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Post-traumatic stress disorder following disasters: a systematic review

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Abstract

Background—Disasters are traumatic events that may result in a wide range of mental and physical health consequences. Post-traumatic stress disorder (PTSD) is probably the most commonly studied post-disaster psychiatric disorder. This review aimed to systematically assess the evidence about PTSD following exposure to disasters.

Method—A systematic search was performed. Eligible studies for this review included reports based on the DSM criteria of PTSD symptoms. The time-frame for inclusion of reports in this review is from 1980 (when PTSD was first introduced in DSM-III) and February 2007 when the literature search for this examination was terminated.

Results—We identified 284 reports of PTSD following disasters published in peer-reviewed journals since 1980. We categorized them according to the following classification: (1) human-made disasters (n=90), (2) technological disasters (n=65), and (3) natural disasters (n=116). Since some studies reported on findings from mixed samples (e.g. survivors of flooding and chemical contamination) we grouped these studies together (n=13).

Conclusions—The body of research conducted after disasters in the past three decades suggests that the burden of PTSD among persons exposed to disasters is substantial. Post-disaster PTSD is associated with a range of correlates including sociodemographic and background factors, event exposure characteristics, social support factors and personality traits. Relatively few studies have

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Note

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Declaration of Interest

None.

employed longitudinal assessments enabling documentation of the course of PTSD. Methodological limitations and future directions for research in this field are discussed.

Keywords

Disaster; post-traumatic stress disorder (PTSD); trauma

Introduction

Exposure to traumatic events is common. Studies have shown that more than two thirds of the general population are likely to be exposed to trauma in their lifespan and up to one fifth of Americans may experience traumatic events in the USA in any given year (Breslau *et al.* 1991, 1998; Norris, 1992; Resnick *et al.* 1993; Kessler *et al.* 1995). However, there is substantial heterogeneity worldwide in the distribution of exposure to traumatic events. Research suggests that there are certain geographical areas where large populations are consistently exposed to large-scale traumatic events such as wars, organized violence, terrorism, and natural disasters. Therefore, the overall exposure to trauma worldwide may exceed rates previously reported in the USA (Kessler, 2000; Brunello *et al.* 2001).

Exposure to disasters is particularly common. A national survey in the USA suggested that more than 15% of females and 19% of males were exposed to disasters at some time in their lifetime (Kessler *et al.* 1995). Although the consequences of disasters may include a wide range of psychopathology (Norris *et al.* 2002; Neria *et al.* 2006a), previous systematic reviews have documented that post-traumatic stress disorder (PTSD) is the most commonly studied psychopathology in the aftermath of disasters (Norris *et al.* 2002; Galea *et al.* 2005) and is likely the central psychopathology after such events (Breslau *et al.* 2002).

The purpose of this article is to review the literature on PTSD following disasters starting from 1980, when PTSD was first presented in DSM-III (APA, 1980) as a psychiatric condition to February 2007, when this review was terminated. This review builds on previously published reviews related to the topic (Norris *et al.* 2002; Galea *et al.* 2005), updates and expands this prior work, and aims to identify key challenges in the extant literature.

Method

Selection criteria

The sampling frame for this review can be summarized based on exposure, outcome, and time-frame. There is little consensus in the literature about what constitutes a disaster. For the purpose of this review, following the example established in a previous review (Galea *et al.* 2005), we considered studies about disasters that were defined as such by their authors. Studies assessing the impact of chronic exposure to trauma (e.g. war) were generally not included in this review. For the outcome, studies eligible for this review included reports based on DSM criteria of PTSD symptoms. Therefore, studies of other psychiatric disorders (e.g. depression, substance abuse) or psychological problems (e.g. unresolved grief) were not included in this review. The time-frame for inclusion of reports in this review was

between 1980 (when PTSD was first introduced in DSM-III) and February 2007 when the literature search for this examination was terminated.

Search strategy

We obtained papers for this review using a four-step procedure. First, we performed a systematic search of the peer-reviewed literature using the Medline, PsycINFO, and PILOTS databases and identified potential studies for inclusion using the following keywords: 'PTSD', 'posttraumatic stress disorder', 'disaster', 'mental health', 'trauma'. Second, we analyzed abstracts for all studies identified and excluded papers that did not satisfy selection criteria. Third, we analyzed the full-text version of all remaining studies and excluded those that did not satisfy selection criteria. Finally, we compared our final sample to previous review papers (Brewin *et al.* 2000; Norris *et al.* 2002; Galea *et al.* 2005) to verify that our search was successful and its results were comprehensive.

