The Epidemiology of Post-Traumatic Stress Disorder after Disasters

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Abbreviations: DSM, Diagnostic and Statistical Manual of Mental Disorders; PTSD, post-traumatic stress disorder.

INTRODUCTION

Traumatic experiences are relatively common. More than two thirds of persons in the general population may experience a significant traumatic event at some point in their lives, and up to one fifth of people in the United States may experience such an event in any given year (1–5). Although comparable international data are limited, large proportions of populations in many countries have been exposed to terrorism, forced relocation, and violence, which suggests that the overall prevalence of exposure to traumatic events worldwide may be even higher than that in the United States (6, 7).

Disasters (e.g., floods, transportation accidents) are traumatic events that are experienced by many people and may result in a wide range of mental and physical health consequences (8). In one survey of US residents, 13 percent of the sample reported a lifetime exposure to natural or human-generated disaster (9). In the National Comorbidity Survey, 18.9 percent of men and 15.2 percent of women reported a lifetime experience of a natural disaster (4). Post-traumatic stress disorder (PTSD) is the most commonly studied and probably the most frequent and debilitating psychological disorder that occurs after traumatic events and disasters (8, 10).

The growing threat of terrorism worldwide has heightened our awareness of disasters as a potentially important determinant of population health and suggests a pressing need both to identify key areas of consensus in post-disaster research and to highlight areas that require additional study (11). It is our purpose in this review to contribute to this overall goal by comprehensively and systematically assessing the epidemiologic evidence about PTSD after disasters.

REVIEW OF THE LITERATURE

We limited this review to studies conducted between 1980, when PTSD was first codified as a disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM), Third Edition (DSM-III) (12), and 2003. Although we limited this review to studies conducted after 1980, there is a substantial body of literature preceding that date, and this research had a profound influence on the empirical work that is reviewed here. Much of this work sought to understand the psychological sequelae of exposure to traumatic events among persons who had fought in or been the victims of war and violent conflict (13). Early terms that were used to describe the psychological symptoms observed after traumatic events included “nervous shock” (14), “shell shock” (15, 16), “traumatic neurosis” (17), and “rape-related fear and anxiety” (18).

Because a number of studies published since 1980 have assessed disasters retrospectively, this review covers disasters occurring over a 40-year period. The earliest disaster included in our review is a 1963 landslide and flood that took place in northeastern Italy (19), and the most recent disaster included is the September 11, 2001, terrorist attacks in New York City (20–32). We identified the published literature using the MEDLINE, PsychINFO, and PILOTS databases, covering both US and international studies that assessed the epidemiology of PTSD after disasters. We also retrieved articles from key reviews (8, 33) that were not included in our own literature review. This review was not intended to cover the full range of consequences of disasters or the epidemiology of PTSD after individual traumatic experiences; we refer the reader to recently published comprehensive reviews of these topics (8, 33, 34). We limited ourselves to studies that either explicitly
assessed PTSD as a disorder or used DSM criteria to assess post-traumatic stress symptoms; we did not include several other studies that assessed only psychological symptoms or other psychiatric disorders after disasters. Keywords and terms used for the search included primarily “post-traumatic stress disorder,” “PTSD,” “disaster,” “trauma,” and “mental health.”

Classifying a traumatic event as a disaster is not always straightforward, and the distinction between individual traumatic experiences and disasters may be unclear. A substantial body of literature, particularly in the fields of sociology and hazard and risk management, has conceptualized disasters and their consequences (35). Much of this work has focused on disasters that are severely damaging and disruptive (36). Different definitions of disasters, at times conflicting, have been offered both by official agencies and by scientists in the field (37, 38). In reviewing the epidemiologic literature about mental health after disasters there are particular challenges that make the use of a single such definition limiting. For example, while commercial airplane crashes are nearly always considered disasters in the literature, personal airplane crashes (which may result in the death of several persons) seldom are. Similarly, although many disaster definitions are predicated, at least in part, on loss of life, some of the most important and best-documented disasters in the past 20 years (e.g., the Three Mile Island nuclear reactor accident (39)) did not involve loss of life. Therefore, for the purposes of this review, we deferred to the characterization of the event in the peer-reviewed literature and considered an event a disaster if it was considered a disaster by the authors of the papers reviewed.

It has already been documented that human-made/technological disasters may have different and more marked consequences than natural disasters (8). As such, we present all findings within these two broad categories of disasters separately. This allows us to draw general inferences from relatively comparable exposures. Within each category, we document findings about the prevalence, correlates, and course of PTSD. A total of 192 references that addressed the epidemiology of PTSD after disasters were included in this review; among these, 106 pertained to technological/natural disasters and 86 pertained to natural disasters.

