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POST-TRAUMATIC STRESS DISORDER IN CHILDREN FOLLOWING NATURAL DISASTERS: A SYSTEMATIC REVIEW OF THE LONG-TERM FOLLOW-UP STUDIES

Akiko Terasaka, Yoshiyuki Tachibana, Makiko Okuyama, and Takashi Igarashi

Abstract: The objective of this article was to conduct a systematic review of long-term follow-up studies on Post-traumatic Stress Disorder (PTSD) symptoms in children and adolescents. The MEDLINE and PsycINFO databases were searched from 1980 through January 2014. Studies that examined PTSD symptoms in children for over three years after mass natural disasters were selected. Ten studies, including four cohort studies, four cross-sectional studies, one descriptive study, and one case-series study following disaster-exposed children, met all the selection criteria and thus were included in this review. The follow-up period ranged from three to 20 years after the disasters. Synthesized results regarding PTSD prevalence rate, changes over time, and influential factors on PTSD were summarized and discussed. The reviewed studies indicated that PTSD symptoms decrease rapidly during the first two years after a disaster; however, the long-term course is not yet clear. Several factors including gender and disaster experience appeared to be influential on PTSD symptoms; however, gender effect was possibly confounded by other factors. To examine moderating effects among those influential factors, as well as to avoid confounding, multivariate analytical methods would be beneficial and recommended in future research. Also, recovery patterns await further investigation for better understanding of the factors associated with chronic PTSD.

Keywords: natural disasters, PTSD, child, long-term, follow-up

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According to *Annual Disaster Statistical Review 2012* (Guha-Sapir, Hoyois, & Below, 2013), 107,000 people were killed and 268 million were affected by natural disasters on annual average between 2002 and 2011. There are 25 natural disasters reported that produced more than 50,000 deaths between 1990 and 2011 in the EM-DAT database (www.emdat.be/database) (Lindell, 2013). Mass natural disaster can be especially traumatic to children. Many of the children who survived mass natural disasters, such as Southeast Asia Tsunami in 2004, Hurricane Katrina in 2005, and Great East Japan Earthquake and Tsunami in 2011, lost family members, friends, neighbors, houses and schools. Furthermore, disaster aftermath could usually last for months or even years. These negative impacts of disasters may create secondary stress and substantially interfere with the availability of support to the child from parents, family, school, and community (Pynoos, Steinberg, & Piacentini, 1999), thus disturbing children's recovery.

A set of psychological post-traumatic symptoms such as re-experiencing, avoidance, and hyperarousal, which last more than a month after the traumatic event, is known as Post-traumatic Stress Disorder (PTSD). PTSD has received a great deal of attention for the last several decades since the diagnosis was introduced in *Diagnostic and Statistical Manual of Mental Disorders, Third Edition* (DSM-III) in 1980. Although the criteria for PTSD were originally developed based on the knowledge from adult samples, several age-related symptoms were added in the subsequent versions (DSM-III-R, DSM-IV, and DSM-V). There have been several comprehensive reviews of post-disaster research in children (e.g., Foy, Madvig, Pynoos, & Camilleri, 1996; Pfefferbaum, 1997; Vogel & Venberg, 1993). In recent years, Hoven, Duarte, Turner, and Mandell (2009) performed a systematic search, and reported 18 selected studies that included more than 100 participants, with first assessment of post-traumatic reactions conducted within a year after the disaster, and employed some type of randomization approach. Wang, Chan, and Ho (2013) identified 60 cross-sectional and 25 longitudinal/long-term follow-up studies of post-disaster research on child psychopathology including PTSD. Additionally, Furr, Corner, Edmunds, and Kendall (2010) conducted a systematic review and meta-analytic examination of 96 identified youth PTSD studies following natural and human-made disasters. These reviews indicated that children show symptoms most in the first year post-disaster, and the symptoms mostly decrease rapidly (Furr et al., 2010; Wang et al., 2013) by nine to 14 months post-disaster (Vogel & Venberg, 1993). However, the long-term course of PTSD is not yet well known since the majority of the identified studies were conducted during the first two years post-disaster. Although most of the children may recover shortly after, there seem to be several pathways of recovery, and PTSD symptoms persist longer for some of the children (Masten & Obradovic, 2008). Moreover, there are not enough longitudinal data that enable us to understand risk and protecting factors for chronic PTSD. As these authors suggested, there is a great need for long-term follow-up studies of PTSD in children and adolescents.

In this article, we focus on studies that investigated post-traumatic symptoms in children over a three-year period after they had experienced mass natural disasters so that we could learn more about the long-term course of PTSD in children and adolescents. We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement

(Moher, Liberati, Tetzlaff, & Altman, 2009), which consists of a 27-item checklist to help authors improve the reporting of systematic reviews and meta-analyses, in reporting this review.

Materials and Methods

Selection Criteria

Studies that (a) examined post-traumatic symptoms in children and adolescents after mass natural disasters, (b) followed the subjects for at least three years post-disaster, (c) assessed PTSD symptoms as outcomes, and (d) were peer-reviewed, were included in this review. Accordingly, studies reporting about the effects of other types of disasters (e.g., war, terrorist attacks, traffic accidents, industrial accidents, etc.), and studies that assessed only other psychiatric problems (e.g., depression, anxiety, serious emotional disturbance, etc.) were excluded from this review. Intervention studies were also excluded since they are beyond the scope of this review. The targeted population was children and adolescents who experienced mass natural disasters when they were under 18 years of age.

Data Sources and Searches

In order to identify potential studies for inclusion, we conducted an electronic database search on MEDLINE and PsycINFO for studies published from January 1980 through January 2014 using the following keywords: (post-traumatic OR posttraumatic stress disorder) AND (disaster OR disasters) AND (child OR children OR adolescent[s]) AND (long-term OR follow-up OR longitudinal). Only peer-reviewed articles were searched.

Study Selection and Data Extraction

After potential studies were identified by the database search (Phase 1), we reviewed all abstracts and titles (Phase 2). Studies that were written in a non-English language, that did not include original data or an assessment of child responses, and that were on irrelevant topics (e.g., the development of assessment tools, physical health related to disasters) were excluded. The full text of selected potential studies were further reviewed to determine their eligibility (Phase 3). Studies reporting other types of disasters, studies that followed the subjects for less than three years, studies that assessed only other psychiatric problems, and intervention studies were excluded in sequence. From the included studies, the study design, study time frame after the disaster, samples (sampling method, size, and age), PTSD measures, PTSD prevalence and classification were abstracted. For the age of the sample, since time frame varied across studies, we showed not only the age at the time of the study, but also the estimated age at the time of the disaster.

