

**PTSD Prevalence in the Aftermath of Natural Disaster Happened in Low- and  
Middle-Income Countries: A Systematic Review and Meta-Analysis**

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**Abstract:**

*Background:* Posttraumatic stress disorder (PTSD) is a common and highly invalidating psychological disorder observed in the aftermath of natural disasters. Research has demonstrated that people living in Low and Middle-Income Countries (LMIC) are particularly threatened by PTSD when natural disasters strike. The aim of the current thesis is to ascertain the prevalence of PTSD in the aftermath of natural disasters occurred in LMIC through a systematic review and meta-analysis. *Methods:* Thirty-eight studies were identified from a systematic search of the PubMed, PsycInfo, Embase and Scopus databases. The combined prevalence of PTSD was estimated by using the Freeman-Tukey double arcsine transformation method and a random-effects model, in addition to 95% confidence intervals, p-values and heterogeneity statistics. Subgroup analyses were conducted using the following variables: gender, bereavement, level of education and time of PTSD assessment. The combined prevalence and heterogeneity statistics were calculated for each population, and a Chi-squared test was performed within each subgroup as to test for significant differences. *Results:* The combined prevalence of PTSD obtained was 25.68% (95% CI: 20.57- 31.15 %). A high degree of heterogeneity (I-squared = 98.8 %;  $p < 0.001$ ) was observed. The subgroup analyses showed that PTSD prevalence was significantly higher in women, bereaved individuals and individual assessed within the first year from the occurrence of the natural disaster. *Conclusion:* The results obtained expand the knowledge about the course of PTSD in LMIC affected by natural disasters. The estimates obtained will hopefully be useful as to inform future research and interventions.

### **Declaration**

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and, to the best of my knowledge, this thesis contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web, via the University of Adelaide's digital thesis repository, the Library Search and through web search engines, unless permission has been granted by the School to restrict access for a period of time.

Giovanni Freschi

Date: 29<sup>th</sup> September 2020

**Contribution:**

In writing this thesis, my supervisor and I collaborated to generate research questions of interest and design the appropriate methodology. I conducted the literature search with the support of my supervisor, who informed me about how to develop and use logic grids to search scientific databases. I was responsible for all articles screening and data collection, data analysis and thesis write-up.

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## **Chapter 1:**

### **Introduction**

#### **1.1 General Overview**

Posttraumatic stress disorder (PTSD) is a psychiatric disorder typically observed in individuals who have experienced or witnessed a traumatic event (American Psychiatric Association, 2013). Following the definition as proposed by the 5<sup>th</sup> edition of the DSM, the most common types of traumatic events influencing the development of such mental disorder include natural disasters, wars, serious accidents or other types of violent personal assault. Despite the diagnostic criteria having changed since the introduction of the disorder in the third edition of the DSM (1980), PTSD has always been described as a severe and highly invalidating form of psychopathology (Vieweg et al., 2006). The clinical characteristics of PTSD strongly challenge the individuals affected to approach their lives functionally, especially when complex and chronic forms are reported (American Psychiatric Association, 2013).

The research in this field has largely demonstrated the crucial role played by specific therapeutic interventions in providing efficient treatment for the clinical symptoms of such psychopathology (Mavranouzouli et al., 2020; Vieweg et al., 2006). As reported by the studies of Mavranouzouli and Vieweg, the various types of evidence-based therapies used when dealing with PTSD are characterized by complex techniques, requiring high levels of preparation and skills by the clinicians

When discussing natural disasters, PTSD has been widely recognized as the most recurrent, impactful and debilitating psychological outcome reported in the aftermath of such events (Galea, Nandi & Vlahov, 2005; Lowe, Bonumwezi, Valdespino – Hayden & Galea, 2019; Neria, Nandi & Galea, 2007). The characteristics of natural disasters, as well as the great devastation typically observed in the aftermath of such events, represent the primary

conditions influencing the risk for survivors to develop PTSD. Both the impact and the different abilities to cope experienced by the population are reported as being critical factors influencing the course of psychopathology (Bonanno et al., 2010).

The countries defined by the World Bank as Low- and Middle-income countries (LMIC) are reported to be particularly vulnerable when natural disasters strike (The World Bank, 2020). Higher numbers of deaths, building collapses and mental health conditions are typically observed in LMIC when compared with that reported by high income countries (Rentschler, 2013). The higher levels of exposure experienced by the population and the limited and often inefficient interventions provided by the local governments result in a severe risk for mental health, with PTSD representing the most recurrent and invalidating type of psychopathology reported (Goldman & Galea, 2014).

In the following sections of the introduction, I will describe the characteristics of natural disasters, the impact that such events can have on both physical and mental health, and the vulnerability conditions experienced by the individuals living in LMIC when natural disasters strike. In addition, the clinical characteristics of PTSD will be examined, and the relationship between the disorder, natural disasters and people living in LMIC will be explored.