Search results

Our search identified 284 reports of PTSD following disasters published since 1980. The earliest disaster included in this review was the 1963 Vajont landslide and tidal wave flood disaster in Northeast Italy, which was studied retrospectively 36 years after and reported in 2004 (Favaro *et al.* 2004), and the latest disaster studied was Hurricane Katrina in 2005, most recently described in a report by the Centers for Disease Control and Prevention (CDC, 2006). We categorized studies according to the following classification: (1) human-made disasters (n=90), (2) technological disasters (n=65), and (3) natural disasters (n=116). Because some studies reported on findings from mixed samples (e.g. survivors of flooding and chemical contamination) we grouped these studies together (n=13). Hence, the results of this review are presented in four Appendix tables (Tables A1–A4, available in the online version of this paper). Each table provides a summary including lead author and year of publication, study design (cross-sectional, prospective cohort), population studied (survivors, responders, community or the general population, mixed), subjects' roles (e.g. disaster workers), sampling method (convenience sample, systematic sample), time-frame of data collection, PTSD instrument, and main findings. Key reports that made use of a random or systematic sample and that studied at least 500 participants are summarized by disaster type in text Tables 1–3. These tables aim to provide the reader with main findings and comparisons between disaster types, populations studied, and time-frames of assessments to facilitate the most meaningful conclusions from the numerous studies conducted in almost three decades of research.

Findings

Although many reports of rates of post-disaster PTSD can use the term 'incidence' rather than 'prevalence' due to the fact that in most cases the exposure duration was brief and limited in time, few studies were designed to ensure that the assessment of incidence was carried out among persons without previous PTSD. We therefore, and consistent with a previous review (Galea *et al.* 2005), opted to use the term 'prevalence' rather than 'incidence' throughout this article unless incidence of PTSD was specifically assessed in individuals without pre-disaster PTSD.

Studies of human-made disasters

Table A1 presents data on human-made disasters reviewed. We located 22 human-made disasters, on which 90 reports have been published. The most frequently studied events were the 11 September 2001 terrorist attacks (n=42) and the 1995 Oklahoma City bombing (n=15). Of those studies, we present 12 key studies in Table 1.

Prevalence—Most studies in this category assessed PTSD in adult populations. The highest prevalence of PTSD was found among survivors and first responders. For example, 1 month after exposure, PTSD prevalence ranged from 20.3% among survivors of the 1993 Sivas religious uprisings in Turkey (Sungur & Kaya, 2001) to 29% among survivors of the 1991 mass shooting episode in Killeen, Texas (North *et al.* 1994). The prevalence of PTSD among first responders assessed following involvement in rescue, recovery and cleaning efforts were especially high. For example 44.3% of police officers involved in the 1989 Hillsborough football stadium disaster in Sheffield, UK, assessed 1–2 years after exposure (Sims & Sims, 1998), were classified with severe symptom severity while 44.1% were classified with moderate symptom severity. Similarly, 22.5% and 20% of disaster workers were found to suffer from PTSD at 2 weeks and 10–15 months after the 9/11 terrorist attacks in New York City and Washington, DC, respectively (CDC, 2004; Fullerton *et al.* 2006).

There are relatively few examples of research based on probability samples of the general population. Only one such study preceded the attacks of 11 September 2001. Using a household probability sample of adults from Los Angeles County (n=1200), Hanson and colleagues (Hanson *et al.* 1995) estimated that the prevalence of current (past 6 months) PTSD was 4.1% 6–8 months after the 1992 Los Angeles County civil disturbances. Subsequent work including general population samples of adults from New York City and the New York City metropolitan areas after the 9/11 attacks (Galea *et al.* 2004; Adams & Boscarino, 2005; Nandi *et al.* 2005; Stuber *et al.* 2006) and from Madrid after the 2004 train bombings (Miguel-Tobal *et al.* 2006) showed comparable levels of PTSD symptoms within the first 12 months after these terrorist attacks.

Several studies after human-made disasters focused on specific populations such as low-income subjects and recent immigrants (Neria *et al.* 2006c), psychiatric patients (Franklin *et al.* 2002), specific ethnic groups (Murphy *et al.* 2003; Galea *et al.* 2004), and parents of children exposed to disasters (Mirzamani & Bolton, 2002). Because there are not enough studies in each group, it is not possible to compare between studies. However, it is noteworthy that these studies suggest that while the prevalence of PTSD is likely to decline over time in the general population, the impact of the trauma among high-risk groups may endure. For example, while the prevalence of PTSD declined among residents of Manhattan from 7.5% 1 month after the 9/11 terrorist attacks to 1.7% and 0.6% at 4 and 6 months after the 9/11 attacks, respectively (Galea *et al.* 2003), the prevalence of PTSD among low-income minorities 1 year after the terrorist attacks was substantially higher (10.2%) (Neria *et al.* 2006c).

