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The incidence of post-traumatic stress disorder among survivors after earthquakes:a systematic review and meta-analysis

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Abstract

Background: Post-traumatic stress disorder (PTSD) is a common psychological disorder caused by unusual threats or catastrophic events. Little is known about the combined incidence of PTSD after earthquakes. This study aimed at evaluating the combined incidence of PTSD among survivors after earthquakes using systematic review and meta-analysis.

Methods: The electronic databases of PubMed, Embase, Web of Science and PsycARTICLES were searched for relevant articles in this study. Loney criteria were used to assess the quality of eligible articles. The combined incidence of PTSD was estimated by using the Freeman-Tukey double arcsine transformation method. Subgroup analyses were conducted using the following variables: the time of PTSD assessment, gender, educational level, marital status, damage to one's house, bereavement, injury of body and witnessing death.

Results: Forty-six eligible articles containing 76,101 earthquake survivors met the inclusion criteria, of which 17,706 were diagnosed as having PTSD. Using a random effects model, the combined incidence of PTSD after earthquakes was 23.66 %. Moreover, the combined incidence of PTSD among survivors who were diagnosed at not more than 9 months after earthquake was 28.76 %, while for survivors who were diagnosed at over nine months after earthquake the combined incidence was 19.48 %. A high degree of heterogeneity ($I^2 = 99.5$ %, $p<0.001$) was observed in the results, with incidence ranging from 1.20 to 82.64 %. The subgroup analyses showed that the incidence of PTSD after earthquake varied significantly across studies in relation to the time of PTSD assessment, gender, educational level, damage to one's house, bereavement, injury of body and witnessing death. However, stratified analyses could not entirely explain the heterogeneity in the results.

Conclusions: Given the high heterogeneity observed in this study, future studies should aim at exploring more possible risk factors for PTSD after earthquakes, especially genetic factors. In spite of that, the results of this study suggest that nearly 1 in 4 earthquake survivors are diagnosed as having PTSD. Therefore, the local government should plan effective psychological interventions for earthquake survivors.

Keywords: Post-traumatic stress disorder, Earthquake, Incidence, Systematic review, Meta-analysis

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Background

Earthquakes are one of the most destructive and frequently occurring natural disasters [1]. They often strike unexpectedly without warning and bring adverse impact to a great deal of people [2]. Earthquakes have caused a lot of deaths and injuries throughout the human history, leaving survivors with endless panic and some mental problems, including post-traumatic stress disorder (PTSD) [3].

PTSD is a psychological disorder caused by unusual threats or catastrophic events. It has been regarded as the most prevalent type of psychiatric disorder after disasters [4], including earthquake, tsunami, flood, etc. Numerous studies have reported the estimated incidence of probable PTSD or PTSD symptoms among earthquake survivors. However, an enormous disparity does exist in the reported incidence of PTSD symptoms.

Previous studies have shown that the estimated incidence of PTSD among earthquake survivors varied from 1.20 [5] to 82.64 % [6]. This variation might have been associated with factors such as the variation in the intensity of the earthquakes, the variation in the degree victims were exposed to the catastrophe, the variation in the assessment time of PTSD after the trauma emerged, the variation in the quantity of property lost and whether bereavement occurred or not [7–9].

Improving the understanding of the accuracy of the incidence of PTSD after earthquakes is important as it may draw more public attention which would lead into finding some effective psychological interventions. However, there has been no systematic review attempting to synthesize these data until now. In this study, a systematic review and meta-analysis of previously published articles on the incidence of PTSD among earthquake survivors were performed in order to obtain a combined incidence of PTSD after earthquakes.

Methods

Search strategy

This systematic review was conducted under the guidance of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria and literature searches were conducted on December 14, 2015. The electronic databases of PubMed, Embase, Web of Science and PsycARTICLES were searched for relevant articles from their inceptions to the present. Search terms for PubMed were:"Earthquakes"[Mesh] AND "Stress Disorders, Post-Traumatic"[Mesh]. Search terms for Embase were: ('post traumatic stress disorder': ab,ti OR 'posttraumatic stress disorder':ab,ti OR 'PTSD':ab,ti) AND ('earthquake':ab,ti' OR earthquakes':ab,ti). These terms were adapted for the other databases and the detailed search strategies are shown in the Additional file 1. The reference list of each published article was also examined to identify relevant studies.

Eligibility criteria

Studies eligible for this review had to fulfill the following inclusion criteria: (1) studies must have been observational and must have assessed PTSD with specific reference to the earthquake; (2) studies must have examined PTSD diagnosis at least 1 month after the earthquake; (3) studies must have identified PTSD by established psychiatric interviews according to the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) criteria or the self-reporting questionnaires that based on DSM-IV; (4) the total sample size of each study must have been no less than 300; (5) the incidence of PTSD among survivors after earthquakes had to be provided or could be calculated from the data the articles provided. The exclusion criteria were: (1) articles were not written in English; (2) articles were reviews, reports, comments or book chapters; (3) erroneous or contradictory information was included in the articles; (4) any kinds of interventions were included in the articles or the participants of the studies were special, such as firefighters, doctors, etc. Besides, the samples in the study should not overlap with other identified studies with the same follow-up period. If two or more publications with the same follow-up period shared all the data or data subsets then only one publication with the largest sample size was included; if the sample sizes of similar studies were the same, then the earlier publication was included; if the data or data subsets were from duplicate publications but they had different follow-up time, then all of them were included.