METHODOLOGICAL ISSUES

In evaluating studies of the epidemiology of PTSD after disasters, the following methodological issues must be considered: 1) the definition and assessment of exposure; 2) the comparability of PTSD assessments across studies; 3) the assessment of PTSD prevalence and incidence; and 4) the cross-disaster comparability of correlates and course.

Complex assessment of exposure

Disasters are mass traumatic events that involve multiple persons and are frequently accompanied by loss of property and economic hardship on a large scale. As such, there may be a wide range of people who may be considered “victims” of a disaster, including those who nearly escape death, those who are injured, family members of the deceased, and those who witness a catastrophic event. From an epidemiologic standpoint, this range of potential disaster exposures complicates both cross-study comparisons and extrapolation of observations from one disaster context to another. It is difficult to avoid this complication in postdisaster epidemiology, since disasters and exposures to them vary dramatically, even when the disasters are similar. For example, schoolchildren exposed to the American Embassy bombing in Nairobi, Kenya, in 1998 could have seen or heard the event, had a parent who died in the event, or simply been in the vicinity of the incident (40). In contrast, after a terrorist bombing of a bus, exposed persons could include those who were on the bus itself, those who were entering or exiting the bus at the time of the bombing, or the families of victims (41). In the context of large disasters such as the September 11, 2001, terrorist attacks in New York City, it is plausible that all residents of a particular city may be somewhat “exposed” to the disaster, though this clearly introduces a broad range of possible individual exposures (11, 30). Therefore, in reviewing cross-disaster comparisons of studies, adequate attention must be paid to the specific definition of the exposed group being studied.

Comparability of different PTSD assessment methods

PTSD was first recognized as a diagnostic entity in 1980, when it was included in the DSM-III (12). PTSD was classified as an anxiety disorder, and diagnostic criteria for PTSD were introduced. These criteria included a gateway criterion (criterion A) which suggested that certain traumas were “eligible” traumas and that only these events were capable of producing PTSD. The DSM-III diagnosis of PTSD also required the presence of one criterion B symptom pertaining to reexperiencing the trauma, one criterion C symptom pertaining to numbing or decreased responsiveness to the outside world, and two criterion D symptoms pertaining to hyperarousal. Since the introduction of PTSD as a diagnostic category, diagnostic criteria for PTSD have been changed twice. The criteria were expanded in the Revised Edition of the DSM-III (DSM-III-R) (42). The criterion A definition was maintained relatively unchanged, and the required B, C, and D criteria were expanded from four symptoms to seven symptoms. A DSM-III-R diagnosis of PTSD required the individual to have one criterion B reexperiencing symptom, three criterion C avoidance symptoms, and two criterion D hyperarousal symptoms. In addition, a duration criterion of “at least 1 month” was added as criterion E. The Fourth Edition of the DSM (DSM-IV) (43) changed the definition of criterion A. The new definition includes criterion A1 (exposure to a traumatic event) and criterion A2, which is a subjective assessment of the criterion whereby the person reports experiencing horror or helplessness at the trauma. DSM-IV criterion A is broader than that in DSM-III-R and provides a list of examples that is more inclusive. For example, such events as the sudden death of a close relative could potentially qualify as criterion A1 events under the DSM-IV definition. However, less extreme stressors (e.g., an expected death of a relative) are explicitly excluded.
Therefore, in comparing studies that have assessed PTSD across studies over the past 40 years, it is important to keep in mind that changing definitions of PTSD may affect the documented prevalence, correlates, and course of PTSD. Web table 1 (posted on the documented prevalence, correlates, and course of PTSD. In addition, although the diagnosis of PTSD (as with all psychiatric disorders) is ideally made by a trained mental health professional following the criteria established in the DSM, many postdisaster studies make use of structured screening tools that have been shown to be valid instruments for the assessment of PTSD either by clinically trained persons or by laypersons. However, with the possible exception of the Clinician Administered PTSD Scale (44) and the Structured Clinical Interview for DSM-III-R (45), which are both clinician-administered interviews, there is no consensus in the PTSD literature about the best instrument for lay administration. The most commonly used instruments in the PTSD research literature are the Impact of Event Scale (46) and the Diagnostic Interview Schedule (47). Newer measures like the PTSD Check List (48), the National Women’s Study PTSD module (49), and the Civilian Mississippi Scale for PTSD (50, 51) have been adapted from some of the older instruments and validated and are becoming more common in PTSD research. Although a full discussion of the implications of the use of different instruments is beyond the scope of this review, we note that differing sensitivities and specificities of screening instruments and their potential role in shaping assessments of PTSD have been well documented (52–55).

PTSD prevalence and incidence

In most instances, disasters take place over a short period of time. For example, a tornado may pass through a town, leaving substantial devastation in its wake. As such, postdisaster studies may be particularly well-suited to providing incidence estimates of PTSD in their aftermath. However, very few studies are designed to follow persons who had been screened for PTSD predisaster to ensure that assessment of incidence is carried out among persons with no previous PTSD. Therefore, although some studies refer to PTSD “incidence,” in most instances this is better considered to be PTSD prevalence at a given postdisaster time point; we use the term “prevalence” to discuss postdisaster PTSD burden throughout this review, except in cases where incidence was clearly calculated among persons without predisaster PTSD.