Quality Assessment

Observational studies are known to be vulnerable to some types of study bias, especially to selection bias and confounding compared to randomized controlled trials (Reeves, Deeks, Higgins, & Wells, 2008; Lu, 2009); thus including quality assessment is recommended when reporting systematic review by PRISMA. In this review, we used the checklist from SAQOR

(Systematic Appraisal of Quality in Observational Research), which was developed especially for observational studies (for details, see Ross et al., 2011), and also employed in the former review article (Wang et al., 2013), to rate the quality of the included studies. The SAQOR consists of six categories with two to five questions for each assessment category: Sample; Control/comparison group; Quality of exposure/outcome measurements; Follow-up; Distorting influences; and Reporting data.

Note that for cross-sectional studies, the "follow-up" category is excluded. and also for case-series studies, the "control/comparison group" category is excluded, due to the feature of the study designs. Each of the included studies was rated as "adequate" in all these categories when the study met the category's requirements stated in SAQOR.

The category of "distorting influences" was developed to rate the risk of confounding (Ross et al., 2011). Confounding is defined as "a mixing of effects between the exposure of interest, the disease, and a third factor (i.e., the confounder) that is associated with the exposure that independently affects the risk of developing the disease" (Mann & Wood, 2012, p. 18). Several strategies are recommended to reduce confounding at three phases of study (Lu, 2009): At the design phase, (a) Restriction – inclusion to the study is restricted to a certain category of confounder (e.g., male); and (b) Matching of controls to cases to enhance equal representation of subjects with certain confounders among study group. At the analysis phase, (c) Stratification – the sample is divided into subgroups or strata on the basis of characteristics that are potentially confounding the analysis (e.g., age); and (d) Statistical adjustments for dissimilarities in characteristics between the study groups, including regression, propensity score, and instrumental variables.

In the literature of child PTSD, there is no confounder commonly recognized so far, although several factors such as children's gender, age, and proximity to the disaster are considered to be affecting PTSD symptoms. Thus, we did not set "primary key confounders" in the quality assessment of this review, which is originally suggested by SAQOR. Studies that counted for at least two potential confounders, including age, gender, disaster experience, depression, etc., using strategies such as those listed above were rated "adequate".

Results

Search Results

The search process is summarized in Figure 1. The database search identified 232 potentially relevant studies (Phase 1), 114 of which were selected for further screening after excluding irrelevant studies based on our screening the titles and abstracts (Phase 2). The numbers of papers published per year are presented in Figure 2, in order to allow readers to grasp the trend in post-disaster follow-up studies in children and adolescents. The earliest work selected in Phase 2 was published in 1987, following the Ash Wednesday fires in Australia in 1983 (McFarlane, 1987). The highest number of selected papers was published in 2009, representing 13.2% (n = 15) of the total 114 studies, followed by 2008 and 2011 (n = 13, 11.4%). Twenty-eight studies followed earthquakes (24.6%), 26 followed hurricanes (22.8%), and 10 followed two tsunamis (8.8%). The most studied event was Hurricane Katrina in 2005 (n = 14,

12.3%), followed by the South Asia tsunami in 2004 (*n* = 9, 7.9%), the World Trade Center attack (*n* = 8, 7.0%) in 2001, and the Jupiter shipping disaster in 1988 (*n* = 7, 6.1%).

In Phase 3, 104 of the 114 previously selected studies (88.6%) were excluded because they did not meet the selection criteria stated earlier; 39 studies followed other types of disasters (34.2%), 59 studies followed the subjects for less than three years (51.8%), two had non-PTSD symptoms as the outcome (1.8%), and four were intervention studies (3.5%). Finally, 10 of the 114 previously selected studies (8.8%) were included in this review as long-term follow-up studies of PTSD symptoms in children following natural disasters.