Data abstraction

Data abstraction was conducted independently by two investigators and any discrepancy between them was resolved by consensus. For the purpose of the meta-analysis, data retrieved from literature included: (1) the title of the study, the first author, the year of publication, the geographic area of the study, the time of PTSD assessment and the quality of the literature; (2) the diagnostic tool of PTSD, the number of victims with PTSD, the number of final participants of a survey, the incidence of PTSD, the demographic information of the participants (age, gender, nationality, religious beliefs, marital status, educational level) and the intensity of the earthquakes measured by witnessing death or not, house damage or not, injury or not and bereavement or not. All the information was collected by EpiData 3.0.

Quality evaluation

The quality of eligible articles was assessed by using the evaluation criteria for prevalence or incidence studies as proposed and recommended by Loney [10]. The evaluation criteria consist of eight items namely, (1) participants (random sample or population); (2) the description

of study procedure; (3) adequate sample size (≥300); (4) efficient diagnostic tools; (5) unbiased appraisal of the outcome; (6) adequate response rate; (7) subgroup analysis; and (8) the detailed description of participants. An article scores points equal to the number of items it has satisfied and if the article satisfies one item of the criteria, it will be given 1 point. Thus, the total quality scores of articles range from 0 to 8 points.

Statistical analysis

The number of PTSD victims and the total sample size were extracted from the original literature for the calculation of incidence. Data were analyzed using the statistical software R version 3.2.0. Freeman-Tukey transformation of inverse hyperbolic sine function was used to calculate the combined incidence. Heterogeneity was evaluated both visually by means of forest-plots and using the χ^2 test on Cochrane's Q statistic, and it was then quantified by calculating the I^2. Heterogeneity test was considered statistically significant when $p \leq 0.05$. In this case the data were analyzed using a random effects model. In contrast, if $p>0.05$, a fixed effects model was used to analyze the data.

Subgroup analyses were carried out to identify the source of heterogeneity in the following variables: the time of PTSD assessment, gender, educational level, marital status, damage to one's house, bereavement, injury of body and witnessing death. A comparison of the incidence between subgroups was done by carrying out a χ^2 test using the software, Statistical Package for the Social Sciences (SPSS) version 19.0. Sensitivity analysis was carried out to verify the influence of low-quality studies on the stability of the combined incidence. In order to verify whether publication bias might have an influence on the validity of the incidence, linear

