5.54)</b>

Not including psychotic disorders, bipolar mood disorders, personality disorders, and the remaining stress-related disorders (all n < 10 among exposed).

Abbreviations: CI, confidence interval; HR, hazard ratio.

<sup>a</sup> Adjusted for any own or parental psychiatric disorders before the tsunami

Table 4. Relative risks of stress-related disorders and other psychiatric disorders at different times after the disaster

Age & Diagnosis category	Time from event, Mo.	Incidence, No. (%)		Hazard ratio (95% CI)	
		Exposed	Unexposed	Crude	Adjusted
<b>Adults</b>					
Stress-related disorders <sup>a</sup>	0–3	56 (0.64)	637 (0.07)	<b>8.58 (6.52-11.3)</b>	<b>10.9 (8.05-14.7)</b>
	4–11	18 (0.21)	1179 (0.14)	1.49 (0.93-2.37)	<b>1.63 (1.02-2.62)</b>
	12–23	33 (0.38)	1763 (0.21)	<b>1.86 (1.32-2.62)</b>	<b>2.00 (1.41-2.83)</b>
	24–60	80 (0.93)	5252 (0.61)	<b>1.52 (1.22-1.90)</b>	<b>1.62 (1.30-2.02)</b>
Other psychiatric disorders	0–3	45 (0.51)	4771 (0.55)	0.93 (0.70-1.25)	1.08 (0.80-1.47)
	4–11	68 (0.78)	7348 (0.86)	0.91 (0.71-1.15)	0.98 (0.77-1.25)
	12–23	99 (1.15)	9450 (1.11)	1.03 (0.84-1.25)	1.09 (0.89-1.33)
	24–60	232 (2.74)	22500 (2.69)	1.01 (0.89-1.16)	1.05 (0.93-1.20)
<b>Children</b>					
Stress-related disorders <sup>a</sup>	0–3	17 (0.45)	53 (0.02)	<b>27.2 (15.4-47.8)</b>	<b>29.7 (16.4-53.8)</b>
	4–11	2 (0.05)	131 (0.04)	1.25 (0.31-5.06)	1.19 (0.27-5.27)
	12–23	2 (0.05)	275 (0.09)	0.63 (0.16-2.54)	0.63 (0.16-2.54)
	24–60	18 (0.49)	1368 (0.43)	1.07 (0.67-1.71)	1.08 (0.67-1.73)
Other psychiatric disorders	0–3	17 (0.45)	1660 (0.52)	0.87 (0.54-1.41)	0.83 (0.49-1.41)
	4–11	30 (0.81)	3130 (0.98)	0.79 (0.55-1.14)	0.88 (0.61-1.28)
	12–23	33 (0.89)	3665 (1.16)	0.75 (0.53-1.06)	0.78 (0.56-1.11)
	24–60	145 (3.97)	13021 (4.18)	0.92 (0.78-1.08)	0.94 (0.79-1.10)

<sup>a</sup> Includes acute stress reaction, posttraumatic stress disorder, adjustment disorder, other reaction to severe stress, and reaction to severe stress not otherwise specified.

## **Research in context**

### *Systematic review*

The literature to date clearly demonstrates that a substantial minority of disaster survivors experience transient posttraumatic stress.<sup>3</sup> Yet, studies of mental health in disaster survivors face methodological challenges. Several comprehensive literature reviews report that most studies are small, cross-sectional, short-term, lack or are limited to retrospective self-report data on preexisting psychopathology, and lack matched unexposed comparison groups.<sup>3,7,8</sup> Uncertainties remain about the capacity of the disastrous event itself, independent of previous psychiatric morbidities and secondary traumata, to produce severe psychopathology, including suicide attempts.<sup>11</sup> We searched existing reviews, as well as PubMed for reports published from Jan 1, 2005 until Jan 1, 2015, and found no similar report on psychiatric outcomes in disaster samples with a matched comparison group.

### *Interpretation*

This study brings solid evidence that a transient disaster can in the absence of severe secondary stressors (loss of property, etc.) lead to long-standing elevated risks of stress-related psychiatric diagnoses and suicide attempts in adults, and short-term effects among children, when accounting for pre-existing psychopathology. These findings emphasize the importance of early surveillance of children and prolonged observation periods in future research and monitoring of adult survivors of natural disasters.