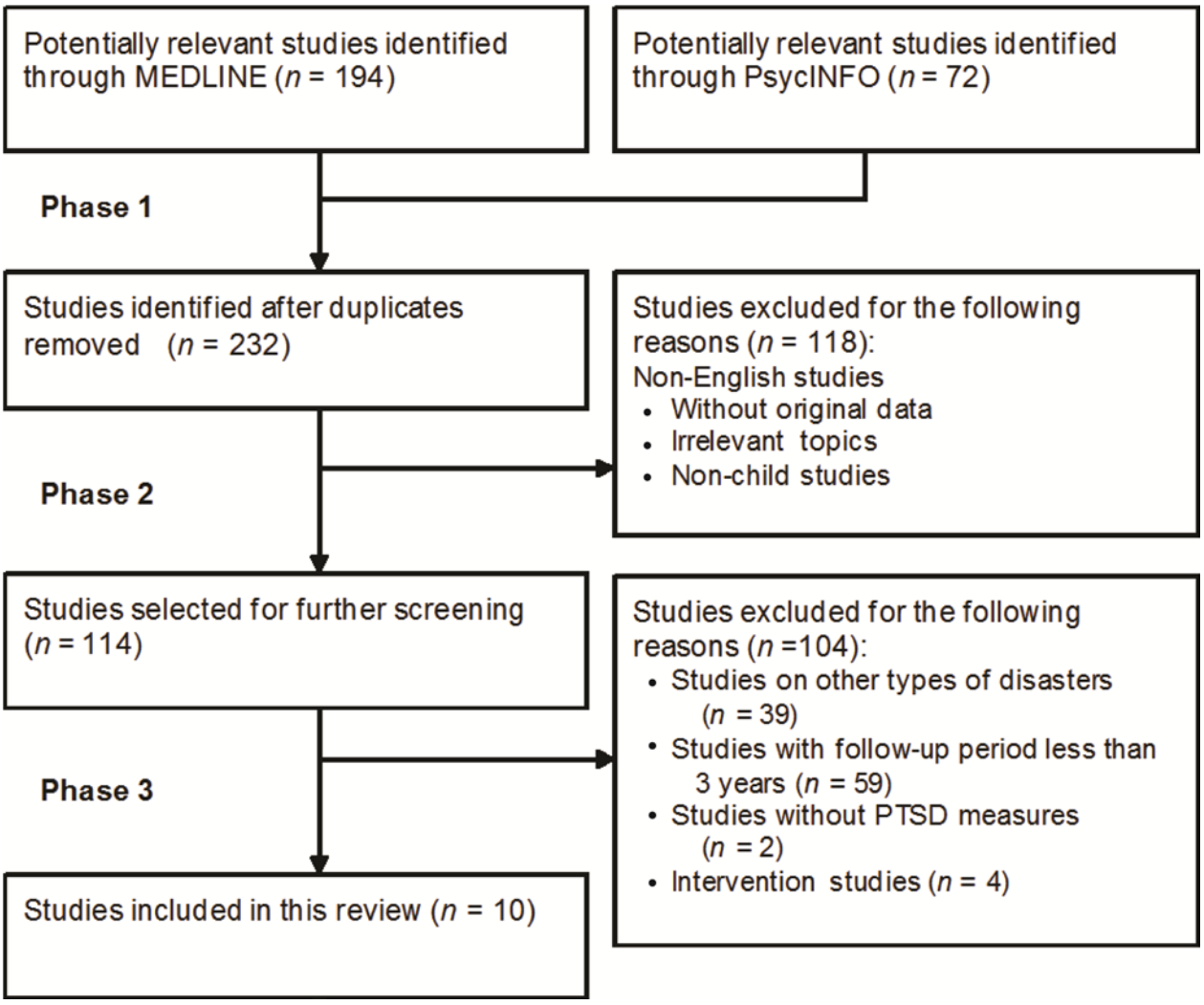

Figure 1. Flow diagram of the study selection

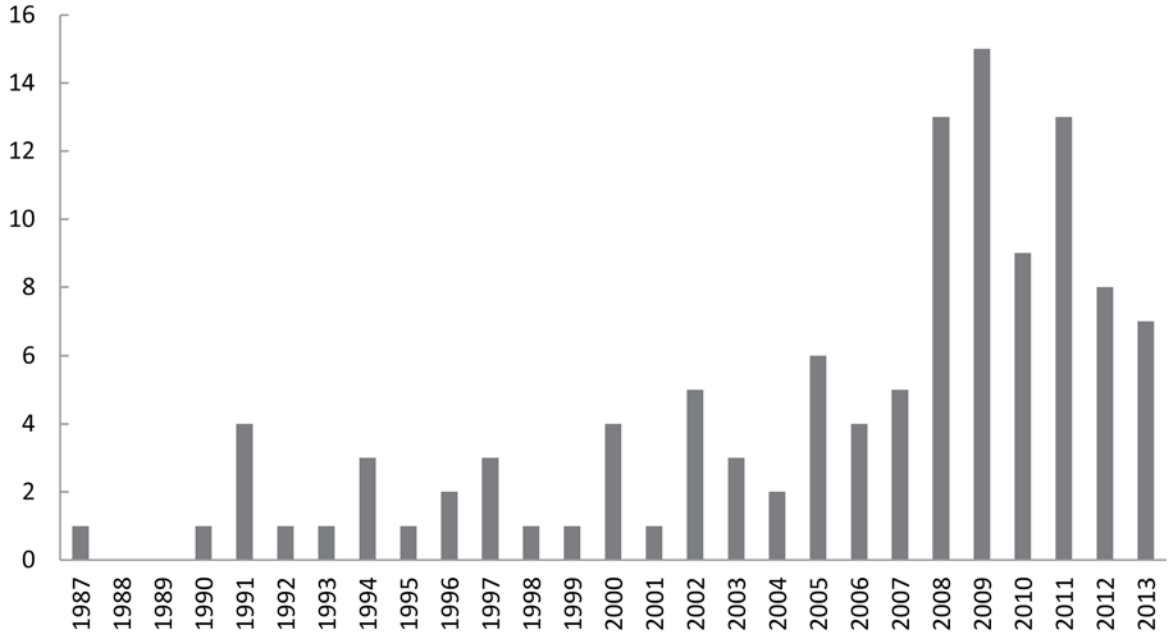

Figure 2. Number of the papers published on long-term follow-up studies of child PTSD

Overview of the Included Studies

The characteristics of the included studies are summarized in Table 1. All included studies were published between 2005 and 2013. Six events were studied in the 10 included studies: three earthquakes, one tsunami, one hurricane, and one wildfire. The earliest event was the Ash Wednesday fires in Australia in 1983 (McFarlane & Hooff, 2009), and the latest was Sichuan earthquake in China in 2008 (Jia et al., 2013). Three of the studies followed the Spitak earthquake in Armenia in 1988, and another three followed South Asia tsunami in 2004. The age of the participants ranged from eight to 19 years for child and adolescent samples, and 23 to 34 for adult samples who had experienced disasters in their childhood (McFarlane & Hooff, 2009; Najarian, Sunday, Labruna, & Barry, 2011). The estimated age of the participants at the time of the disasters ranged from three to 16 years old.

With respect to study design, four of the 10 studies were cohort studies (Goenjian, Walling, Steinberg, Karayan, & Pynoos, 2005; Jia et al., 2013; Kronenberg et al., 2010; Najarian, et al., 2011), another four were cross-sectional studies (Agustini, Asniar, & Matsuo, 2011; Goenjian et al., 2009; Kilic, Kilic, & Yilmaz, 2008; McFarlane & Hooff, 2009), one was a descriptive study (Piyasil et al., 2011), and the other study was based on a case-series design (Ularntinon et al., 2008). One of the cohort studies compared PTSD symptoms between the subjects who had and had not received group/individual psychotherapy (Goenjian et al., 2005). Since intervention studies were not the focus of this review, we did not include the information regarding treatment effect in the summary table, and included the results of non-treated subjects only. The length of the follow-up period ranged from three to 20 years after the disasters. Four

studies followed disaster-experienced children for three to four years after the disaster (Agustini et al., 2011; Jia et al., 2013; Kronenberg et al., 2010; Ularntinon et al., 2008), four studies followed them for between five and six-and-a-half years after (Goenjian et al., 2005, 2009; Kilic et al., 2008; Piyasil et al., 2011), and two followed them for more than 20 years after the disaster (McFarlane & Hooff, 2009; Najarian et al., 2011). None of the included studies conducted a pre-disaster assessment.