Only 18 studies focused on samples of children. They studied samples exposed to the: 1984 school playground sniper attack in Los Angeles; 1988 school shooting in Winnetka, Illinois; 1993 World Trade Center bombing; 1995 Oklahoma City bombing; 1998 American

Embassy bombing in Nairobi, Kenya; 1998 discotheque fire in Goteborg, Sweden; and the 9/11 terrorist attacks in New York City and Washington, DC. Because the assessment measures that were used in these studies were different, and some studies chose to measure post-traumatic symptoms only, cross-study comparisons of the prevalence of PTSD in children is limited. Yet, the evidence suggests a particularly high prevalence of PTSD among directly exposed children. For example, the prevalence of PTSD among exposed children was 38.4% at 1 month after the 1984 school playground sniper attack in Los Angeles (Pynoos *et al.* 1987), 27% at 3 months after the 1993 World Trade Center bombing (Koplewicz *et al.* 2002), and 18.4% at 6 months after the 9/11 terrorist attacks in New York City (Hoven *et al.* 2005).

Course—A number of studies examined PTSD longitudinally, enabling documentation of the course of PTSD in samples exposed to human-made disasters. All studies provided evidence of a general decline in the prevalence of PTSD over time. For example, data from the 1991 mass shooting in Killeen, Texas, suggest that the prevalence of PTSD decreased from 27.2% at 6–8 weeks to 17.7% at 13–14 months after the episode (North *et al.* 1997). Findings from a large nationally representative sample of adults residing outside of New York City show that the prevalence of PTSD decreased from 17.0% at 2 months after 9/11 to 5.8% at 6 months after 9/11 (Silver *et al.* 2002). The same pattern has been observed in a random sample of adults living in Manhattan (Galea *et al.* 2003). Similarly, research among children directly exposed to the 1993 World Trade Center bombing suggests that the prevalence of severe to very severe PTSD symptomatology decreased from 27% at 3 months to 14% at 9 months (Koplewicz *et al.* 2002). It is noteworthy that no study to date has assessed the course of PTSD over a long enough period of time (e.g. years) to reliably examine whether PTSD monotonically declines over time or whether there is reliable evidence for the late onset of PTSD.

Studies of technological disasters

We identified 65 studies from 40 technological disasters, starting with the 1966 Aberfan mining disaster in South Wales and ending with the 2002 near sinking of the USS Dolphin Navy research submarine (Table A2). Of these studies, we present in Table 2 the three key studies based on probability samples of the general population conducted following the 1986 Chernobyl nuclear reactor accident (Havenaar *et al.* 1997), the 1989 *Exxon Valdez* oil spill (Palinkas *et al.* 1993), and the 2001 chemical factory explosion in France (Godeau *et al.* 2005).

Prevalence of PTSD—Many of the reports suggest a high prevalence of PTSD when survivors or rescue workers involved in technological disasters were assessed for the first time after exposure. The prevalence of PTSD following technological disasters ranged from 15% to 75%. For example, 15% of residents exposed to the 1991 toxic chemical railroad spill in California had PTSD at 3–4 months after the disaster (Freed *et al.* 1998). Similarly, 26% of adult survivors from the buildings most severely damaged by the 1992 Bijlmermeer plane crash in The Netherlands were found to have PTSD 6 months after the disaster (Carlier & Gersons, 1997). On the other extreme, 73% of survivors from the 1988 Piper

Alpha oil rig disaster were found to have PTSD when assessed 10 years after exposure (Hull *et al.* 2002).

Course of PTSD—A number of studies have conducted longitudinal assessments following exposure to technological disasters, enabling documentation of the course of PTSD symptoms. One study found a significant decline from 54% in the first month after an airplane crash-landing in Alabama to 10–15% one year after the disaster (Sloan, 1988). Similarly, rapid declines in the prevalence of PTSD over time were documented after the USS *Iowa* gun turret explosion (Ursano *et al.* 1995), the Piper Alpha oil rig disaster (Alexander, 1993), and the Lockerbie disaster (Scott *et al.* 1995).

Studies of natural disasters

Observations of studies of natural disasters confirm key observations from human-made and technological disasters. Hence, we will summarize key findings of PTSD after natural disasters while highlighting the main differences between types of disasters. We located 116 studies from 40 natural disasters starting with the 1963 Vajont landslide and tidal wave flood disaster in Northeast Italy and ending with Hurricane Katrina in August of 2005 (see Table A3 for further details about individual studies). From those studies we present in Table 3 findings from key studies.

