

# SYSTEMATIC REVIEW

## The Incidence of Posttraumatic Stress Disorder After Floods: A Meta-Analysis

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### ABSTRACT

This study analyzes the incidence of posttraumatic stress disorder (PTSD) among flood victims, between different flood intensities, and between different time points after a flood. A search of several electronic literature databases was conducted to collect data on the incidence of PTSD after a flood. Loney criteria for research quality were used to evaluate the quality of selected search results. The combined incidence of PTSD was estimated using the Freeman-Tukey double arcsine transformation method. Subgroup analyses were conducted on different trauma intensities and different time points after a flood. Sensitivity analysis was performed to evaluate the impact of research quality. Fourteen articles were included in this meta-analysis, including a total of 40 600 flood victims; 3862 victims were diagnosed with PTSD. The combined incidence of PTSD was 15.74%. The subgroup analyses showed that the incidence of PTSD in victims who experienced severe and moderate flood intensity was higher than that in victims who experienced mild flood intensity. The incidence of PTSD was lower at 6 or more months after a flood (11.45%) than within 6 months (16.01%) of a flood. In conclusion, the incidence of PTSD among floods of different trauma intensities was statistically significant. (*Disaster Med Public Health Preparedness*. 2015;9:329-333)

**Key Words:** flood, posttraumatic stress disorder, incidence rate, meta-analysis

Research has shown that natural disasters such as floods leave victims with a wide range of psychosocial and mental health issues, such as psychological distress, anxiety, depression, and post-traumatic stress disorder (PTSD).<sup>1,2</sup> PTSD is a common and serious mental disorder that manifests in victims after a traumatic event and is characterized by persistent intrusive memories about the traumatic event, persistent avoidance of stimuli associated with the trauma, and persistent symptoms of increased arousal.<sup>3</sup> PTSD can cause long-term damage to an individual's social functions, family life, and health.<sup>4</sup> Flood is one of the top 10 natural disasters that threaten human survival.<sup>5</sup> Besides the significant damage it can inflict on the industrial and agricultural sectors, a flood can unleash a variety of serious health hazards onto people. However, an enormous divergence in the reported incidence of PTSD after flooding is observed between studies.

Studies currently available in the literature show that the occurrence of PTSD symptoms in flood victims ranges from 8% to 80%.<sup>6</sup> Among many factors influencing the rate of PTSD, the power of stressors connected with the catastrophe, the degree of exposure to trauma, and the amount of time elapsed since the event have emerged as critical variables.<sup>7</sup>

Unfortunately, there is no study available currently that tries to accurately estimate the incidence of PTSD after flooding. In addition, accurate information on the incidence of PTSD is important for planning psychological interventions for flood victims. In this study, the incidence of posttraumatic stress disorder occurring between 1980 and 2013 worldwide was analyzed to obtain a combined incidence of PTSD. The incidence of posttraumatic stress disorder of different trauma intensities and at different time points post flooding was analyzed to provide a theoretical basis for future studies of posttraumatic stress disorder after flooding.

### MATERIALS AND METHODS

#### Identification of Relevant Studies

Both the English and Chinese literature associated with flood-related PTSD published between 1980 and 2013 were searched using the keywords posttraumatic stress disorders and flood. The retrieval time was March 2014. The searched databases included PubMed, China Knowledge Resource Integrated Database (CNKI), and Wanfang resource systems. Each search result was carefully examined. The inclusion criteria for this study were: (1) an observational study of the flood victims; (2) scales or diagnostic criteria of traumatic stress