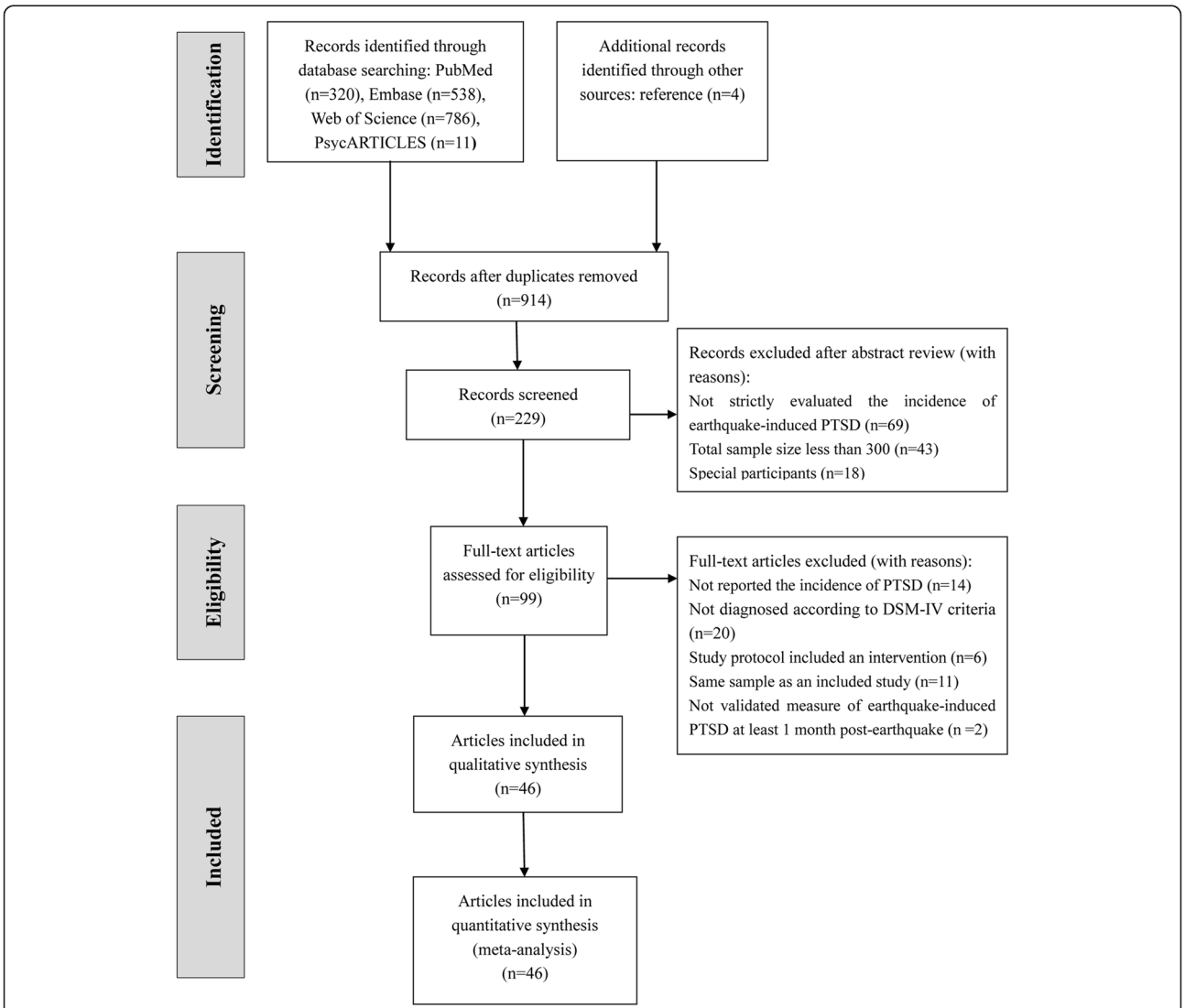

Fig. 1 PRISMA flow chart of article selection; illustration of how eligible articles were selected

Table 1 Characteristics of the studies included in this systematic review and meta-analysis

Author	Year	Study design	Region	Richer scale	Questionnaire	Clinical interview	Time after earthquake (month)	Victims with PTSD	Total sample size	Quality evaluation
Wu et al [22]	2006	Cross-sectional	Chi-Chi,Taiwan	7.3	NO	MINI	36	18	405	5
Chou et al [23]	2005	Cross-sectional	Chi-Chi,Taiwan	7.3	NO	MINI	6	35	442	6
Flores et al [24]	2014	Cross-sectional	Pisco, Peru	7.9	PCL-C	NO	48	161	1012	6
Kadak et al [25]	2013	Cross-sectional	Van, Turkey	7.2	CPTSD-RI	NO	6	295	725	5
Zhou et al [26]	2015	Cross-sectional	Wenchuan, China	8.0	PCL-C	NO	12	224	817	5
Emin et al [27]	2006	Cross-sectional	Marma, Turkey	7.4	TSSC	NO	36	131	683	5
Metin et al [28]	2004	Cross-sectional	Marma, Turkey	7.4	TSSC	NO	14	177	950	6
Zhang et al [29]	2015	Cross-sectional	Wenchuan, China	8.0	PCL-C	NO	60	63	684	6
Peng et al [30]	2009	Cross-sectional	Wenchuan, China	8.0	HTQ	NO	2.5	251	447	7
Roussos et al [31]	2005	Cross-sectional	Ano Liosia, Greece	5.9	PTSD-RI	NO	3	87	1937	4
Jude et al [32]	2015	Cross-sectional	Haiti	7.0	IES-R	NO	30	322	872	5
Fu et al [33]	2013	Cross-sectional	Wenchuan, China	8.0	PCL-C	NO	12	420	2987	5
Hsu et al [34]	2002	Cross-sectional	Chi-Chi,Taiwan	7.3	NO	ChIPS	1.5	70	323	7
Jia et al [35]	2015	Cross-sectional	Wenchuan, China	8.0	CPSS	NO	12	179	631	5
Tian et al [36]	2014	Cross-sectional	Wenchuan, China	8.0	PCL-C	SCID	36	261	4604	6
Wang et al [37]	2013	Cross-sectional	Yingjiang, China	5.8	CPSS	NO	1	445	1198	4
Zhang et al [38]	2015	Longitudinal study	Lushan, China	7.0	CRIES	NO	3	834	2229	5
							6	556	2299	
Cem et al [39]	2013	Cross-sectional	Konya, Turkey	4.3	CPTSD-RI	NO	6	110	450	7
Chan et al [40]	2011	Cross-sectional	Wenchuan, China	8.0	IES-R	NO	7.5	526	1725	5
Fan et al [41]	2011	Cross-sectional	Wenchuan, China	8.0	PTSD-SS	NO	6	329	2081	6
Guo et al [42]	2014	Longitudinal study	Wenchuan, China	8.0	IES-R	NO	2	620	1066	6
							8	297	1344	
							14	239	1210	
							26	223	1174	
							44	102	1281	
Jia et al [43]	2013	Longitudinal study	Wenchuan, China	8.0	CPTSD-RI	NO	15	74	596	7
							36	46	430	
Ying et al [44]	2013	cross-sectional	Wenchuan, China	8.0	CPSS	NO	12	262	3052	5
Xu et al [45]	2011	cross-sectional	Wenchuan, China	8.0	PCL	NO	12	835	2080	6
Ali et al [46]	2012	cross-sectional	Kashmir, Pakistan	7.6	DTS	NO	30	124	300	5
Ayub et al [47]	2012	cross-sectional	Kashmir, Pakistan	7.6	CRIES	NO	18	699	1078	6
Jude et al [48]	2014	cross-sectional	Haiti	7.0	IES-R	NO	30	498	1355	6
Gigantesco et al [49]	2013	cross-sectional	L'Aquila, Italy	6.3	NO	Mini	12	39	957	7
Liu et al [50]	2010	Longitudinal study	Wenchuan, China	8.0	PCL-C	NO	4	165	1474	6
							6	129	1474	
							9	100	1474	
							12	84	1474	
Naeem et al [51]	2011	cross-sectional	Kashmir, Pakistan	7.6	TSSC	NO	18	601	1291	7