Two studies included subgroups of the subjects: Goenjian et al. (2005) included groups of children from three different cities located at increasing distances from the epicenter of the earthquake; Goenjian et al. (2009) included groups of children with different types of parental loss (loss of both parents, loss of father, and loss of mother). Four studies included control/comparison groups: Three studies had non-affected groups as controls (Kilic et al., 2008; McFarlane & Hooff, 2009; Najarian et al., 2011); however, two of them did not include PTSD assessment of the control group (Kilic et al., 2008; Najarian et al., 2011). One study had children who were exposed to the disaster but did not experience any parental loss as a comparison group to bereaved children who lost one or both of their parents (Goenjian et al., 2009).

Three of the studies stated that the subjects did not receive any psychological treatment following the disaster (Goenjian et al., 2005, 2009; Najarian et al., 2011). Two studies stated that some of the subjects received psychological intervention during the follow-up period (Jia et al., 2013; Kronenberg et al., 2010; Piyasil et al., 2011), and one study stated that school-wide intervention was conducted at the targeted schools (Ularntinon et al., 2008).

Risk of Bias

A summary of the quality assessment for six categories is presented in Table 2, together with a summary of the findings of each study. Four cohort studies were rated for all six categories: three studies were rated “adequate” in four (Goenjian et al., 2005; Jia et al., 2013; Kronenberg et al., 2010) and one study was “adequate” in three of the six categories (Najarian et al., 2011). Four cross-sectional studies were rated for five categories (the category of “Follow-up” was excluded): One was rated “adequate” in all five categories (Kilic et al., 2008); one was “adequate” in four (McFarlane & Hooff, 2009); one was “adequate” in three (Goenjian et al., 2009); and the remaining was “adequate” in two of the five categories (Agustini et al., 2011). One case-series study was rated for five categories (the category of “Control/comparison group” was excluded), being “adequate” in four of them (Ularntinon et al., 2008). One descriptive study was rated for all six categories, being “adequate” in two of the six categories (Piyasil et al., 2011).

Table 1. Summary of the included studies

Author (year)	Study design	Time After	Sample	Size	Age[1] Study	Age[1] Disaster	Control/ comparison group	PTSD[2] Measure	PTSD prevalence and classification
2008 Sichuan earthquake, China (May 12, 2008)									
Jia et al. (2013)	Cohort	15mths 36mths	Random sample of students in the severely affected areas	430	8-16	7-15	-	CPTSD-RI	12.4% to 10.7%, from 15th to 36th month (probable PTSD) 4.2% to 4.7% (comorbid with depression)
2005 Hurricane Katrina, U.S. (August 29, 2005)									
Kronenberg et al. (2010)	Cohort	2yrs 3yrs	Students in 4-12th grades from the targeted community	387	9-18	7-16	-	NCTSN screener	23.0% (breakdown without recovery), 4.7% (delayed breakdown), 27.1% (normal response and recovery), 45.2% (stress resistant)
2004 Southeast Asia tsunami (December 26, 2004)									
Agustini et al. (2011)	Cross-sectional	4.5yrs	Students from 4 boarding schools in the same community	482	11-19	6-15	-	CPTSD-RI	22.4% (probable PTSD)
Piyasil et al. (2011)	Descriptive	6ws, 6mths 1, 2, 3, 4, 5yrs	Students in 2 selected schools from the most affected area	1,625	9-14	8-14	-	Psychiatric interview	57.3%, 46.1%, 31.6%, 7.6%, 4.5%, 3.9%, and 2.7%, from 6ws to 5yrs after disaster, respectively.
Ulamtinon et al. (2008)	Case-series	1y 3yrs	Children diagnosed with PTSD at 1y post disaster	45	11.35	8.31	-	Psychiatric interview	11.1% (Cronic PTSD), 11.1% (Depressive Disorder), 11.1% (Anxiety Disorder), 46.7% (Partial remission), 24.4% (Full recovery)
1999 Bole earhquake, Turkey (November 12, 1999)									
Kilic et al. (2008)	Cross-sectional	5yrs	Children in the housholds randomly selected from the city center	81	8-15	3-10	Non exposed (n = 87)	CPTSD-RI	18.5% (probable PTSD)
1988 Spitak earthquake, Armenia (December 7, 1988)									
Najarian et al. (2011)	Cohort	2yrs 20yrs	Adults who experienced the disaster, and were selected for the previous study at 2 years after the disaster	19	28-30	8-10	Non-exposed (n = 44)	CPTSD-RI DICA-R	21.1% (probable PTSD) at 20yrs post disaster
Goenjian et al. (2009)	Cross-sectional	6.5yrs	Students at a trade school for bereaved students	48	13.8	7.3	Exposed no-parental loss (n = 44)	CPTSD-RI	N/A
Goenjian et al. (2005)	Cohort	1.5yrs 5yrs	Students in the selected schools from 3 cities located at increasing distances from the epicenter	125	15-17	10-12	-	CPTSD-RI	N/A
1983 Ash Wednesday Fires, Australia (February 16, 1983)									
McFarlane & Hooff (2009)	Cross-sectional	20yrs	Adults who experienced the disaster, and were recruited as children 2y after the disaster	540	23-34	3-13	Non-exposed (n = 464)	CIDI PTSD	15.2% (past month PTSD) 36.7% (lifetime PTSD)

[1] The range of participants' age at the time of the study and the disaster. Mean age was noted when the range was not available.