There are two further complications in considerations of PTSD prevalence after disasters. First, in some but not all studies, investigators explicitly assess PTSD related to the disaster. As such, it can be argued that even if persons had preexisting PTSD linked to a different traumatic experience, the PTSD being documented is incident postdisaster PTSD. However, this obscures the fact that the clinical manifestation of the disorder is the same, irrespective of qualifying traumatic event exposure. Second, the postdisaster PTSD literature is predominantly concerned with assessing PTSD at any time between a particular disaster and the time of the assessment itself. These assessments are typically carried out during the first year after a disaster (41, 56–61), with notable exceptions, particularly in studies where disaster victims have been assessed years and sometimes decades after the disaster occurred (62–64). Therefore, the prevalence of PTSD reported in most studies is properly understood as a period prevalence. However, a few studies have documented “current” PTSD (frequently PTSD prevalence in the previous month or the previous 6 months) (24, 65) which may not be directly comparable to the period prevalences documented in other studies. Unfortunately, the peer-reviewed postdisaster literature is frequently unclear about both the period of PTSD assessment and whether the assessment instruments explicitly linked PTSD to the disaster event. Therefore, it is important to be cautious when interpreting reported postdisaster PTSD prevalence. Although, because of space constraints, we do not explicitly discuss different time frames of assessment of PTSD postdisaster for all of the studies discussed in our review, these considerations guided the observations made here. Web tables 2 and 3 provide more comprehensive detail about papers reviewed to allow for cross-study comparison.

Cross-disaster comparability of PTSD correlates and course

The overwhelming majority of studies that have assessed postdisaster PTSD have used cross-sectional study designs. However, there is substantial heterogeneity in study analysis. Although regression modeling is frequently used to document important correlates of PTSD, the range of correlates tested and the model-building techniques used to assess statistically significant correlates vary dramatically between studies. In addition, model-building techniques are not specified in a substantial proportion of published studies, suggesting a need for caution when drawing general inferences about the universe of important correlates of PTSD after disasters. For example, although we can deduce with some certainty that women are at higher risk of PTSD after disasters (as discussed below), it is unclear whether the lack of a significant gender-PTSD association in many studies’ final analyses means that 1) in specific disaster contexts, gender is not an important correlate of PTSD or 2) the inclusion of potential mediators (e.g., social support) obscures the gender-PTSD relation in multivariable analyses.

The study of the course of PTSD is complicated both by the relatively small number of longitudinal studies that have been designed to test the course of PTSD and by inconsistent assessment in the studies that have documented the course of PTSD. For example, in one assessment of PTSD in a cohort study of persons exposed to a mass shooting in Killeen, Texas, in 1991, PTSD prevalence was documented 6–8 weeks and 13–14 months after the incident (66). While it is possible to directly compare these findings with those from a study of PTSD conducted after a 1992 courthouse shooting in Missouri that also employed similar assessment time frames (67), it is less feasible to compare these findings with those of a cohort study of firefighters exposed to bush fires in southeastern Australia in 1983 who
were assessed 4, 11, and 29 months after the incident (68). In the absence of sufficient numbers of studies that have replicated methods and timing of postdisaster PTSD assessment, inference about the course of PTSD after disaster is necessarily limited.

FINDINGS

On the Epidemiologic Reviews website (http://epirev.oupjournals.org/), we present findings from human-made/technological disasters (Web table 2) and natural disasters (Web table 3) separately. Web table 4 is a summary table that presents, for easy reference, findings on the prevalence and course of PTSD from studies that presented data on these two parameters. While we intended our tables to be comprehensive and included in them, for reference, all relevant epidemiologic studies of postdisaster PTSD that we identified, we do not discuss all of those studies in this review. Instead we focus on general observations from these studies for the purpose of drawing meaningful overall inferences.

Studies of human-made or technological disasters

Prevalence and incidence. It is useful to consider the prevalence of PTSD as documented in multiple studies after human-made/technological disasters within specific population groups that are typically studied after these incidents. Here we present findings from studies concerning adult victims of disasters, rescue workers, the general population, and children, respectively.