Table 1 Characteristics of the studies included in this systematic review and meta-analysis *(Continued)*

Parvaresh et al [52]	2009	cross-sectional	Bam,Iran	6.3	NO	Watson interview	4	182	433	5
Takeda et al [53]	2013	cross-sectional	Great East Japan	9.0	IES-R	NO	9	118	1180	5
Wang et al [54]	2011	cross-sectional	Wenchuan, China	8.0	PTSD-SS	NO	1	257	409	7
Wang et al [55]	2013	cross-sectional	Wenchuan, China	8.0	PCL-C	NO	42	145	319	6
Wang et al [56]	2012	cross-sectional	Wenchuan, China	8.0	CRIES	NO	10	522	1841	7
Wen et al [57]	2012	cross-sectional	Wenchuan, China	8.0	PCL-C	NO	36	113	2525	6
Yuqing et al [6]	2011	cross-sectional	Wenchuan, China	8.0	IES-R	NO	2	790	956	4
Zhang et al [5]	2012	Longitudinal study	Wenchuan, China	8.0	PCL-C	NO	6	53	548	5
							12	7	584	
							18	9	548	
Zhang et al [58]	2011	cross-sectional	Wenchuan, China	8.0	PCL-C	NO	12	311	1181	6
Zhen et al [59]	2012	cross-sectional	Yushu, China	7.1	PCL-C	NO	3	170	505	5
Hou et al [60]	2011	Longitudinal study	Wenchuan, China	8.0	PCL-C	NO	3	613	1677	5
							6	515	1677	
							9	416	1677	
							12	373	1677	
Lau et al [61]	2010	cross-sectional	Wenchuan, China	8.0	CRIES	NO	1	741	3324	4
Liu et al [62]	2010	cross-sectional	Wenchuan, China	8.0	PCL-C	NO	9	346	569	6
Ying et al [63]	2014	cross-sectional	Wenchuan, China	8.0	CPSS	NO	12	101	788	5
Kun et al [64]	2013	cross-sectional	Wenchuan, China	8.0	HTQ	NO	3	529	1820	7
Sezgin et al [65]	2012	cross-sectional	South Eastern Turkey	6.4	PDS	NO	12	764	1253	5

MINI mini international neuropsychiatric interview, *PCL-C* PTSD checklist-civilian version, *CPTSD-RI* child PTSD–reaction index, *TSSC* traumatic stress symptom checklist, *HTQ* harvard trauma questionnaire, *PTSD-RI* PTSD reaction index, *IES-R* impact of event scale-revised, *ChIPS* children's interview for psychiatric syndromes, *CPSS* child PTSD symptom scale, *SCID* structured clinical interview for DSM-IV disorders, *CRIES* children's revised impact of event scale, *PTSD-SS* PTSD self-rating scale, *DTS* Davidson trauma scale, *PCL* PTSD checklist, *PDS* post traumatic stress diagnostic scale

regression method was used and an Egger funnel plot was then presented. All p values were two sided and the cut-off for statistical significance was set at 0.05.

Results

Literature search

An aggregate of 1,659 relevant articles were identified for this study, of which 99 full papers were shortlisted for eligibility test. Further examination of the 99 full papers resulted in 14 articles excluded for not reporting the incidence of PTSD; 20 articles excluded for identifying PTSD neither by established psychiatric interviews according to the DSM-IV criteria nor by the self-reporting questionnaires that based on DSM-IV; 6 articles excluded for including interventions; 2 articles excluded for not measuring earthquake-induced PTSD at least 1 month post-earthquake and 11 articles excluded for repeated data with same follow-up periods. Thus, 46 eligible articles were finally included in this study (Fig. 1).

Characteristics of eligible articles

The 46 eligible articles considered destructive earthquakes of magnitudes ranging from 4.3 to 9.0 on a Richter scale, which occurred between 1999 and 2013. They analyzed and described the PTSD of the survivors of these catastrophes with follow-up periods ranging from 1 to 60 months. Only 6 of the 46 eligible articles analyzed and described longitudinal studies while the rest analyzed and described cross-sectional studies. In addition, 40 eligible articles identified PTSD only by self-reporting questionnaires and the other 6 eligible articles identified PTSD through clinical interviews. In the quality assessment of the 46 eligible articles, 9 articles scored 7 points; 15 articles scored 6 points; 18 articles scored 5 points and 4 articles scored 4 points. The characteristics of the 46 eligible articles are summarized in Table 1.