[2] CPTSD-RI = The Child Post-Traumatic Stress Disorder Reaction Index (Pynoos et al., 1987; Steinberg et al., 2004),
NTCTSN screener = NTCSN Hurricane Assessment and Referral Tool for Children and Adolescents (NTCTSN, 2005), CIDI = Composite International Diagnostic Interview (WHO, 1997),

Table 2. Quality assessment and major findings of the included studies

Author (year)	Study design	SAQOR[1]						Summary of the findings
		Sample	Control/comparison group	Exposure/outcome measurement	Follow-up	Distorting influences	Reporting of data	
2008 Sichuan earthquake, China								
Jia et al. (2013)	Cohort	+	-	+	+	+	-	Overall prevalence rates of PTSD and depression symptoms did not change significantly from 15 to 36 months post disaster. The linear regression model showed that depression, objective experiences, subjective experiences, and earthquake-related loss had influence on PTSD symptoms at 36 months after the disaster. Gender was not significant in the regression analysis, although females scored higher than males.
2005 Hurricane Katrina, U.S.								
Kronenberg et al. (2010)	Cohort	+	-	-	+	+	+	Not only did overall symptoms decreased from the 2nd to the 3rd post disaster year, but also 72.3% of the children were classified as "stress resistant" or "normal response and recovery". However, 27.7% of the children were classified as "breakdown without recovery" or "delayed breakdown". Younger age, female gender, consulting with a mental health professional, and endorsing family and school problems were found to be the most associated with the recovery patterns. Pre- and post- disaster loss or trauma and current living conditions were not associated with the recovery patterns.
2004 Southeast Asia tsunami								
Agustini et al. (2011)	Cross-sectional	+	-	+	n/a	-	-	Gender (female), loss of parents, somatic response and support level were significantly associated with PTSD symptoms among the tsunami-affected adolescents at 4.5 years after the tsunami.
Piyasil et al. (2011)	Descriptive	+	-	-	+	-	-	The prevalence of PTSD was 57.3% after the disaster, and gradually decreased to 2.7% throughout the 5-year follow-up period. Female to male ratio of the students with PTSD was 1.7: 1.
Ulantinon et al. (2008)	Case-series	+	n/a	+	+	-	+	About 25% of the students, who were diagnosed with PTSD at 2 yeas post disaster, had full recovery at 3 years post disaster. The history of previous trauma and physical injury at the time of the disaster were associated with the outcome. Gender was not associated with the outcome. Previous work: Piyasil et al. (2007)
1999 Bole earthquake, Turkey								
Kilic et al. (2008)	Cross-sectional	+	+	+	n/a	+	+	No significant difference on anxiety and depression between the earthquake-exposed group and the non-exposed group at 5 years post disaster. Trait anxiety and anxiety sensitivity contributed to the severity of PTSD reactions in the subject group, but not depression. Gender and age were not significant factors in regression analysis.
1988 Spitak earthquake, Armenia								
Najarian et al. (2011)	Cohort	-	+	+	+	-	-	Earthquake-exposed group had higher scores on several symptoms than the non-exposed adults, and 4 out of 19 earthquake-exposed adults scored probable PTSD at 20 years post disaster. 63% of the earthquake experienced adults had at least one clinical elevation in the symptom chicklist-90-R; whereas 64% of the control group had no clinical elevation. No correlation was found between Time1 and Time2 depression scores and number of the PTSD symptoms. Previous work: Najarian et al. (1996)
Goenjian et al. (2009)	Cross-sectional	+	+	+	n/a	-	-	No significant difference was found in PTSD symptom scores by the type of parental loss at 6.5 years post disaster. However, orphans had the highest depression scores, followed by those who lost fathers, those who lost mothers, and those who did not have parental loss.
Goenjian et al. (2005)	Cohort	+	+	-	+	+	-	Students from the city located the closest to the epicenter had higher PTSD reactions at 1.5 years after the disaster, and remained higher at 5 years after the disaster than the other 2 groups farther from the epicenter, although scores decreased over time significantly in all 3 groups. Meanwhile, depression scores did not decrease over time in all 3 groups; even a significant increase was found in the group second closest to the epicenter from 1.5 to 5 years after the disaster. Previous work: Goenjian et al. (1995)
1983 Ash Wednesday Fires, Australia								
McFarlane & Hoff (2009)	Cross-sectional	+	+	-	n/a	+	+	Although 75% of the bushfire-exposed group still reported some degree of distress in relation to the bushfires, there was no significant difference between bushfire group and the controls in the prevalence of PTSD resulting from the self-nominated worst lifetime event. In the bushfire-exposed group, individuals who nominated the bushfire as their worst event had lower risk than individuals who nominated other traumatic events as their worst event. Previous work: McFarlane et al. (1987)

[1] '+' = adequate, '-' = inadequate

Regarding "Distorting influences", five studies were rated "adequate", adjusting for more than two potential confounders that are listed in Table 2. In four of the studies, age and gender were controlled for, by matching (Kronenberg et al., 2010) and statistical adjustment (Goenjian et al, 2009; Kilic et al., 2008; Kronenberg et al., 2010; McFarlane & Hooff, 2009). Two studies controlled for disaster-related loss (Goenjian et al., 2009; Jia et al., 2013), and two studies controlled for depression (Jia et al., 2013; Kilic et al., 2008) in their analyses phase. Pre- or post-disaster loss or trauma was treated in Jia et al. by restricting the enrollment, and in Kronenberg et al. by statistical adjustment. As for the method, three studies employed multivariate methods to control confounding. Two of them employed linear regression analyses: Jia and colleagues included depression, residence, gender, ethnicity, objective/subjective experience of the disaster, disaster-related loss, and perceived social support in their analysis, with the subject without any pre- or post-traumatic experience; also Kilic and colleagues included state/trait anxiety, anxiety sensitivity, gender, age, and depression, as explanatory variables to the PTSD scores. One study conducted multi-nominal logistic regression, including age, gender, recovery stressors related to the disaster, pre- or post-disaster significant loss or trauma, and current perceptions of life problems as explanatory variables to the recovery patterns (Kronenberg et al., 2010).

The Measurement and Prevalence of PTSD

The most commonly used outcome measure was the Child Post-Traumatic Stress Disorder Reaction Index or CPTSD-RI (Pynoos et al., 1987; Steinberg, Brymer, Decker, & Pynoos, 2004), which is a self-report questionnaire assessing the severity of PTSD symptoms and also probable PTSD prevalence using a cut-off score, and was employed in six studies (Agustini et al., 2011; Goenjian et al., 2005, 2009; Jia et al., 2013; Kilic et al., 2008; Najarian et al., 2011). Kronenberg et al. (2010) used the Hurricane Assessment and Referral Tool for Children and Adolescents developed by the National Child Traumatic Stress Network (2005), which is based on the CPTSD-RI and also includes a number of questions regarding depressive symptoms. McFarlane and Hooff (2009) employed the computerized version of the Composite International Diagnostic Interviews or CIDI (World Health Organization, 1997). Two other studies involved diagnostic interviews conducted by psychiatrists using the DSM-IV (Piyasil et al., 2011; Ulartinon et al., 2008).