TABLE 1

## Meta-Analysis of Literature for Posttraumatic Stress Disorder (PTSD) After Flooding During 1980–2013

First Author	Year of Publication	Region	PTSD Diagnosis Standard	Number of PTSD Victims	Total Sample Size	Intensity of Flood	Time of Survey After Flood, mo	Score of Literature Quality
McMillen <sup>11</sup>	2002	St Louis, US	DSM-III-R	35	162	Severe	2	6
Norris <sup>12</sup>	2004	Mexico	DSM-IV	134	561	Moderate, severe	6	6
Chae <sup>13</sup>	2005	South Korea	DSM-IV	134	339	–	4–6	5
Liu <sup>14</sup>	2006	Hunan, China	DSM-IV	2875	33 340	Mild, moderate, severe	6–9	7
Bokszczanin <sup>15</sup>	2007	Poland	DSM-IV	94	533	severe	28	6
Heo <sup>16</sup>	2008	South Korea	DSM-IV	13	58	–	18	5
Mason <sup>17</sup>	2010	UK	DSM-IV	124	444	Severe	6	6
Paranjothy <sup>18</sup>	2011	UK	DSM-IV	138	2019	Mild	3–6	7
Chen <sup>19</sup>	2012	Gansu, China	DSM-IV	125	268	Severe	3	6
Bei <sup>23</sup>	2013	Australia	DSM-IV	8	53	Severe	1.5	5
Ishikawa <sup>24</sup>	2013	Ladakh, India	DSM-IV	2	318	–	7	5
Azuma <sup>22</sup>	2013	Japan	DSM-IV	18	297	Severe	1–6	5
Alderman <sup>21</sup>	2013	Australia	DSM-IV	69	929	Mild, severe	4	7
Peek-Asa <sup>20</sup>	2012	US	DSM-IV	93	1279	Mild, severe	1	7

Abbreviations: DSM, Diagnostic and Statistical Manual of Mental Disorders.

disorder; (3) a survey conducted at least 1 month after the flood; and (4) an accurate number of participants and number of victims with PTSD after the flood or data available to calculate these numbers. The exclusion criteria were: (1) a review or report of the posttraumatic stress disorder after the floods; (2) incomplete or erroneous information; and (3) duplicate publications, studies, or data collection.

### Data Extraction

Information on the title and year of publication, the first author, the geographic area of study, PTSD diagnostic criteria, the number of victims with PTSD, total participants for the survey, the intensity of flood trauma, the amount of time after the flood when the survey was conducted, and the quality of the literature were collected in an EpiData 3.0 database (as shown in Table 1).

### Evaluation of the Literature Quality

The quality evaluation criteria for prevalence or incidence studies published by Loney et al<sup>8</sup> were adopted to evaluate the quality of each included study. The Loney criteria include 8 items covering mainly the validity of research methods, a reasonable explanation of results, and study scope to evaluate the quality of the study. Each criterion is given a score of 0 to 8 points. Higher scores represent better study quality. Literature searches, literature screening, information extraction, and quality assessment were performed by 2 trained personnel independently. Disagreements on issues pertaining to the literature review process were solved through a meeting of experts in the research group.

### Statistical Analysis

The metaprop package of the R 3.1.0 software was used for the meta-analysis of incidence of PTSD among flood victims.

Freeman-Tukey transformation of inverse hyperbolic sine function was used to calculate the combined incidence.<sup>9</sup> A  $P > .05$  for the heterogeneity test suggests homogeneity of the included literature, and a fixed effect model was then used. In contrast, a  $P < .05$  for the heterogeneity test suggests heterogeneity of the literature, and a random effect model was used. SPSS version 18.0 was used for subgroup analysis of the degree of different trauma intensities and the incidence of PTSD at different time points after the floods. Wilcoxon rank sum test was used for comparing the PTSD incidence between 2 independent samples, while Kruskal-Wallis H test was used for comparing the PTSD incidence among multiple samples with a completely randomized design.<sup>10</sup> Linear regression method was used to assess publication bias and draw an Egger funnel plot. A  $P \leq .05$  was considered statistically significant.