Combined incidence of PTSD after earthquakes

A total of 76,101 survivors after earthquakes were available for this systematic review and meta-analysis, of

which 17,706 victims were identified to have PTSD. The incidence of PTSD among survivors after earthquakes ranged from 1.20 [5] to 82.64 % [6] and the heterogeneity test of the included studies showed that they were heterogeneous (I^2 = 99.5 %; p<0.001). Therefore, the random effects model was used to assess the combined incidence of PTSD. The combined incidence of PTSD among survivors after earthquakes was 23.66 % (95 % confidence interval (95 % CI): 19.34-28.27 %). The combined incidence of PTSD among survivors who were diagnosed at not more than 9 months after earthquake was 28.76 % (95 % CI: 22.28-35.71 %), while for survivors who were diagnosed at over nine months after earthquake the combined incidence was 19.48 % (95 % CI:14.09-25.50 %). Figures 2 and 3 show the details.

Subgroup analyses

Subgroup analyses were performed with respect to the time of PTSD assessment after earthquakes, gender, educational level, marital status, damage to one's house, bereavement, injury of body, and witnessing death (Table 2). The results indicated that studies with longer follow-up periods (>9 months) showed lower incidence of PTSD (combined incidence = 19.48 %, 95 % CI = 14.09-25.50 %) than did studies with shorter follow-up periods (≤9 months; combined incidence = 28.76 %, 95 % CI = 22.28-35.71 %). The combined incidence of PTSD among female survivors after earthquakes (34.82 %, 95 % CI: 26.85-43.24 %) was higher than that of male survivors (22.57 %, 95 % CI: 16.53-29.23 %). Besides, the combined incidence of PTSD among survivors after earthquakes with educational level at most elementary school (31.56 %, 95 % CI: 21.22-42.90 %) was higher than that of survivors with educational level higher than elementary school (19.76 %, 95 % CI: 14.33-25.82 %). Furthermore, the combined incidence of PTSD among survivors who had their houses damaged (38.49 %, 95 % CI: 25.11-52.82 %) was higher than that of survivors with their houses not damaged (23.97 %, 95 % CI: 8.08-44.81 %). In addition, the combined incidence of PTSD among survivors with bereavement after earthquake (39.10 %, 95 % CI: 25.74-53.33 %) was higher than that of survivors without bereavement (19.92 %, 95 % CI: 10.89-30.83 %). Also, the combined incidence of PTSD among injured survivors after earthquake (23.28 %, 95 % CI: 13.91-34.16 %) was higher than that of non-injured

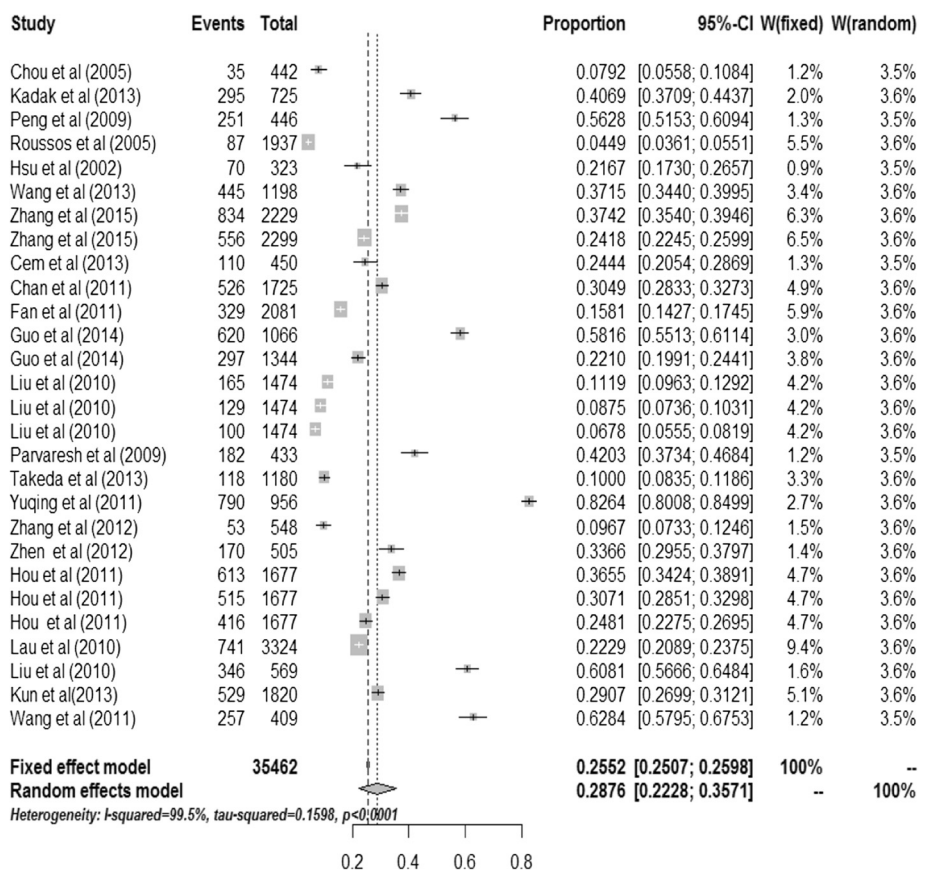

Fig. 2 Incidence tree of PTSD diagnosed at not more than nine months follow-up after earthquake; graphical representation of a meta-analysis of incidence of PTSD diagnosed at not more than nine months follow-up after earthquake