The overall (probable) prevalence rates over three years post-disaster were available in six of the included studies. At three years after, the prevalence rates were 10.7% following Shichuan earthquake in 2008 (Jia et al., 2013) and 4.5% following South Asia tsunami in 2004 (Piyasil et al., 2011). At 4.5 to five years after the disaster, the rates were 22.4% and 2.7% following South Asia tsunami in 2004 (Agustini et al., 2011; Piyasil et al., 2011), and 18.5% following Bolu, Turkey earthquake in 1999 (Kilic et al., 2008). After 20 years, the rates were 15.2% following the Ash Wednesday fires in 1983 (McFarlane & Hooff, 2009) and 21.1% following Spitak earthquake in 1988 (Najarian et al., 2011).

Three studies compared the subjects who experienced the disaster with the controls who did not experience the disaster in PTSD and related symptoms; of these, one compared these two groups in PTSD prevalence rates 20 years after the disastrous bushfire; McFarlane and Hooff (2009) found no significant difference in PTSD prevalence between the bushfire-exposed and non-exposed groups; however, bushfire-exposed participants who experienced other traumatic event showed a higher risk, with a rate 1.8 times as likely as the controls.

Changes Over Time in PTSD symptoms

Two studies examined change over time in the prevalence of PTSD. Piyasil and colleagues (2011) showed that the prevalence rate decreased over time: 57.3% (six weeks post-disaster), 46.1% (six months), 31.6% (one year), 7.6% (two years), 4.5% (three years), 3.9% (four years), and 2.7 % (five years); however, the statistical significance of the decrease was not tested. In Jia et al. (2013), the probable prevalence rate was 12.4% at 15 months and 10.7% at 36 months post-disaster, but the change was not significant. On the other hand, Goenjian et al. (2005) examined over time changes in the PTSD scores rather than the prevalence rate, and found a significant decrease from 1.5 to five years post-disaster.

Two studies examined post-disaster recovery. Ularntinon et al. (2008) followed 45 children diagnosed with PTSD a year after the disaster, and found that 11% of them still met the criteria for PTSD diagnosis at three years post-disaster, whereas 24% of them had a full recovery. Kronenberg et al. (2010) investigated the recovery patterns of post-traumatic symptoms including PTSD and depression from the second to the third post-disaster year, categorizing children into four different groups: (a) stress resistant; (b) normal response and recovery; (c) delayed breakdown; and (d) breakdown without recovery. The percentages of the children included in each of these groups were 45.2%, 27.1%, 4.7%, and 23.0%, respectively; the total percentage of children who scored above the cutoff was 50.1% and 27.7% at the second and third year post-disaster.

Influential Factors

***1. Gender*:** Seven of the included studies investigated gender difference in PTSD symptoms. Of these, five studies found that females had higher scores than males on PTSD measures (Agustini et al., 2011; Goenjian et al., 2005, 2009; Jia, et al., 2013; Kronenberg et al., 2010). Piyasil et al. (2011) described that the PTSD prevalence at six weeks after the disaster for female to male was 1.7 : 1; however, the statistical siginificance of this difference was not tested. Additionally, Kronenberg and colleagues investigated gender influence on the recovery patterns from the second to the third year post-disaster, as well as on PTSD scores, with females being more likely to be classified in the “breakdown without recovery” compared to “stress resistant”, although gender did not alter the relation between other variables and the recovery patterns in the moderation analysis. However, multiple linear regression analyses in Jia et al. (2013) and Kilic et al. (2008) revealed that gender did not contribute to the PTSD scores when entered with other variables at three and five years after the disaster, respectively, although girls showed signifiantly higher PTSD scores. One study found no significant gender

difference in the recovery patterns among the clinical group with PTSD diagnosis from the first to the third post-disaster year (Ularntinon et al., 2008).

***2. Age*:** Five studies investigated age-related differences. Four of them found no significant age diffrernce in PTSD symptoms. Further, Kilic et al. (2008) showed no age effect on PTSD symptoms in the linear regression analysis when entered with other variables at five years after the disaster. Conversely, Kronenberg et al. (2010) found that younger children (ages 9 to 11) scored higher than older children (ages 15 to 18) at both the second and third post-disaster years, and that the recovery patterns of older children were about four times more likely to be in the "stress resistant" group than the "breakdown without recovery" group when other factors were adjusted for; however, age did not alter the relation between other variables and the recovery patterns in the moderation analysis.

***3. Disaster experience and loss*:** Goenjian and colleagues (2005) found that students who lived closest to the epicenter of the earthquake had higher PTSD symptoms at 1.5 years post-disaster, and their symptoms remained higher at five years post-disaster than students who lived a greater distance from the epicenter. Similarly, physical injury (Ularntinon et al., 2008), and both the objective and subjective experience of the disaster (Jia et al., 2013) were associated with PTSD symptoms at three years post-disaster. Regarding disaster-related loss, loss experience including family members, significant others, houses, and important belongings (Jia et al., 2013) and loss of parents (Agustini et al., 2011) were associated with PTSD at three and 4.5 years after the disaster, respectively. However, Goenjian et al. (2009) found no significant difference in PTSD symptoms at 6.5 years post-disaster between students who lost their parents and students without parental loss, although orphans had the highest depression scores followed by those who lost fathers, compared to those who lost mothers and those who did not have parental loss.

***4. Depression and anxiety*:** Jia et al. (2013) found that PTSD symptoms were predicted by depression, together with objective and subjective experiences and disaster-related loss at three years post-disaster when entered with other variables into the regression analysis; however, Kilic et al. (2008) included anxiety factors into the linear regression analysis and found that PTSD symptoms were predicted by trait anxiety and anxiety sensitivity, but not by depression or state anxiety at five years post-disaster.

***5. Other traumatic experiences*:** Ularntinon and colleagues (2008) showed that a history of previous trauma influenced the recovery of the children previously diagnosed with PTSD at three years post-disaster. McFarlane and Hooff (2009) found that there was a significant difference between bushfire-exposed adults and the controls in PTSD symptoms at 20 years post-disaster, only if the bushfire-exposed adults experienced additional trauma. Conversely, Kronenberg et al. (2010) found that previous loss or trauma, and post-disaster major loss or trauma did not affect the recovery patterns from the second to the third year post-disaster when other factors were adjusted for.