Most studies have focused on adults who were direct victims of the disaster. This includes adults who survived the 1989 air disaster in Kegworth, United Kingdom, in which a Boeing 737 jet crashed into an embankment, killing 47 persons on board (69); commercial fishers from a community near the 1989 Exxon Valdez oil spill in Alaska (70); and persons who were in the Murrah Federal Building during the 1995 terrorist bombing in Oklahoma City, Oklahoma (10). Most investigations of adult victims of these disasters suggested a high prevalence of PTSD at first assessment, generally within the first year after the disaster. The prevalence of PTSD in the first year after human-made/technological disasters has been documented to range between approximately 25 percent and 75 percent. For example, the prevalence of PTSD was 29 percent among persons exposed to the mass shooting episode in Killeen, Texas, in 1991 (71) and among Indianapolis, Indiana, Ramada Inn employees who were on-site when a fighter jet crashed into the hotel in 1987 (72). At the other extreme, the prevalence of PTSD was 73 percent among survivors of the Piper Alpha oil rig disaster in 1988, where a gas leak induced an explosion and fire took the lives of 167 men (73). All three of these assessments were carried out during the first 3 months after the disaster in question. Most studies of adult survivors of disaster have found a PTSD prevalence of 30–60 percent after a disaster (10, 70, 74–78).

Among persons involved in rescue efforts after disasters, the prevalence of PTSD ranges from approximately 5 percent to 40 percent (79–87)—lower than the prevalence documented among direct survivors of disasters. Most studies have found a PTSD prevalence of 5–20 percent among rescue workers during the first year after a disaster (88, 89). A few studies have compared samples of rescue workers and persons directly affected by a disaster, allowing direct comparison between the two groups (89, 90). For example, in a study carried out after the 1995 Oklahoma City bombing, the prevalence of PTSD in the first 34 months after the bombing among firefighters (13 percent) was lower than that among those primarily exposed (23 percent) (89).

Studies that have documented the prevalence of PTSD in the general population after disasters have uniformly documented a lower prevalence of PTSD in the general population than among direct victims and rescue workers (11, 25, 30, 65, 91, 92). The prevalence of PTSD in the general population during the first few years after a disaster has been shown to range from approximately 1 percent to 11 percent (30, 91, 92). For example, in a cross-sectional study of 13 Alaska communities after the Exxon Valdez oil spill, the overall population prevalence of PTSD in the first year after the accident was 9.4 percent (92). In two different studies of the general New York City population after the September 11, 2001, terrorist attacks, the prevalence of PTSD was 7.5 percent in a telephone-based sample (24) and 11.2 percent in a World Wide Web-based sample (30) 1–2 months after September 11. The latter study also found an overall 4.3 percent prevalence of PTSD in the US population after the attacks (30). A study that assessed the prevalence of PTSD among two general populations in the former Soviet Union, one closer to the Chernobyl nuclear reactor site and the other further away from the reactor, found that 6.5 years after the 1986 accident, the prevalence of PTSD in the population nearer the site was 2.4 percent, as compared with 0.4 percent in the population 500 miles (800 km) away from the site (91). Studies that have included both samples of direct victims of disaster and persons in the general population have confirmed that the prevalence of PTSD is higher in the former type of group (72, 76, 77). For example, a cohort study of schoolchildren who survived the 1988 crash of the cruise ship Jupiter with another ship in Greece and friends or acquaintances from their school, who were not directly involved in the disaster, showed that the prevalence of PTSD was 51.5 percent among the survivors at some time during follow-up, as compared with 3.4 percent among other children in the school (77). There is a substantial body of literature that has assessed post-traumatic stress symptoms and symptom severity after disasters in the general population but has not used validated instruments that allow assessment of PTSD prevalence or incidence (31, 32, 93, 94).

A smaller number of studies have evaluated the prevalence of PTSD among children after disasters (22, 40, 95–102). The assessment measures that have been used in studies of children are inconsistent, and many of the studies of children have documented PTSD symptoms only, limiting cross-study comparisons of the prevalence of PTSD. For example, a cross-sectional study of children conducted after a 1984 sniper attack on a school playground in Los Angeles, California, showed that 38.4 percent of the children had moderate or severe levels of PTSD symptoms 1 month after the incident (100). Following another school shooting in
Winnetka, Illinois, in 1998, the prevalence of PTSD based on DSM-III-R criteria was assessed to be 8 percent among children 8–14 months later (101).

A few studies have been conducted among other specific groups after disasters, including psychiatric or medical patients (23, 103), specific racial/ethnic groups (28), and parents of children who are exposed to disasters (22, 63). There are insufficient numbers of these studies to draw general inferences about the prevalence of PTSD after disasters in these groups.

**Correlates of PTSD.** A wide range of correlates of PTSD after disasters have been studied, ranging from demographic characteristics to personal psychological factors and event exposures. Female gender has consistently been shown to be a risk factor for the onset of PTSD after disasters (26, 29, 31, 70, 92, 95, 104). Psychological factors such as guilt (73, 101, 105–107), anger (73, 108), external locus of control (109, 110), and weaker coping ability (32, 111–114) have been associated with PTSD onset. A history of prior traumas and stressors (24, 25, 65, 82, 115, 116) and a history of prior or comorbid psychiatric conditions (66, 77, 89, 108, 117–119) have both been associated with PTSD onset across multiple studies, as has low social support (67, 109, 120, 121) and having poor relationships with family members and coworkers (which is probably a proxy for low social support) (70, 95, 122). Media exposure, particularly television watching, has been associated with PTSD (30, 96, 98, 123), although all of the studies demonstrating this association have been cross-sectional, raising issues about the causal direction of the association.