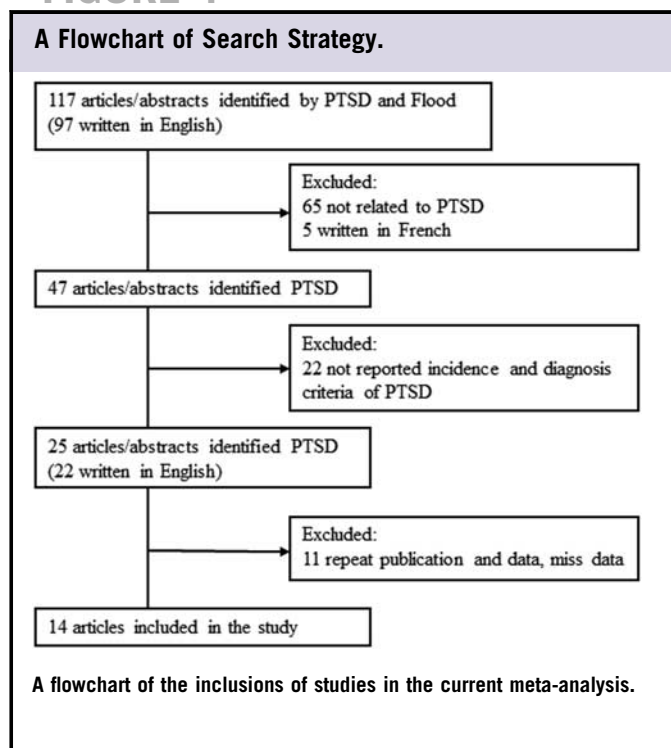
## RESULTS

### Basic Information of Studies

A total of 117 articles published between 1980 and 2013 were retrieved. Among the 117 articles, 102 were retrieved from PubMed, 9 from the Wanfang database, and 6 from the Chinese journal full-text database. After excluding 65 articles with research topics not related to PTSD, 5 articles written in French, 22 articles without information of incidence and diagnostic criteria of PTSD, and 11 articles of duplicate publications, duplication of data, and missing data, 14 full texts were included in this study<sup>11–24</sup> (Figure 1). The included 14 studies cover a time span of 18 years (1993 to 2011). A total of 40 600 participants were included in the 14 studies. A large difference in study sample size can be seen (53 to 33 340),<sup>12,23</sup> with a median of 392 samples. One study used DSM-III-R criteria for the diagnosis of PTSD,<sup>11</sup> while DSM-IV criteria were used for 13 studies.

Among the 14 studies, quality evaluation scores were 7 points for 4 studies, 6 points for 5 studies, and 5 points for 5 studies. The main problems were generally low response rates, no interpretation of the potential impact of missing or invalid questionnaires, and not reporting the 95% confidence interval of the incidence of PTSD.

FIGURE 1



**Combined Incidence of PTSD**

The heterogeneity test of the 14 studies showed the studies were heterogeneous ( $Q = 771.22$  and  $P < .0001$ ). The random effect model was then used for the combined incidence of PTSD. The total sample size was 40 600 victims, and 3862 were identified to have PTSD. The weighted combined incidence of PTSD after flooding was 15.74% with a 95% confidence interval of 11.25%–20.82% (Figure 2).