## **1.2 Natural Disasters: definition and characteristics**

Natural disasters represent some of the most dramatic and life challenging events that individuals can experience during a lifetime. Following the definition as proposed by the World Health Organization, a natural disaster can be considered “as an act of nature of such magnitude as to create a catastrophic situation in which the day-to-day patterns of life are suddenly disrupted, and the people are plunged into helplessness and suffering” (Assar, 1971, p. 14). As reported by Assar, the individuals affected by natural disasters have a variety of primary needs

in order to cope and survive, such as food, clothing, shelter and medical and nursing care for protection against the consequences produced by such catastrophic events.

Natural disasters include different types of events, such as earthquakes, tsunamis, volcanic eruptions, landslides, hurricanes, floods, wildfires, heat waves and droughts (World Health Organization, 2020). Following the data reported by the World Health Organization, these events kill around 90 000 people every year, affecting close to 160 million more worldwide. The numbers reported underline the dramatic consequences typically observed in the aftermath of such events. The destruction of the physical, biological and social environment of the people affected often results in both short and long-term consequences on their health, well-being and survival possibilities (Hidalgo & Baez, 2019).

Natural disasters can produce both severe physical and mental consequences, affecting people's life in two different ways (Bonanno et al., 2010). The first effect is characterized by the physical "one to one" impact of the disaster experienced by the individuals, defined in terms of traumatic injuries, death or injury of family members and loved ones, losses of personal belongings (e.g. houses, devices) and psychological distress. The second effect is characterized by the broader impact experienced by the communities and the societies affected by disasters, such as the need for rebuilding the affected areas, the uncontrolled interruption of work and productive activities (e.g. schools, offices, private and public business) and the extensive need for economical and health support. However, the actual consequences of natural disasters are difficult to predict before the occurrence of the event, as they will depend on a combination of risk and resilience factors which are complex to foresee and control (Bonanno et.al., 2010).

Bonanno reports that the particular characteristics of the individuals, the contexts and the disasters involved define different levels of risk and vulnerability. The concept of vulnerability, defined as "the degree to which a population, individual or organization is unable to anticipate,

cope with, resist and recover from the impacts of disasters” (Wisner & Adams, 2002, p. 25.), is directly correlated with the consequences experienced by the people and communities affected by natural disasters. Therefore, high levels of vulnerability will define severe and dramatic consequences for the people involved.

Following the definition as proposed by the World Health Organization, children, pregnant women, the elderly and people with medical conditions (physical and psychiatric) are considered at risk populations, experiencing high levels of vulnerability when a natural disaster strikes (World Health Organization, 2020). Furthermore, poverty and its common consequences, in conjunction with the limited ability for a country to provide adequate interventions, infrastructures and social support, are identified as major contributors to vulnerability. Specific vulnerability conditions are also defined by the geographical characteristics of each context, as the probability of a natural disaster, as well as the degree of magnitude and type, are influenced by the particular environments involved. Evaluating the vulnerability conditions of both the context and its population represents a great opportunity as to gather useful information about how and where to act in order to prevent and limit the catastrophic consequences caused by natural disasters (Bonanno et al., 2010). Subsequently, the functional planning and implementation of specific context-based interventions is fundamental, to provide efficient support for the specific needs experienced in the aftermath of such events (Bonanno et.al, 2010; Hidalgo & Baez, 2019).

Some examples of typical interventions provided when dealing with natural disasters are the implementation of disaster-ready infrastructures, evacuation programs for the areas at risk, temporary settlements and health-care facilities like hospitals, primary health-care centres, isolation camps, burn patient units, feeding centres and other services aimed to support and protect the health and wellbeing of the population affected (Ferrier & Spickett, 2007). The primary purpose of these interventions is to limit the post disaster consequences by providing

prevention programs, direct support for the basic survival needs and physical and mental health assistance in the immediate aftermath of disasters (Goldman & Galea, 2014). However, as discussed by Goldman & Galea, the planning and the implementation of context-based interventions are sometimes difficult to execute at the right time and with efficiency.

The countries defined as low- and middle-income face a much stronger burden to react and recover from natural disasters when compared to the high-income countries (Rentschler, 2013). Research in the field has shown how the levels of preparedness demonstrated by low- and middle-income countries to prevent and react from natural disasters is often not efficient, and that a vast majority of the primary needs experienced by the population remain unmet (Ferrier & Spickett, 2007; Lowe et al., 2019).

### **1.3 Natural Disasters and Low- and Middle-Income Countries**

In accordance with the information reported by the World Bank Open Data, low- and middle-income countries (LMIC) are defined as those countries characterized by economies with a GNI (gross national income) per capita per year between 0 US\$ and 12,535 US\$ (The World bank, n.d.).