Degree of exposure to a disaster is consistently associated with the likelihood of PTSD (80, 114, 123–131). There is a wide range of potential exposures to disasters, and they vary dramatically between disasters. For example, being blocked while trying to escape flood waters and having prolonged exposure to flood waters were important correlates of PTSD after the 1972 Buffalo Creek, West Virginia, dam collapse (125). After the Winnetka, Illinois, school shooting, correlates of PTSD included fear of being shot (101). After the Bijdmermeer plane crash of 1992, in which an airplane crashed into a residential area of Amsterdam, the Netherlands, having lost a home was an important correlate of PTSD onset (132). Among rescue workers, the length of time spent exposed to the Oklahoma City bombing site was associated with the likelihood of PTSD (89). Range of exposure, as assessed across studies, also provides an opportunity for comparison and suggests that the nature of a person’s exposure to a disaster is an important determinant of the likelihood of developing PTSD after a disaster. As we noted above, the prevalence of PTSD after a disaster is highest among persons who were directly exposed to the disaster (frequently characterized as “victims”), lower among rescue workers, and lower yet in the general population. These groups probably represent different levels of exposure to disasters, with direct victims having the highest exposure and associated PTSD prevalence while persons in the general population have the lowest levels of exposure and prevalence. Studies that have assessed multiple groups after the same disaster allow for direct comparison. For example, an assessment of hotel employees who were either on-site or off-site when a fighter jet crashed into their hotel in 1987 showed that the prevalence of PTSD among employees who were on-site was 29 percent, as compared with 17 percent for off-site employees (72). A number of studies have assessed areas close to and distant from a disaster site, consistently showing that the prevalence of PTSD is higher among persons closer to the disaster than among those further away (30, 91).

Other factors that have been shown to be correlates of PTSD after disasters include low socioeconomic status (21, 67, 82), age (69, 88, 102, 133), race/ethnicity (134), and employment status (25, 135). These factors have not been studied sufficiently for us to draw conclusions about their reproducibility in other postdisaster situations.

**Course of PTSD.** Relatively few studies have included longitudinal assessments allowing evaluation of the course of PTSD after human-made/technological disasters. In a cohort study of male college basketball players who were aboard a chartered aircraft that crash-landed in 1984, the prevalence of PTSD declined from 54 percent in the first month after the incident to 10–15 percent 12 months after the incident (136). This rapid decline has been corroborated in prospective studies of rescue workers after an oil rig accident, a school bus accident, and the USS Iowa gun turret explosion (79, 81, 137); among elderly community residents after the Lockerbie disaster, in which a terrorist bomb destroyed Pan Am Flight 103 over southern Scotland in 1988, killing all on board (138); and in a serial cross-sectional study of the general population after the September 11 terrorist attacks (25). However, most studies that have assessed the course of PTSD after disasters among direct victims suggest that PTSD is persistent for a few years after the disaster among victims with early PTSD onset. Seminal studies carried out after the Buffalo Creek dam collapse showed that 25 percent of adults had current PTSD 14 years after the incident, as compared with 59 percent at any time in the 14 years after the incident (75). In a cohort study of victims of the Jupiter cruise ship disaster in Greece, 34 percent of persons who had PTSD in the first 5 months after the incident still had PTSD 5–8 years after the incident (77). This long-term course of PTSD among victims of disasters has been corroborated in prospective studies of Pan Am Flight 103 litigants (139), persons exposed to the mass shooting in Killeen, Texas (66), persons affected by the Oklahoma City bombing (10), and survivors of a 1996 subway bombing in Paris, France (135). None of these studies assessed the course of PTSD over a long enough period of time to reliably document whether the course of PTSD represents a monotonic decline over time and whether there is late-onset PTSD, although two of the aforementioned studies (66, 139) did not document any cases of delayed PTSD onset. A recent serial cross-sectional study conducted after the September 11 terrorist attacks suggested that there were different determinants of PTSD persistence as compared with determinants of PTSD onset (25), although this has not been explored in enough studies for generalized inference.

**Studies of natural disasters**

Many of the observations that can be drawn from studies of natural disasters confirm what was discussed above in the

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context of human-made or technological disasters. We summarize here the key observations about PTSD after natural disasters, highlighting differences between the epidemiology of PTSD after natural disasters and PTSD following human-made/technological disasters. We refer the reader to Web table 3 for further details about individual studies.