Prevalence of PTSD—Consistent with previous observations (Norris *et al.* 2002; Galea *et al.* 2005) we note that the prevalence of PTSD documented in the aftermath of natural disasters is often lower than the rates documented after human-made and technological disasters. Large-scale natural disasters affect broad geographic areas, leading investigators to study mixed populations that often include both direct and indirect victims (Thompson *et al.* 1993; Shannon *et al.* 1994; Carr *et al.* 1995). Consequently, as previously suggested (Galea *et al.* 2005), the relatively low prevalence of PTSD among populations studied after natural disasters compared to human-made or technological disasters may stem from a lower average dosage of exposure among people exposed to the disaster. This is supported by a study of the Turkey earthquakes that showed a higher prevalence of PTSD closer to the epicenter compared to 100 km away (Basoglu *et al.* 2004). Overall studies of natural disasters report PTSD prevalence ranging from 3.7% (Canino *et al.* 1990) to 60% (Madakasira & O'Brien, 1987) in the first 1–2 years after the disaster, with most studies reporting prevalence estimates in the lower half of this range (Norris *et al.* 2004; Liu *et al.* 2006; Parslow *et al.* 2006). However, higher prevalence estimates of PTSD have been reported in specific groups such as clinical samples (Livanou *et al.* 2002; Soldatos *et al.* 2006) and populations in areas heavily affected by the disaster (Najarian *et al.* 2001; Finnsdottir & Elklit, 2002). Moreover, a study based on a community sample following the Turkey earthquakes estimated the prevalence of PTSD to be 11.7% even 3 years after the disaster (Onder *et al.* 2006).

Few studies examined PTSD among first responders, particularly firefighters and police officers in the wake of natural disasters (McFarlane, 1988; McFarlane & Papay, 1992; Spurrell & McFarlane, 1993; Chang *et al.* 2003; Ozen & Sir, 2004; Armagan *et al.* 2006; CDC, 2006). Those that did, generally showed high-prevalence estimates of PTSD. For

example, 21% of firefighters responding to the 1999 Chi-Chi earthquake in Taiwan (Chang *et al.* 2005) and 22% of firefighters responding to Hurricane Katrina in 2005 (CDC, 2006) had PTSD at 5 months and 2–3 months after the disaster, respectively.

A number of studies investigated PTSD among children following natural disasters. In the aftermath of the 1988 Armenian earthquake, 95% of the children from a severely exposed city and 26% of the children from a mildly exposed city had severe levels of PTSD symptoms 1.5 years after the event (Goenjian *et al.* 1995). The prevalence found among the mildly exposed children is comparable to the prevalence of PTSD among children exposed to the 1989 Loma Prieta earthquake (Bradburn, 1991), 1992 Hurricane Andrew (Vernberg *et al.* 1996), 1999 Hurricane Floyd (Russoniello *et al.* 2002), 2002 Typhoon Rusa (Lee *et al.* 2004), and the 2004 earthquake and tsunami (Neuner *et al.* 2006).

Course of PTSD—Few studies have examined the course of PTSD after natural disasters. A longitudinal study of firefighters who participated in rescue efforts after the 1983 Australian bushfire found that more than one-fifth of the sample (21%) had persistent PTSD over a 2-year period (McFarlane, 1988). This study extended extant knowledge about PTSD from human-made disasters by examining multiple patterns of PTSD, including acute onset (9.2%) and delayed onset (19.7%) PTSD. In parallel to findings from studies of human-made disasters, some longitudinal research of natural disasters documented a decline in PTSD prevalence over time (Carr *et al.* 1997a, b; van Griensven *et al.* 2006); however, some studies also showed an increase in PTSD prevalence over time. For example, a cohort study of residents of Dade County, Florida exposed to Hurricane Andrew in 1992 found that the prevalence of PTSD increased from 26% to 29% between 6 and 30 months after the disaster. More specifically, this study showed that while intrusion and arousal symptoms declined over time, avoidance symptoms increased (Norris *et al.* 1999). Similarly, an increase in prevalence of PTSD was observed between 3 and 9 months after the 1998 Zhangbei-Shangyi earthquake in China (Wang *et al.* 2000).