***6. Environmental factors*:** Kronenberg et al. (2010) found that family and school problems were associated with the recovery patterns from the second to the third year after the disaster, but that the current living conditions, family connectedness, or friend problems were not associated with them. The perceived support level was also found to be associated with PTSD symptoms at three and 4.5 years after the disaster (Jia et al., 2013; Agustini et al., 2011). However, the influence was no longer significant when entered into the regression analysis with other variables in the study of Jia et al; it decreased depression symptoms, rather than PTSD symptoms.

Discussion

This review exclusively looked at long-term follow-up studies of PTSD symptoms in children after natural disasters. The included studies followed children who experienced disaster for three to 20 years post-disaster. The results of the study selection in Phase 2 showed that the number of such studies has largely increased in the last 10 years. Of these studies, about 35% followed other types of disasters (e.g., war, terrorist attacks, ship sinking, accidents, etc.), indicating that natural disaster is the major focus of long-term PTSD research in children, as Furr et al. (2010) and Hoven et al. (2009) mentioned earlier. However, almost 80% of the natural disaster studies followed the subjects for less than three years after disasters. Although Hurricane Katrina in 2005 was the most studied event among the selected studies in Phase 2, only one of them was included in this review in Phase 3. In addition, all included studies were published between 2005 and 2013. The importance of the long-term follow-up study seems to have been recognized relatively recently in post-disaster research, and thus the research over time awaits further investigation.

The studies included in this review varied in the study design, sample size and age, assessment method and timing, magnitude of the disaster, etc. Considering this heterogeneity, we presented the results as a narrative synthesis of the individual findings from the original studies. The results of the quality assessment using SAQOR indicated that the included studies had mostly moderate to high quality; however two studies were rated “adequate” in only two categories. Thus, these findings need to be interpreted cautiously.

Long-term Course of PTSD and Recovery

As previous reviews have summarized (e.g., Furr et al., 2010; Vogel and Venberg, 1993; Wang et al., 2013), we have already learned that post-traumatic symptoms decrease substantially during the first year after the disaster; however, the course of PTSD after the first few years is not yet well known. The results reported by Piyasil et al. (2011) suggested that PTSD symptoms decrease largely during the first two years (from 57.3% to 7.6%), and there may not be a significant decrease after that up to five years post-disaster.

Although Piyasil and colleagues did not test the statistical significance of the decrease, this data delineated the course of PTSD symptoms. However, it should be noted that in their study, a school-based intervention was conducted in the targeted school, so

there must have been some intervention effect on the prevalence rate. Although McFarlane and Hooff (2009) indicated that PTSD symptoms would be mostly remitted to the level of the non-exposed group by 20 years post-disaster, two studies that investigated change over time of between 15 months and five years showed inconsistent results: Goenjian et al. (2005) found a significant decrease in PTSD scores from 1.5 to five years post-disaster, whereas Jia et al. (2013) found no significant decrease in prevalence rate from 15 to 36 months post-disaster. The significance of the decrease of PTSD prevalence after the first post-disaster year may not be large enough to be captured in a short period.

Regarding post-disaster recovery, Kronenberg et al. (2010) examined the recovery patterns proposed by Masten and Obradovic (2008) based on post-traumatic symptoms – including PTSD and depression – and reported that among the children who scored above the cutoff score on the screening at the second post-disaster year, 54% were considered to have recovered at the third year. These findings were similar to the result of Perkonigg et al. (2005) on youth PTSD, showing that about a half of the youth, previously diagnosed with PTSD, had recovered at 50 months after the disaster. Ularntinon et al. (2008) also found that about 25% of the children, who were diagnosed with PTSD at the first year after the disaster, had full recovery at the third year after the disaster, whereas 11% continued to have PTSD. Although the recovery rate would vary across studies due to the employed symptom measures, study time frame, study population, magnitude of the disaster, etc., these studies enable us to examine the course of PTSD in children, which is not captured by overall prevalence rates. Also, both risk and protective factors to the development of chronic PTSD could be examined. More studies that investigate recovery patterns or followed case samples would be needed in the future.

Risk Factors

Gender and disaster experience were the most studied influential factors on PTSD symptoms among the included studies. On the other hand, age effect was supported by only one study. These findings were consistent with the meta-analysis reported by Furr et al. (2010), which demonstrated that gender, but not age, was significantly associated with PTSD in youth. With regard to gender difference, although seven of the 10 included studies found that girls were more likely to have PTSD symptoms than boys, the linear regression analyses did not support the gender influence on PTSD symptoms (Jia et al., 2013; Kilic et al., 2008), indicating that the gender-related differences might be confounded or moderated by other variables. The gender difference in PTSD symptoms may due to the gender difference in depression, as it is known that girls report more depression symptoms than boys (see Hankin & Abramson, 2001; Jordan, 2013). It is necessary to determine whether gender has a significant influence on PTSD when other potentially influencing variables are accounted for. Furthermore, there might be a moderating effect of gender on the relation between some risk factors and PTSD symptoms; for example, lack of social support may impact girls more adversely than boys considering that women's coping style is more relational than men's (Jordan, 2013; Lazarus & Folkman, 1984).

Regarding disaster experience, physical proximity and subjective experience were associated with PTSD symptoms, as has been suggested by Vogel and Venberg (1993) and Furr et al. (2010). However, the influence of parental loss on child PTSD was not clear: Two studies showed its influence on PTSD symptoms at three and 4.5 years after the disaster (Agustini et al., 2011; Jia et al., 2013), whereas Goenjian et al. (2009) demonstrated that parental loss was associated with depression, not with PTSD symptoms at 6.5 years after the disaster. Loss of parents may be a risk factor for developing PTSD after the disaster, but may not be a strong predictor for chronic PTSD. Children who lost their parents may continue to suffer from depression even after recovering from PTSD symptoms.

Depression is one of the most studied post-disaster symptoms except for PTSD (Hoven et al., 2009), and is known to often be comorbid with PTSD (45.9% in Eksi & Braun, 2009; 79% in Goenjian et al., 2001). As it has been suggested that depression symptoms predict subsequent PTSD symptoms (Roussos et al., 2005; Ying, Wu, & Lin, 2012; Zhang et al., 2012), so too Jia et al. (2013) found that PTSD symptoms were explained by depression. Considering that children with comorbid symptoms of PTSD and depression have poorer recovery (Lai, La Greca, Auslander, & Short, 2013), having depression symptoms seems to be a risk factor for prolonged PTSD in children. With regard to the risk factors for depression, Goenjian et al. (2009) showed that parental loss is associated with depression. On the other hand, Jia et al. (2013) demonstrated that depression was not predicted by disaster-related loss, but by perceived social support. Disaster-related loss may lead to impaired social support available to the child, which could increase the child's depression symptoms, but this relation was not yet known.