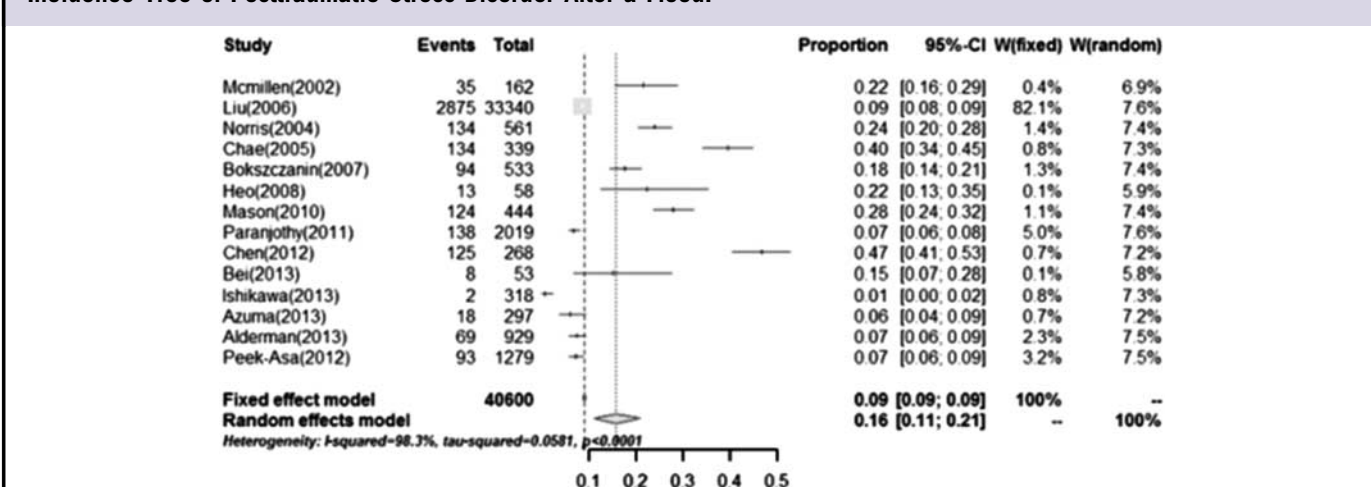
The hierarchical merger results of the incidence of PTSD after the flood are shown in Table 2. Among them, the combined PTSD rates for severe flood trauma,<sup>11,12,14,15,17,19,21–23</sup> moderate flood trauma,<sup>12,14,20</sup> and mild flood trauma<sup>14,18,20,21</sup> were 20.06% (95% CI: 12.55%–28.79%), 12.82% (95% CI: 12.16%–13.50%), and 4.41% (95% CI: 2.24%–7.25%), respectively. The combined PTSD rates for studies conducted 6 months or more<sup>14–16,21</sup> and within 6 months<sup>11–13,17–19,22,23</sup> after the flood were 16.01% (95% CI: 8.77%–24.89%) and 11.45% (95% CI: 6.54%–17.48%), respectively. Subgroup analysis showed that incidences of PTSD were statistically significant ( $H = 7.906$ ,  $P = .019$ ) between floods of different trauma intensity. No significant differences in the incidence of PTSD were observed between severe flood trauma and moderate flood trauma ( $P > .05$ ). The incidence of PTSD in the mild flood trauma (4.41%) was significantly lower than that in the severe flood trauma (20.06%) and moderate flood trauma (12.82%) ( $P < .05$ ). No significant difference in PTSD incidence was observed between different time points post flooding ( $Z = -0.707$ ,  $P = .480$ ).

**Sensitivity and Bias Analysis**

After excluding literature with a quality evaluation score less than 5 for meta-analysis, the combined incidence of PTSD

FIGURE 2

**Incidence Tree of Posttraumatic Stress Disorder After a Flood.**



The area of each square is proportional to the study's weight in the meta-analysis, and each line represents the confidence interval around the estimation. The diamond represents the aggregate estimation, and its lateral points indicate confidence intervals for this estimation.

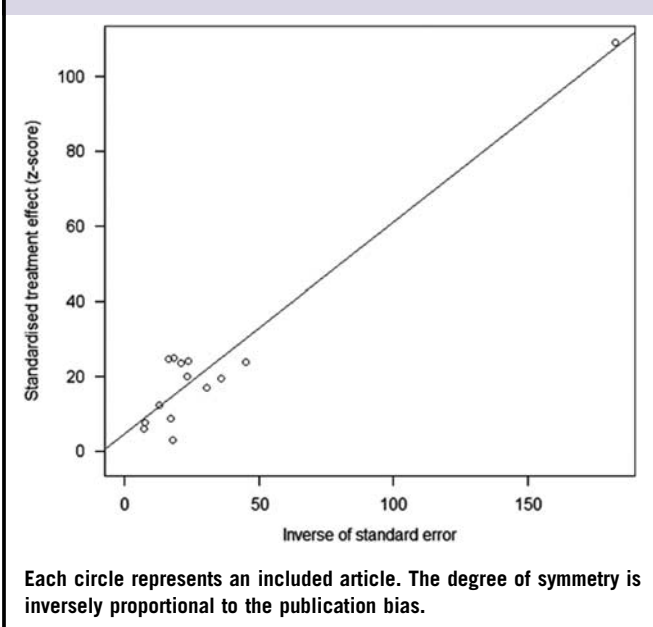
TABLE 2

## Meta-Analysis of the Incidence of Posttraumatic Stress Disorder (PTSD) After a Flood During 1980–2013

Group		Study Number	Total Samples	Medium, %	Minimum, %	Maximum, %	Incidence (95% CI), %
Trauma intensity	Severe	9	14 521	16.90	4.58	46.64	20.06 (12.55–28.79)
	Moderate	3	9646	12.91	11.76	13.77	12.82 (12.16–13.50)
	Mild	4	15 718	4.54	2.56	6.84	4.41 (2.24–7.25)
Time after flood	<6 mo	10	6351	18.35	6.06	46.64	18.44 (10.98–27.28)
	≥6 mo	4	34 249	13.13	0.63	22.41	9.78 (3.68–18.26)
Total		14	40 600	16.37	0.63	46.64	15.74 (11.25–20.82)