Multiple disaster aggregate studies

We identified 13 studies that included samples from more than one disaster (see Table A4 for a detailed description of these studies). While some studies investigated samples from the same disaster type, such as survivors from multiple terrorist attacks in France (Abenhaim *et al.* 1992; Verger *et al.* 2004), survivors from earthquakes in Santiago, Chile, and California, USA (Durkin, 1993), and survivors from the Oklahoma City bombing and the Nairobi bombing (North *et al.* 2005), other studies focused on survivors of different types of disasters, including a study that included subjects exposed to either a plane crash, tornado or shooting spree (Smith *et al.* 1993) and a study that included persons exposed to either a plane crash or train collision (Chung *et al.* 2005). One advantage of these studies is that they used the same instrument in different samples, facilitating comparisons. One study comparing different populations exposed to terrorist bombings (North *et al.* 2005) found lower rates of PTSD (22% among males and 40% among females) among survivors 6 months after the Oklahoma City bombing compared to survivors 8–10 months after the Nairobi bombing (34% among males and 49% among females). Only one study assessed the course of PTSD over time. Interestingly, while the prevalence of PTSD decreased over time

among earthquake survivors, it increased among survivors of political abuse between 1.5 and 4.5 years after exposure (Goenjian *et al.* 2000).

Discussion

Classification of disasters

The trauma literature has yet to provide a consistent distinction between individual traumatic events and disasters (which arguably are best considered as collectively experienced, or mass traumas), leaving the question what qualifies a traumatic event to meet criteria for a disaster open (Quarantelli, 1995). Earlier work in sociology and hazard and risk management has attempted to address this problem (Quarantelli, 1998; Mileti, 1999). It has been suggested that an incident is a disaster if it is extremely harmful and disruptive (Tierny *et al.* 2001). However, definitions of 'extremely' vary and there remains no universal or even widely used definition of disasters making for inconsistencies between studies in which events are considered as disasters by some studies, but not by others. For example, while massive loss of life seems to be central for an event to be classified as a disaster, some of the most studied disasters (e.g. Three Mile Island) did not result in any loss of life. Similarly, while the literature is generally unified in classification of events as disasters if they are disruptive events and restricted in time (e.g. plane crash, flood, fire), the status of ongoing repeated exposure to massive interpersonal trauma (e.g. Holocaust, ongoing ethnic cleansing, and genocide) is not clear. Although this review was not committed to a single definition of disaster, we suggest that a definitive definition of a disaster would need to account for at least two dimensions: scale and outcome (Norris *et al.* 2002; Galea & Resnick, 2005; Neria *et al.* 2006b). Hence, an incident may be appropriately classified as a disaster if its scale is 'large', i.e. it has affected a considerable number of people regardless of loss of life, and its consequences are 'significant', i.e. it has resulted in quantifiable mental and/or physical health outcomes among the affected population.

Measurement of PTSD—The classification of PTSD has been modified since it was first introduced in DSM-III in 1980. For example, in DSM-IV the definition of the A criterion was changed to include both exposure (A1) and the subjective response to the exposure (A2), and specifically whether the exposed person experienced horror and helplessness facing the exposure. Notably, compared to previous DSM editions, the recent DSM-IV definition of exposure is broader and provides a list of potential examples, which includes a sudden death of a close relative. Changes in definitions of PTSD may influence rates, correlates and course of PTSD as documented across studies over time. Moreover, while PTSD is a clinical condition, regularly assessed by clinical interviewers, many post-disaster studies have utilized screening instruments administered by laypersons or well trained research assistants. Although most screening instruments showed sufficient psychometric properties there is no evident agreement in the PTSD literature in general and the disaster literature in particular about what is the best screening instrument that can be reliably administered by laypersons in the aftermath of disasters. Similarly, there is a lack of consensus of whether a face-to-face interview is needed for a reliable assessment of post-disaster psychopathology or alternatively whether telephone-based (Galea *et al.* 2002) or

internet-based (Schlenger *et al.* 2002; Silver *et al.* 2002; Neria *et al.* 2007) surveys are similarly qualified to assess disaster-related PTSD.

Exposure and post-disaster PTSD—The role of event exposure in the development of PTSD has received considerable attention across studies. A wide range of potential types of exposure has been studied. Importantly, the risk of PTSD has been repeatedly shown to be associated with severity of exposure to the disaster across numerous studies (Durham *et al.* 1985; Green *et al.* 1990, 1994; Abenhaim *et al.* 1992; Joseph *et al.* 1994; Tyano *et al.* 1996; Cwikel *et al.* 2000; Tucker *et al.* 2000; Sungur & Kaya, 2001; Galea *et al.* 2002; Neria *et al.* 2006c). As we already noted above, the prevalence of PTSD is higher among persons who were directly exposed to the disaster (often referred as the 'victims' of a disaster in disaster studies), lower among rescue workers and first responders, and yet even lower in the general population. These three types of samples studied are likely to represent different levels of severity of disaster exposure, with direct victims having the highest exposure and associated PTSD prevalence and people in the general population having the lowest levels of exposure and PTSD prevalence. Studies that focused on several groups, with different levels of exposure enabled direct comparisons between people with different levels of disaster exposure. For example, studies that assessed areas close and distant from a disaster site have repeatedly showed that the prevalence of PTSD is higher among persons closer to the disaster than among those who are in distant areas (Havenaar *et al.* 1997; Schlenger *et al.* 2002; Jordan *et al.* 2004; Neria *et al.* 2006c).