Anxiety is considered to be another influential factor: Asarnow et al. (1999), La Graca, Silverman, and Wasserstein (1998), and Weems et al. (2007) showed that pre-existing anxiety and trait anxiety significantly contributed to the subsequent development of PTSD in children, after controlling for the effects of other variables. Among the studies included in this review, Kilic and colleagues (2008) found that PTSD symptoms were explained by trait-anxiety and anxiety sensitivity, but not by depression and state-anxiety. Trait-anxiety and anxiety sensitivity are considered to be personal traits functioning as vulnerability factors, which precede post-traumatic symptoms, rather than symptoms following the disaster. As mentioned in Furr et al. (2010) and Hoven et al. (2009), pre-disaster assessment is rare in disaster research, since disaster research is usually initiated after the disaster occurrence. More studies are needed to understand these preceding and potentially predisposing factors to identify children at risk at an earlier stage.

Finally, the influence of being exposed to multiple traumas was not yet clear, with two studies showing a significant influence on chronic PTSD (McFarlane & Hooff, 2009; Ularntinon et al., 2008), which was consistent with the results of Pekonigg et al. (2005), while one study showed no significant influence (Kronenberg et al., 2010). All three studies employed different measures for assessing the experience of other traumas. There is a need to develop a more standardized measure to assess pre- and post-disaster traumatic experience.

Limitations and Future Directions

Several limitations regarding study design were found. First, among the studies included in this review, none conducted a pre-disaster assessment. Although there are constraints, pre-disaster information would be beneficial for obtaining a better understanding of the risk factors for chronic PTSD, such as pre-existing anxiety. Second, a control/comparison group was included in only three studies, and none of them had longitudinal data for the comparison. There are many barriers to having comparable groups to in post-disaster research, as well as having representative samples in disaster research (Masten & Osofsky, 2010). However, it is ideal to include control groups in cohort studies as well so that the long-term impact of the disaster can be evaluated properly. Using some strategies to reduce confounding caused by sampling and selection flaws is also required. Third, some of the subjects in the included studies received psychological interventions after the disaster. Such information should be taken into account when evaluating the influence of the disaster on PTSD symptoms and the recovery from them. It is recommended to have both an intervention and a non-intervention group in the study, as with Goenjian and colleagues in their 2009 work, although we did not report that information in this review.

Regarding the risk of confounding, five of the included studies used one to two strategies recommended to avoid confounding by Lu (2009). Thus, some of the possible confounding was controlled in these studies. Such strategies, especially multivariate methods, enable us to have a better understanding of the mediation and moderation effects of the factors on the PTSD symptoms, as well as to avoid confounding. Gender influence was suggested to be more complicated than a simple risk factor in this review. Studies investigating dimensional factors, including pre-disaster trait (e.g., gender, trait anxiety), disaster experience (i.e., proximity, physical injury, threat to life, loss of important others), other post-traumatic symptoms (e.g., depression, anxiety), and current distress (e.g., social support, parental symptomatology, school stress, living conditions), using multivariate strategies would be beneficial and thus recommended in the future research.

Age was not found to be an influential factor, with only one study showing a significant age effect on the PTSD symptoms (Kronenberg et al., 2010). The age range of the participants of the included studies was not small, especially the age at the time of the disaster (ages three to 16). Disaster experience may affect children's development differently depending on their developmental levels. Considering that younger children are more dependent on care from adults, loss of parents or impaired parental functioning associated with parents' symptomatology may influence younger children's recovery more adversely than that of older children. Additionally, Masten and Osofsky (2010) mentioned the possibility that psychological or physical adversity experienced become embedded in child development through a variety of pathways, from the effects of elevated cortisol on the developing brain to the effects of maternal deprivation on attachment, emotional security mastery, motivation, the development of self-regulation, and later relationships. Thus, not just an age difference among study participants, but also a difference in developmental stage needs be taken into account to examine its influence

on PTSD symptoms and recovery. Also, an age-sensitive assessment method based on DSM-V (American Psychiatric Association, 2013), which separated PTSD in children younger than six years, await development.

Two of the included studies examined the post-disaster recovery patterns (Ularntinon et al., 2008; Kronenberg et al., 2010). However, the influential factors on the recovery patterns were not yet clear. Considering that there would be limited resources for psychological interventions in severely affected areas, and most of the children would show recovery over time, identifying children and adolescents at the highest risk for chronic PTSD would be particularly important. Several studies mentioned the importance of the ongoing life stress in the disaster research as well as the magnitude of the disaster (see Masten & Osofsky, 2010). Disaster magnitude and experience is known as a strong risk factor to the development of PTSD, whereas secondary stress associated with family loss, family symptomatology, peer support, et cetera may function as risk factors to the recovery from PTSD. Also, factors protective against the onset or later development of PTSD, and factors associated with resilient recovery from PTSD versus chronic forms of the disorder (Pynoos et al., 1999) may be different. More studies focusing on recovery would be needed in the future in order to reveal risk and protecting factors associated with chronic PTSD.

Conclusions

This article reported a systematic reiew of the long-term follow-up studies of PTSD symptoms in children and adolescents after natural disasters. The results of the database search demonstrated that the number of long-term follow-up studies has increased in the last 10 years. The synthesized results of the included studies indicated that PTSD symptoms decrease over time, especially during the first two years after the disaster, as mentioned in the previous reviews (Furr et al., 2010; Hoven et al., 2009; Vogel & Venberg, 1993); however, the long-term course is not yet clear. Among possible risk factors, gender, disaster experience, depression, trait-anxiety, experiencing multiple trauma, and parental loss were considered to be associated with PTSD; however, there is a possiblility that the gender effect on PTSD might be confounded by other factors, such as depression and anxiety. More detailed reseach, including assessments of, among others, children’s pre-disaster traits, disaster experience, depression, current living distress, and social support, using multivariate analytical methods would be needed. Furthermore, studies that examine recovery would be beneficial in order to provide a better understanding of the factors associated with chronic PTSD, and thus await futher investigation.

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