**Prevalence of PTSD.** Consistent with previous observations (8), the prevalence of PTSD documented in studies after natural disasters is generally lower than that documented in studies after human-made/technological disasters. However, in studies of natural disasters, it is more difficult to explicitly identify groups of persons who can be considered direct victims. Most research after natural disasters has been carried out after events such as earthquakes, hurricanes, or tornadoes (140–144). While in studies of human-made/technological disasters there is usually an obvious group of direct victims—for example, passengers on an airplane that crashes (136)—this is less often the case in natural disasters such as earthquakes, which affect large areas. As such, among studies of PTSD after natural disasters, study samples predominantly include persons from a broader area affected by the disaster (145–147). This group may plausibly include both persons who were markedly exposed to the disaster (through personal exposure or through the exposure of a family member) and persons who were less directly exposed. Therefore, the lower prevalence of documented PTSD in studies of PTSD after natural disasters as compared with studies of PTSD after human-made/technological disasters is not surprising. Overall, studies carried out after natural disasters report a PTSD prevalence ranging from approximately 5 percent (148) to 60 percent (140) in the first 1–2 years after a disaster, although most prevalences reported are in the lower half of this range (142, 144, 145, 147, 149–157). Higher prevalences have been reported among specific groups, including clinical samples (158) and persons who were in areas heavily affected by the disaster (159–161).

A number of studies of PTSD after natural disasters have studied PTSD among rescue workers, particularly firefighters. After the 1983 bush fires in southeastern Australia, a 50 percent prevalence of PTSD was observed among firefighters during the first 2 years of follow-up (162). A similar high prevalence of post-traumatic morbidity was documented among male firefighters after the Chi-Chi earthquake in Taiwan in 1999 (163).

Post-traumatic stress symptoms have been documented among children after natural disasters in a number of studies. After the Armenian earthquake of 1988, 95 percent of children from a severely exposed city and 26 percent of children from a mildly exposed city had severe levels of post-traumatic stress symptoms 1.5 years after the incident (164); the prevalence of symptoms among mildly exposed children is consistent with assessments of children from three San Francisco Bay Area communities exposed to the Loma Prieta earthquake in 1989 (165), from Florida after Hurricane Andrew in 1992 (166), and from North Carolina after Hurricane Floyd in 1999 (167). A cross-sectional study carried out after the 1999 Chi-Chi earthquake in Taiwan showed a 20 percent prevalence of PTSD among children during the first 6 weeks after the incident (168).

**Correlates of PTSD.** Correlates of PTSD after natural disasters are comparable to correlates documented after human-made/technological disasters. These include psychological factors such as neuroticism (68, 169, 170), guilt (171), difficulty concentrating (172), coping strategies (62, 173–175), obsessive traits (176), and psychiatric comorbidity (140, 144, 149, 177–182). Women are more likely than men to have PTSD after natural disasters (145, 147, 150, 183–186), and low social support is associated with a higher likelihood of PTSD (166, 187, 188). A greater degree of exposure to a disaster is consistently associated with the likelihood of PTSD (143, 146, 165, 189–202).

Exposure to stressors before or after the incident (150, 189, 203–208) and television viewing (162) have been associated with PTSD after natural disasters, albeit in fewer studies. A few studies have documented an association between parental symptoms of PTSD and symptoms of PTSD among their children (59, 206, 209–213). Race/ethnicity (10, 150, 151, 187), relocation (159, 192), and low socioeconomic status (212, 214) are inconsistently associated with PTSD after natural disasters.

**Course of PTSD.** There have been few published peer-reviewed studies that have assessed the course of PTSD after natural disasters. Notably, in a cohort study of firefighters conducted after the 1983 Australian bush fire, 21 percent of the firefighters were documented to have persistent PTSD over a 2-year period (162). In contrast to the studies of PTSD after human-made/technological disasters (66, 139) discussed above, this study also documented multiple patterns of PTSD, including delayed-onset PTSD. In a random sample of adults studied after the 1989 earthquake in Newcastle, Australia, the prevalence of PTSD was shown to decrease by approximately one half in the first 2 years after the earthquake (211). A cohort study of residents of Dade County, Florida, exposed to Hurricane Andrew in 1992 found that the prevalence of PTSD increased slightly from 26 percent to 29 percent between 6 months and 30 months after the hurricane and, importantly, that while intrusion and arousal symptoms declined over time, avoidance symptoms increased (207). An increase in PTSD was also documented between 3 months and 9 months after the 1998 Zhangbei-Shangyi earthquake in China (215).

**DISCUSSION**

**Limitations**

In preparing this paper, our goal was to carry out a systematic review of the evidence regarding PTSD after disasters that might suggest a direction for research and intervention. However, there were specific decisions made in the conduct of this review and particular limitations of the literature in the field that, to some extent, influenced the conclusions drawn here.