Disasters frequently involve populations which are not directly exposed to the trauma such as people who experience loss of family members or friends or colleagues, or those who suffered property loss, were forced to relocate, or were exposed to the event through the media. This raises two critical points about the burden and the nature of post-disaster psychopathology. First, the mental health consequences of such events among those indirectly exposed to a disaster may well exceed the mental health consequences among those who were directly exposed or close to the disaster epicenter. Although, as we note in this review, there is little question that there is a dose–response relationship between the extent of trauma and the mental health burden of disasters, this relation may not necessarily mean that the principal population mental health burden of a disaster is among those who were most directly affected by the disaster (Galea *et al.* 2005). Second, the extant post-disaster literature provides an opportunity to assess the relation between indirect exposure to a trauma and risk of PTSD. The literature reviewed here is mixed on this latter point. For example, while Neria and colleagues, in their study of primary-care patients exposed to the 9/11 terrorist attacks in Northern Manhattan, found that indirect exposure to the attacks on the World Trade Center was not associated with risk of PTSD (Neria *et al.* 2006b), other studies conducted in national samples after the same attacks (Schlenger *et al.* 2002; Silver *et al.* 2002) and in distant areas after the Oklahoma City bombing (Pfefferbaum *et al.* 1999) provide evidence for a probable relation between indirect exposure and PTSD. These findings may challenge one of the core criteria of PTSD according to DSM-IV (Criteria A). Most of the persons interviewed in post-9/11 national surveys reported an indirect exposure to the attacks, mostly through TV broadcasts. The inclusion of this type of exposure is certainly new to the discipline of trauma research and deserves further attention (Ahern *et al.*

2002). The events of 9/11 and the recent terrorist attacks in Europe and Asia, as well as recent major natural disasters, all provide an opportunity to examine whether direct exposure to trauma is a necessary condition for PTSD, or whether alternatively, an interaction between a 'sufficient' level of exposure (even indirect), and certain risk factors (e.g. genetic susceptibility) can result in true post-exposure psychopathology.

Burden of PTSD in the aftermath of disasters—A large body of research conducted after disasters in the past three decades suggests that the burden of PTSD among persons who were exposed to disasters is significant. The post-disaster PTSD literature suggests that there are fairly consistent estimates of PTSD that can be expected in the first year after exposure among specific risk groups. Specifically, the prevalence of PTSD among direct victims of disasters ranges between 30% and 40%; the range of PTSD prevalence among rescue workers is lower, ranging between 10% and 20%, while the range of PTSD rates in the general population is the lowest and expected to be between 5% and 10%. The most consistently documented determinants of the risk of PTSD across studies are measures of the magnitude of the exposure to the event. Particularly, degree of physical injury, immediate risk of life, severity of property destruction and frequency of fatalities are especially predictive of high rates of PTSD. Therefore, across samples and studies, survivors and direct victims of a disaster are consistently shown to have increased risk of PTSD than persons in the general population, regardless of the national or political consequences of a particular disaster. Aside from the observation of the centrality of trauma exposure as a determinant of PTSD, as previously noted (Galea *et al.* 2005), many post-disaster studies vary considerably in the range of correlates tested and the model-building techniques used to assess statistically significant correlates, suggesting the need for caution when drawing inferences about associations of PTSD with correlates in post-disaster research. For example, while it is generally true to suggest that direct victims or females are at higher risk for PTSD in the wake of disasters, it is sometimes unclear whether the lack of significant associations between proximity of exposure and PTSD, or gender and PTSD are due to specific disaster type and its consequences or the mediating role of other variables (e.g. relationship with deceased, social support) which obscure the exposure–PTSD and gender–PTSD associations in multivariate analyses.

Most of the studies in the wake of disasters have used cross-sectional designs. The relatively small body of research on the course of PTSD over time is complicated by major methodological limitations. Variability in sample types, sample sizes, point of times of assessments, screening or diagnostic instruments, reduction is sample size over time, are only some of the differences noted between studies assessed here, limiting comparability and the drawing of definitive inference about the course of PTSD.