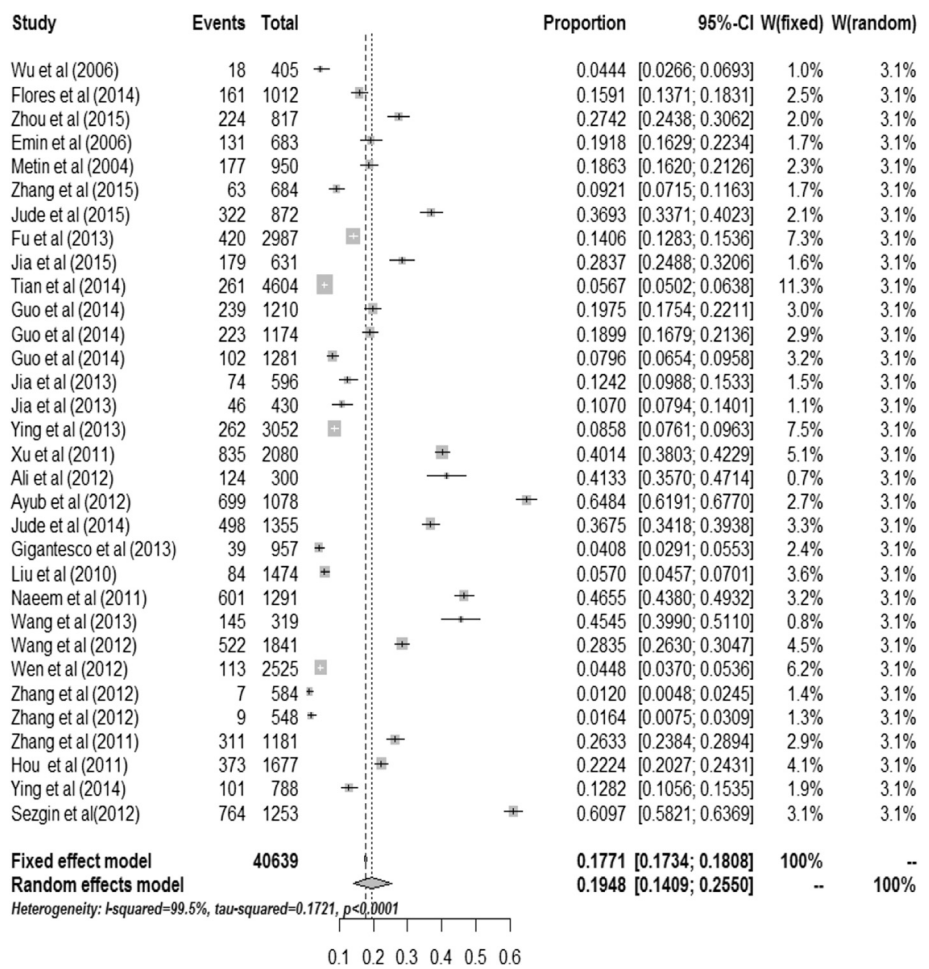

Fig. 3 Incidence tree of PTSD diagnosed at over nine months follow-up after earthquake; graphical representation of a meta-analysis of incidence of PTSD diagnosed at over nine months follow-up after earthquake

survivors (9.63 %, 95 % CI: 3.62-18.09 %). What is more, the combined incidence of PTSD among survivors who had witnessed death after earthquakes (26.28 %, 95 % CI: 7.05-52.14 %) was higher than that of survivors who had not witnessed death (14.69 %, 95 % CI: 0.06-41.35 %). However, stratification according to these parameters could not entirely explain the heterogeneity of the results, with I^2 still being high within each stratum.

Sensitivity and bias analysis

After excluding articles with the quality evaluation score equal to 4 points for this meta-analysis, the combined incidence of PTSD declined from 23.66 to 22.95 %. This small change in combined incidence of PTSD, after excluding low quality eligible articles, indicated low sensitivity and hence credible results of this study.

Publication bias was assessed by using the linear regression analysis. An Egger funnel plot was produced and it indicated that there was a negligible chance for publication bias (Fig. 4). In agreement with the Egger funnel plot, Egger's test scored a p value of 0.057, implying that there was a very low probability of publication bias.