FIGURE 3

## Egger Plot of Literature on the Incidence of Posttraumatic Stress Disorder After a Flood.



increased from 15.74% to 16.88%. The small change indicates low sensitivity and credible results. Publication bias was analyzed using regression analysis, and an Egger funnel plot was drawn (Figure 3). Results showed that the score of quality evaluation of the included literatures were distributed symmetrically. Egger test showed no significant bias for the included studies ( $P > .05$ ).

## DISCUSSION

Flood is one of the most common and most severe forms of natural disaster that can lead to serious health hazards for people everywhere. Although accurate information on the incidence of PTSD after flooding is important for both researchers and government officials to plan psychological interventions, there is no study currently that accurately estimates the incidence of PTSD after flooding. In this study, a meta-analysis was performed to calculate the combined

incidence of PTSD in literature published from 1980–2013. Fourteen articles were finally included in the analysis. Although there are a limited number of papers and regional differences between studies, the total participants reached 40 600. Therefore, the current study is still able to reflect to some extent the actual occurrence of PTSD after flooding, and the combined incidence of PTSD is valuable for both researchers and government officials. The meta-analysis showed that the combined incidence of PTSD after a flood is 15.74% with a 95% CI of 11.25%–20.82%.

The meta-analysis of 14 included studies shows a large difference in the incidence of PTSD among victims of flood between studies (0.63% to 46.64%). The huge difference may be caused by several factors. (1) The genetic background, education, and cultures of populations in different countries have regional differences. The psychological stress in these populations is significantly different in response to natural disasters and other traumatic events. (2) The epidemiologic investigation of disaster victims is difficult and costly. Therefore, studies investigating the incidence of PTSD after a flood selected different populations and sample sizes. The sample size varies from 53 cases<sup>23</sup> to 33 340 cases.<sup>24</sup> (3) Although most studies used DSM-IV<sup>25</sup> as diagnostic criteria of PTSD, the DSM-IV-related PTSD scale, such as the PCL-C (PTSD checklist-civilian version), CIDI (composite international diagnostic interview), DIS (the diagnostic interview schedule), and others have also been used, which resulted in a variety of diagnosis criteria. Therefore, the survey methods investigating the incidence of flooding-related PTSD could not be unified completely. And (4), there is a big time difference between studies. The time span is 11 years (2002 to 2013). During this period, the postdisaster psychological intervention is different between countries and the susceptibility to PTSD is different between victims.

Consistent with a previous study that the type, severity, and duration of exposure to the traumatic events are the most important risk factors for PTSD,<sup>26</sup> in this meta-analysis, the subgroup analysis showed that the incidence of PTSD after a flood varies with different trauma intensity. Severe flood trauma (such as witnessing the death of friends after flash floods) has a high incidence of PTSD compared to mild flood



trauma (such as property damage caused by diffuse embankment). These observations tell us that severe floods can lead to more cases of PTSD and require more attention and intervention. The subgroup analysis showed that the incidence of PTSD for 6 or more months and less than 6 months after flooding was 16.01% and 11.45%, respectively. The incidences were not statistically different because few studies were included in this study and higher heterogeneity was observed between studies.

In this study, strict inclusion and exclusion criteria were applied for literature search. Studies with incomplete data, repeated data, and repeated publication were excluded from the analysis. No significant publication bias was observed. However, the number of included studies was small and a large heterogeneity in literature was observed. Therefore, more studies need to be investigated to get a more realistic combined incidence of PTSD after a flood. This meta-analysis failed to stratify for factors such as age, sex, and education because these factors could not be extracted from the included literature.

In conclusion, the combined incidence of posttraumatic stress disorder after flooding was 15.74%. The incidence of PTSD among floods of different trauma intensities was statistically significant. The combined incidence is important for both researchers and government officials to plan psychological interventions and make an optimum control strategy to decrease the incidence of PTSD in the populations that experienced flooding.

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