Limitations

The aim of the current review was to build on and update previous work and to systematically review up-to-date evidence regarding post-disaster PTSD. Several decisions made in the conduct of this review need to be borne in mind when interpreting the results we present here. First, we opted to include a wide range of PTSD studies, with notable differences in sampling and measurements methods. Consequently, we included studies with

different levels of research quality. Moreover, the studies reviewed here come from different disciplines and frequently present results quite differently, limiting our capacity to employ uniform principles of study inclusion. Second, there may be cross-cultural factors that limit the validity of instruments applied in different countries when these instruments were primarily designed to assess psychopathology in developed countries, or majority populations. This suggests caution in interpreting data from studies across countries. Third, this review summarizes the published English-language peer-reviewed literature. Hence, we do not here provide information about PTSD across the entire universe of disasters that do happen worldwide. There is likely a substantial imbalance between studies that are carried out and where disasters do actually occur. Cross-cultural differences between rich and poor countries may mean that the epidemiology of PTSD in less rich countries may be different than that documented here, arising from the available literature. Fourth, given the complexity of defining traumatic event exposure, as noted above, we are not able, in this review, to systematically shed much light on the conditional probability of PTSD differential on specific traumatic event exposure. Fifth, following previous lines of work (Brewin *et al.* 2000; Galea *et al.* 2005) we decided to include findings of studies which specifically assessed PTSD in the wake of disasters. We did not include studies of depression, complicated grief or substance abuse in the wake of disasters and as such, we may be limiting our appreciation of the centrality of co-morbidity to the burden and trajectory of PTSD after disasters. Similarly, our review did not describe studies which assessed changes in service utilization or mental health treatment-seeking and the relations between such behaviors and PTSD; service utilization and mental health treatment-seeking are of considerable interest to public mental health planners and not including consideration of these subjects may be underrepresenting the social and economic burden of PTSD after disasters. Service utilization and treatment may fruitfully be considered as subjects of study in future work.

Conclusion and implications for future disaster research

Several high-profile disasters during the past three decades, combined with improvements in communication and transportation enabling access to areas where disasters occur, have enabled mental and public health researchers, around the globe, to examine various aspects of the associations between exposure to disasters and PTSD. The evidence suggests that the burden of PTSD among populations exposed to disasters is substantial. Post-disaster PTSD is associated with a range of correlates including sociodemographic and background factors, event exposure characteristics, emotional states, social support factors and personality traits. Relatively small numbers of studies have employed longitudinal assessments enabling documentation of the course of PTSD.

However, the review of the literature reveals that several areas remain underexplored and limit the extent to which the wealth of available data may fruitfully guide intervention. We hope that future research will provide better guidance with regard to at least two key questions. First, the course of PTSD after disasters remains unclear. Our review indicates that in order to provide reliable estimates of course of post-disaster psychopathology and to enable comparisons between studies, substantial progress is needed in all areas of measurement (e.g. instruments and methods of administration), time-frames for follow-ups

and sampling procedures. Notably, a clearer understanding of the trajectory of PTSD and the determinants of this trajectory, including the groups among whom PTSD resolves spontaneously, those among whom it persists in the long-term, and those with more complicated lapsing/relapsing pattern will be invaluable in guiding the implementation of effective intervention strategies. Second, future development of interventions would benefit from work that more explicitly and clearly identifies populations at risk (e.g. minorities, elderly, children, direct victims, first responders). Our review suggests that while it is safe to expect a significant decline in psychopathology in the general population, a number of groups remain highly vulnerable to PTSD in the short-term and may well have a different long-term course of PTSD and bear the brunt of the social and economic consequences associated with this condition. The literature to date has yet to comprehensively discuss what the psychological, cultural, and biological factors might be that shape vulnerability to traumatic events. It is our view that such progress is critical to highlight the needs of high-risk populations, and is necessary for tailoring appropriate interventions to the right people in the wake of disasters.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Summary of key studies assessing post-traumatic stress after human-made disasters