Discussion

Literature search for this meta-analysis found no evidence of existing meta-analyses that investigated the incidence of PTSD among survivors after earthquakes. Therefore, this is probably the first meta-analysis to investigate the incidence of PTSD among survivors after earthquakes. This meta-analysis considered articles which analyzed and described PTSD among earthquake survivors, which happened between 1999 and 2013 all over the world, whose magnitude on Richter scale ranged from 4.3 to 9.0. It is therefore understood that the results of this meta-analysis could, to some extent, reflect the actual and precise incidence of PTSD after earthquakes in the world. The 46 eligible articles for this

Table 2 Subgroup analyses of the incidence of PTSD after earthquakes[a]Incidence rates were obtained using a random-effects model

Group	Number of studies	Incidence[a] (95 % CI)%	*p* value (heterogeneity**)	I^2(%)	*p* value (interaction***)
Total	60	23.66 (19.34–28.27)	<0.001	99.5	
Assessment time after earthquake					<0.001
≤9 months	28	28.76 (22.28–35.71)	<0.001	99.5	
>9 months	32	19.48 (14.09–25.50)	<0.001	99.5	
Gender					<0.001
Male	26	22.57 (16.53–29.23)	<0.001	98.8	
Female	29	34.82 (26.85–43.24)	<0.001	99.3	
Educational level					<0.001
Elementary school or below	13	31.56 (21.22–42.90)	<0.001	99.1	
Beyond elementary school	29	19.76 (14.33–25.82)	<0.001	99.3	
Marital status					0.069
Married	7	25.61 (13.74–439.68)	<0.001	99.0	
Unmarried	7	22.74(12.23–35.32)	<0.001	97.2	
Damage to one's house					<0.001
Yes	6	38.49 (25.11–52.82)	<0.001	98.2	
No	6	23.97 (8.08–44.81)	<0.001	99.3	
Bereavement					<0.001
Yes	12	39.10 (25.74–53.33)	<0.001	98.5	
No	10	19.92 (10.89–30.83)	<0.001	99.2	
Injury of body					<0.001
Yes	6	23.28 (13.91–34.16)	<0.001	96.4	
No	5	9.63 (3.62–18.09)	<0.001	98.2	
Witnessed death					<0.001
Yes	3	26.28 (7.05–52.14)	<0.001	98.8	
No	3	14.69 (0.06–41.35)	<0.001	99.3	

** *p* values for heterogeneity across studies were computed using Cochrane's Q test
*** *p* values for comparisons between subgroups were computed using the χ^2 test with one degree of freedom

meta-analysis accounted for 76,101 earthquake survivors, of which 17,706 had been diagnosed with PTSD. It was found, from this information, that the combined incidence of PTSD among survivors after earthquakes was 23.66 % (95 % CI: 19.34-28.27 %). Edmondson D [11] showed that the prevalence of PTSD in survivors of stroke and transient ischemic attack was 13 % (95 % CI: 11 %-16 %) and Chen L [12] found that the incidence of PTSD after floods was 15.74 % (95 % CI: 11.25 %-20.82 %). Thus, this study's combined incidence of PTSD among earthquake survivors was much higher than that found among flood survivors and stroke survivors. This was mainly because earthquakes were often much more devastating and destructive, and often happened unexpectedly without warning. Therefore they might have brought more damage to one's properties and health, including both physical health and mental health [13]. Hence, the local government should pay more attention to the mental health of earthquake survivors and try to find some effective interventions to provide high standard rehabilitation services.

The subgroup analyses showed that the combined incidence of PTSD among survivors who were identified at not more than nine months after earthquakes was 28.76 %, while for survivors who were assessed of PTSD at over nine months after the earthquakes the combined incidence of PTSD was 19.48 %. This variation tendency in the incidence of PTSD was consistent with Edmondson D's study [11]. The incidence of PTSD symptoms were higher in the immediate aftermath of the earthquake [14]. In line with some previous studies [15], the subgroup analyses also indicated that damage to one's house, bereavement, injury of body and witnessing death would contribute to the different incidences of PTSD, suggesting that those who suffered more property loss or personal injury or had witnessed death or had experienced bereavement were more likely to develop PTSD [16]. In addition, the subgroup analyses showed that gender and educational level may lead to different incidences of PTSD after earthquakes. Females and those who had low educational level were more likely to develop