First, we chose to present a comprehensive review, filling a gap in the epidemiologic literature. This approach allowed us to understand and draw inferences from the body of work in the field that is likely to influence other researchers and practitioners. However, in providing a comprehensive review, we considered both studies that were
epidemiologically sound and studies that may have included biases or may have been poorly designed. There are two reasons why we opted not to limit our review exclusively to “well-designed” studies. First, the evidence in the field is published in journals that cross disciplines, and different reporting styles make it virtually impossible to systematically assess all studies according to uniform epidemiologic criteria. Second, given the nature of disasters, it is typically the case that only one or two studies are conducted after a given disaster, frequently by local researchers. In several instances this work has been important, given the unique nature of the event being studied, and has influenced subsequent research. Although we have provided Web tables that comprehensively review the body of work in the field, our discussion in the text has focused primarily on studies that were well-designed and that made unique contributions to the field. We endeavored in the tables to provide sufficient information in a concise format to allow readers to evaluate the contribution of each paper and weigh the evidence for themselves.

Second, as we noted above, the changing diagnostic criteria for PTSD over time make cross-study comparisons challenging. In addition, although disasters occur all over the world and are studied all over the world, there are cross-cultural limitations inherent in the use of assessment instruments that were primarily designed and validated in developed countries, primarily the United States. These factors both limit and suggest caution about inferences that can be drawn from cross-study comparisons across disasters, as in this review. A full assessment of how the changing diagnostic criteria for PTSD have affected prevalence estimates obtained across studies would require comparative analysis of raw data across studies or, at the least, a comparison of symptom profiles across studies. Unfortunately, very few studies have documented specific symptoms, making such comparisons difficult. Similarly, without appropriate validation of assessment instruments in the relevant cultural context, it is impossible to determine whether specific instruments introduce systematic bias when used in a different culture than the one for which they were designed.

Third, our review, intended for an epidemiologic audience, focused on PTSD as a categorical disease outcome; we did not consider other mental (or physical) health consequences of disasters. Our goal was to summarize the epidemiologic literature as it pertains to one disorder that probably remains the most prevalent and debilitating consequence of disasters. In using this approach, we do not mean to suggest that other disorders do not also impose important burdens after disasters or that PTSD frequently occurs in isolation (8). Other psychiatric disorders, such as anxiety and depression, have been documented after disasters, and there has been discussion in the literature about the problems involved in focusing only on PTSD as the outcome of interest after disasters (216, 217). Subsequent reviews would do well to systematically assess the literature on other psychiatric conditions after disasters, as well as (perhaps more importantly) the literature on comorbidity.

Fourth, our review was limited by the extant epidemiologic literature and did not include important factors in PTSD epidemiology about which there is a paucity of empirical research. For example, features of the postdisaster environment, including access to services and social cohesion in the affected communities, may be as important in the long-term course of PTSD after disasters as the disasters themselves (218). However, the epidemiologic literature on these factors is limited, and as such, a fuller discussion of their potential role in the course of PTSD after disasters is not included here. Features of the postdisaster environment that affect the PTSD trajectory may be a particularly fruitful area for future research.

Summary and future research

Studies conducted in the aftermath of disasters during the past 40 years have shown that there is a substantial burden of PTSD among persons who experience a disaster. In particular, the published peer-reviewed literature is consistent in showing that the extent of exposure to a disaster is probably the most important risk factor for the development of disaster-related PTSD. Therefore, persons who are direct victims of a disaster—for example, those who are injured during the disaster—have a greater likelihood of developing PTSD than other groups. In comparison, the prevalence of PTSD after disasters is lower among rescue workers and lower yet in the general population.

Although the prevalence of PTSD has been found to be higher after human-made/technological disasters than after natural disasters, this appears to be largely due to differences in sampling. Most studies conducted after human-made/technological disasters have focused on direct victims (e.g., persons who witnessed the N149 supertanker explosion in 1994 (105)), while a smaller set of studies has assessed PTSD in the general population (e.g., New Yorkers after the September 11 attacks (24)). However, studies of natural disasters typically include samples of people in the overall community who were potentially affected by the disaster (e.g., residents of a city where an earthquake occurred (219)). These samples are likely to include both persons who are direct victims and others in the general population who probably had substantially lower exposure to the disaster.