			Prevalence					
Study	**Sample type**	**Sample size (*n*)**	**T1[a]**	**%**	**T2**	**%**	**T3**	**%**
1992 Los Angeles County civil disturbances (29 April 1992)								
Hanson *et al.* (1995)[b]	Community	*n*=1200 in LA County	6–8 months	4.1%				
2001 Terrorist attacks, New York City and Washington, DC (11 September 2001)								
Galea *et al.* (2002)[b]	Community	*n*=988 in Manhattan	5–8 weeks	7.5%				
Schlenger *et al.* (2002)[b]	Community	*n*=2273 nationally	1–2 months	11.2% in NYC, 4.3% nationally				
Nandi *et al.* (2005)[b]	Community	*n*=2001 in NYC	4 months	7.4%				
Hoven *et al.* (2005)[b]	Community	*n*=8236 NYC students	6 months	10.6%				
Galea *et al.* (2004)[b]	Community	*n*=2616 in NYC metropolitan area	6–9 months	5.2% (non-Hispanics), 14.3% (Dominicans), 13.2% (Puerto Ricans), 6.1% (other Hispanics)				
Stuber *et al.* (2006)[b]	Community	*n*=2752 in NYC metropolitan area	6–9 months	6.5% (women), 5.4% (men)				
Silver *et al.* (2002)[c]	Community	*n*=933 nationally at 2 months, 787 nationally at 6 months	2 months	17.0%	6 months	5.8%		
Galea *et al.* (2003)[d]	Community	*n*=988 in Manhattan at 1 month, 2001 in NYC at 4 months, 1570 in NYC at 6 months	1 month	7.5%	4 months	1.7%	6 months	0.6%
Adams & Boscarino (2005)[b]	Community	*n*=2368 in NYC	1 year	4% (Whites), 5.5% (African Americans), 5.3% (Dominicans), 8.4% (Puerto Ricans), 5% (other Latinos)				
Neria *et al.* (2006c)[b]	Mixed	*n*=930 NYC primary care patients	7–16 months	10.2%				
Miguel-Tobal *et al.* (2006)[b]	Community	*n*=1589 in Madrid	1–3 months	2.3%				

[a] Timing of assessment(s) after the disaster.

[b] Cross-sectional study design.

[c] Prospective cohort study design.

[d] Serial cross-sectional study design.

Table 2

Summary of key studies assessing post-traumatic stress after technological disasters

			Prevalence	
Study	**Sample type**	**Sample size (*n*)**	**T1[a]**	**%**
1986 Chernobyl nuclear reactor accident, Ukraine (26 April 1986)				
Havenaar *et al.* (1997)[b]	Community	*n*=1617 from Gomel (near accident) and *n*=1427 from Tver (far from accident)	6.5 years	2.4% in Gomel, 0.4% in Tver
1989 Exxon Valdez oil spill, Alaska (24 March 1989)				
Palinkas *et al.* (1993)[b]	Community	*n*=593 from variably affected communities	1 year	9.4%
2001 Chemical factory explosion, Toulouse, France (21 September 2001)				
Godeau *et al.* (2005)[b]	Community	*n*=1477 students from directly and indirectly exposed communities	9 months	44.6% (directly exposed 11- to 13-year-olds), 28.5% (directly exposed 15- to 17-year-olds), 22.1% (indirectly exposed 11- to 13-year-olds), 4.4% (indirectly exposed 15- to 17-year-olds)

[a] Timing of assessment(s) after the disaster.

[b] Cross-sectional study design.

Table 3

Summary of key studies assessing post-traumatic stress after natural disasters

			Prevalence			
Study	**Sample type**	**Sample size (*n*)**	**T1[a]**	**%**	**T2**	**%**
1989 Newcastle earthquake, Newcastle, Australia (28 December 1989)						
Carr *et al.* (1995)[b]	Community	*n*=3007 in Newcastle	6 months	18.3% among highly exposed		
Carr *et al.* (1997b)[c]	Community	*n*=845 in Newcastle	6 months	11% (low exposure), 19% (disruption), 23% (threat), 40 % (disruption and threat)	2 years	3% (low exposure), 8% (disruption), 13% (threat), 19% (disruption and threat)
1998–1999 Floods, Hunan Province, China (1998–1999)						
Liu *et al.* (2006)[b]	Community	*n*=33 340	Within 2.5 years	8.6%		
1999 Turkey earthquakes, Marmara region, Turkey (17 August 1999 and 12 November 1999)						
Basoglu *et al.* (2004)[b]	Community	*n*=530 near epicenter, 420 from 100km away	14 months	23% (near epicenter), 14%(100km away)		
Onder *et al.* (2006)[b]	Community	*n*=683 near epicenter	36 months	19.2% (36 month prevalence), 11.7% (current)		
1999 Mexican floods and mudslides, Mexico (October 1999)						
Norris *et al.* (2004)[c]	Community	*n*=561 from two affected communities	6 months	24%		
2003 Wildfire disaster, Australia, 18 January 2003						
Parslow *et al.* (2006)[c]	Community	*n*=2085	3–18 months	5%		
2004 Earthquake and tsunami, Asia (26 December 2004)						
van Griensven *et al.* (2006)[c]	Community	*n*=371 displaced and 690 non-displaced from Phang Nga, Krabi, and Phuket provinces of Southern Thailand	2 months	11.9% (displaced in Phang Nga), 6.8% (non-displaced in Phang Nga), 3.0% (non-displaced in Krabi and Phuket)	9 months	7.0% (displaced in Phang Nga), 2.3% (non-displaced in Phang Nga)

[a]Timing of assessment(s) after the disaster.

[b]Cross-sectional study design.

[c]Prospective cohort study design