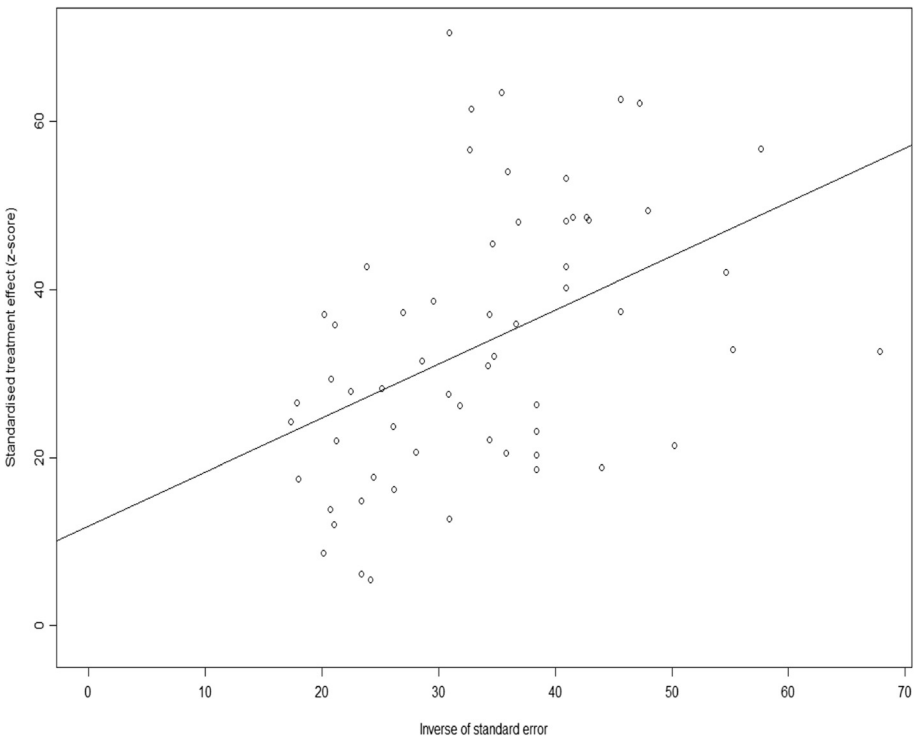

Fig. 4 Egger plot of literatures on the incidence of PTSD after earthquakes. Egger plot/graph for assessing publication bias

PTSD. Those findings were consistent with conclusions of many studies in disaster psychology [17, 18]. Some studies revealed that women and people with lower educational level were less likely to use positive coping strategies, were more sensitive to threats and tended to interpret disasters more negatively [19, 20].

In this meta-analysis, substantial information was obtained for determining the combined incidence. However, quality assessment showed that most of the eligible articles did not report the 95 % CI of the observed incidence and lacked enough subgroup analyses. In addition, they identified PTSD by self-reporting questionnaires rather than clinical interviews by professional psychiatrists, as a consequence of which, the combined incidence of PTSD may have been overestimated. Furthermore, subgroup analyses did not identify major sources of the heterogeneity although a high degree of heterogeneity between studies was observed. Therefore, there might be a considerable amount of uncertainty regarding the combined incidence of PTSD after earthquakes. It is also believed that genetic background might have played an important role in the incidence of PTSD after earthquakes with increasing evidence showing that genetic factors and gene-environment interaction were both associated with the onset of PTSD [21]. Future research should, therefore, explore more potential risk factors for PTSD after earthquakes, especially genetic background.

Also, this study did not observe significant publication bias and the sensitivity was low after excluding articles with the quality evaluation score equal to 4. The strengths of this study included its large sample size and a large number of subgroup analyses. However, several limitations do exist. First, although many possible risk factors from the eligible articles were extracted, a high degree of heterogeneity was detected when analyzing the combined incidence and conducting the subgroup analyses. Second, it was not possible to analyze the incidence of PTSD among survivors after earthquakes by age, religious beliefs, nationality, social support and genetic background because these data were not reported in most of eligible articles.

Conclusions

Results of this study suggest that nearly 1 in 4 earthquake survivors are diagnosed as having PTSD. Thus, this is remarkable evidence that natural disasters, such as earthquakes, may have a great influence on survivors' mental health. Therefore, the local government should plan effective psychological interventions for earthquake survivors. However, there might be a considerable amount of uncertainty regarding the incidence of PTSD after earthquakes due to the high degree of heterogeneity observed in the previous studies. Thus, future studies should aim at discovering more possible risk factors for PTSD after earthquakes, especially genetic background.

Additional file

Additional file 1: Search strategies: details of search strategy. (DOCX 14 kb)

Abbreviations

PTSD, post-traumatic stress disorder; PRISMA, preferred reporting items for systematic reviews and meta-analyses; DSM-IV, diagnostic and statistical manual of mental disorders, 4th edition; SPSS, statistical package for the social sciences; 95 % CI, 95 % confidence interval; MINI, mini international neuropsychiatric interview; PCL-C, PTSD checklist-civilian version; CPTSD-RI, child PTSD–reaction index; TSSC, traumatic stress symptom checklist; HTQ, harvard trauma questionnaire; PTSD-RI, PTSD reaction index; IES-R, impact of event scale-revised; ChIPS, children's interview for psychiatric syndromes; CPSS, child PTSD symptom scale; SCID, structured clinical interview for DSM-IV disorders; CRIES, children's revised impact of event scale; PTSD-SS, PTSD self-rating scale; DTS, Davidson trauma scale; PCL, PTSD checklist, PDS, post traumatic stress diagnostic scale

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Availability of data and materials

Available upon request to the corresponding author Aizhong Liu: lazroy@live.cn

Authors' contributions

WD and AL contributed to the study design, while WD, LC and ZL contributed to the data collection. Statistical analyses and interpretation of results were performed by WD, LC, ZL and YL. WD, AL and JW drafted the manuscript and edited the language. All the authors participated in the critical revision, and approved the final version of the manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Ethical approval and participant consent were not applicable for this systematic review and meta-analysis, since this study involved data and materials from published articles.

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