Arguably, the available information is sufficient to suggest plausible ranges of PTSD prevalence that can be expected in the first year after disasters, within exposure groups. The empirical evidence suggests that the prevalence of PTSD among direct victims of disasters is 30–40 percent, the prevalence among rescue workers is approximately 10–20 percent, and the prevalence in the general population is approximately 5–10 percent. These summary estimates, by definition, are simplifications, and there are abundant studies showing that the prevalence of PTSD is substantially higher or lower than these ranges for particular groups. The scope of the disaster and the group’s exposure to the disaster are probably the most important factors in determining the eventual prevalence of PTSD. Simply put, some disasters are more horrifying than others and are accompanied by more injury, property destruction, and threats to individuals. Particularly high prevalences of PTSD have been reported among victims of disasters such as the Buffalo Creek dam collapse (75) and
the Piper Alpha oil rig fire (73), where survivors had been in imminent danger of dying during the disaster and lost colleagues and friends. In contrast, the documented prevalence of PTSD in the general population after the September 11, 2001, terrorist attacks in New York City (24) was not disproportionately higher than that in other studies of PTSD in the general population after disasters (65); this probably reflects the fact that while the September 11 attacks dramatically affected US national discourse, exposure to the disaster for most persons in the general New York City population was relatively limited.

In addition to exposure to an event, a number of risk factors for PTSD have been identified and shown to be important across multiple studies. Women are consistently shown to have a higher prevalence of PTSD after disasters than men (70, 184). Persons with preexisting or concurrent psychiatric comorbidity and persons who have previously experienced traumatic events or substantial stressors (203) also have higher risks of disaster-related PTSD. Low social support has been shown to be a risk factor for PTSD in several studies (166, 187). Although there are a number of psychological characteristics that have been associated with postdisaster PTSD, there is no one psychological profile, with the possible exception of poor coping (32), that emerges as particularly predisposing to postdisaster PTSD after psychiatric comorbidity has been accounted for. The potential role of television viewing as a correlate of postdisaster PTSD is intriguing (123); future research should assess this further using longitudinal study designs. In addition, although the general social and economic context may change after a disaster—including, for example, changes in employment opportunities and social capital—there is a paucity of research that has systematically assessed the role of macro-level factors in shaping postdisaster risk of PTSD. The role of a number of factors, including race/ethnicity and socioeconomic status, in postdisaster PTSD risk remains unclear.

The course of PTSD after disaster has been studied in relatively few studies, making it difficult to draw general conclusions. Studies carried out among direct victims of disasters have demonstrated the persistence of at least one third of cases of early-onset PTSD for more than 2 years after disaster exposure (139); some studies have shown the persistence of PTSD in more than one third of original cases more than a decade after the disaster exposure (75). Existing studies provide conflicting evidence about the trajectory of PTSD after disasters (10, 68, 220). Although there has been a suggestion that the determinants of PTSD persistence are different from the determinants of PTSD onset (25), there is scant evidence addressing this possibility in the disaster literature.

There is little scientific rationale for carrying out additional studies specifically aiming to document the burden of PTSD after disasters. An ample body of work, reviewed here, provides compelling evidence regarding the prevalence of PTSD after disasters. We recognize, of course, that documenting the prevalence of PTSD after a particular disaster may have important implications for delivery of mental health services and that reporting of baseline prevalence is the first step in more ambitious studies. In contrast, there is a paucity of research documenting the incidence of PTSD after disasters. In large part, this reflects the fact that disasters are unpredictable and establishing population cohorts that may be used to assess PTSD incidence in the event of a disaster is not feasible. However, population cohorts do exist in the United States and in several European countries. Through the establishment of baseline PTSD assessments, these cohorts could be positioned to document PTSD incidence in the event of disaster exposure by some or all of the cohort participants. Although some correlates of PTSD are well established and provide sufficient support for intervention targeted at specific groups after a disaster, there has been little research attempting to understand why certain groups are at higher risk. This is particularly important in the case of immutable factors such as gender. We are aware of only one study that has attempted to explain why gender is a risk factor for PTSD after a disaster (29). Further etiologic work assessing behavioral, psychological, and biologic explanations for the observed associations between specific correlates and PTSD would be helpful and could provide guidance for intervention.

The course of PTSD in the intermediate and long term after disasters remains largely unexplored. This is undoubtedly due to the difficulties inherent in establishing long-term cohort studies that have adequate statistical power to detect different trajectories of PTSD. However, the potential of such research should not be underestimated. While postdisaster PTSD may be associated with decreased quality of life and decreased productivity (6), it is likely that most early-onset PTSD after a disaster will eventually resolve. As such, understanding who is at risk for long-term PTSD after disasters and exploring different PTSD trajectories, such as lapsing-relapsing patterns or late-onset PTSD, is critical. More importantly, identifying factors associated with these PTSD patterns and trajectories has potential for guiding early intervention that may minimize the long-term psychological consequences of disasters, which may impose a greater societal burden than the short-term transient burden of early-onset PTSD. As we noted above, there is a paucity of evidence about the role of the social context in the postdisaster environment in shaping the course of PTSD; this may be a particularly important area for future research. Consideration of the features of the postdisaster environment that may shape the burden of PTSD could provide guidance for interventions designed to improve population mental health after disasters.

Editor's note: References 221–234 are cited in Web tables 2–4, which are posted on the Epidemiologic Reviews website (http://epirev.oupjournals.org/).

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