Reports on people living in LMIC identify particular characteristics increasing the vulnerability conditions experienced in the aftermath of natural disasters. Patel (2007) reported that the key characteristics influencing a population's vulnerability to a natural disaster are: limited economical response, lower levels of education, increased rates and exposure to crime and violence, poor infrastructures and lack of health and public services (Patel, 2007). These conditions have a direct impact on the levels of stress experienced, as the degree of unpredictable changes, such as losing the source of income or being affected by an injury or illness, can drastically influence an individual's ability to survive (Patel, 2007). Moreover, mental health resources are extremely limited in low- and middle-income countries, influencing the prevalence, severity and course of psychopathology (Patel, 2007). Patel

identified that the capacity to provide either adequate or basic psychological support is not guaranteed on a daily basis, and when traumatic events such as natural disasters occur, the situation doesn't improve. The services provided are often inadequate, lacking in programs, professionals and resources needed to develop functional interventions aimed to protect mental health in the immediate aftermath of the disaster as well as during the following periods (Patel & Thara, 2003; Patel, 2007).

The characteristics influencing vulnerability vary from situation to situation, being affected by high levels of poverty, poor health conditions and lack of adequate resources. Therefore, the inefficiency of political and governmental institutions to provide functional interventions plays a crucial role (Ferrier & Spickett, 2007). The implementation of efficient pre and post disaster interventions represents a fundamental factor limiting the impact of natural disasters, also promoting physical and mental recovery of populations involved (Bonanno et al., 2010; Goldman & Galea, 2014). Receiving efficient sanitary, economical, physical and psychological support play the most important role for coping with the health issues typically observed in post disaster environments (Bonanno et al., 2010; McFarlane & Williams, 2012). However, to be able to provide such services, the resources needed must be efficiently supplied, which is a challenge that often proves to be unfeasible for LMIC (Ferrier & Spickett, 2007). Therefore, the consequences on both the physical and mental of people living in LMIC are more severe when compared with the consequences reported in high income countries, which on the contrary are better prepared to react from natural disasters (Ferrier & Spickett, 2007; Lowe et al., 2019). The research in the field has demonstrated that the impact of natural disasters defined in terms of deaths, traumatic injuries, infrastructures destruction, displacement of the people and mental disorders reported, is much more severe in low- and middle-income countries when compared with high income ones (Rentschler, 2013).

In the next section of the introduction, the relationship between natural disasters and mental health will be explored in more depth.

#### **1.4 Natural Disasters and Mental Health**

In the aftermath of natural disasters multiple types of mental disorders are typically observed. The levels of stress perceived related to the traumatic events experienced represents a severe psychological threat for the individuals involved (Bonanno et al., 2010). The types and severity of the psychological outcomes observed can vary significantly and are proportionate to the characteristics of the individuals affected, including both resilience and psychopathological outcomes (Bonanno et.al, 2010). However, the research in the field has demonstrated that some types of mental disorders are more likely to occur in the aftermath of natural disasters (Bonanno et al., 2010; Goldman & Galea, 2014).

As discussed, PTSD is considered one of the most severe and recurrent mental disorders observed in post disaster condition. However, it is important to specify that PTSD cannot be considered as the only severe threat for mental health in disasters' aftermath (Bonanno et al., 2010). The research identifies that high prevalence of depressive and anxiety disorders are often reported, as well as substances abuse, suicidal ideation and specific symptoms related to the prolonged grief and distress experienced (Bonanno et al., 2010; Goldman & Galea, 2014). Regardless of the particular type of mental disorder observed, the risk of developing severe symptoms and chronic forms of psychopathology represents a serious threat in post disaster conditions (Goldman & Galea, 2014). In addition, it has been identified that the disorders mentioned above, especially PTSD, are rarely present in isolation. In post-traumatic environments, comorbidity of different mental disorders represents a serious issue (Bonanno et al., 2010; Goldman & Galea, 2014). The high rates of comorbid conditions observed are typically followed by complex and severe development of symptoms, limiting an individual's ability to recover stable mental health (Bonanno et al, 2010). For this reason, having highly

qualified professionals engaged in the assessment and treatment of the various psychological condition is essential (Bonanno et al., 2010; Goldman & Galea, 2014).

However, it is very complicated to predict the course of psychopathology in a disaster's aftermath, as the occurrence and course of the different mental disorders are affected by multiple risk factors (Bonanno et al., 2010; Goldman & Galea, 2014). Examining the research and studies conducted in the field, three main clusters of risk factors have been found to play a central role in influencing the course of psychopathology: Pre, Peri and Post disaster risk factors (Goldman & Galea, 2014). The pre-disaster risk factors are defined as individual characteristics such as female gender, young age (children and adolescents), having a family, low levels of education, previous history of medical conditions (physical and psychological) and low socio-economic status or conditions of poverty (Bonanno et al., 2010; Neria et al., 2008; Norris et.al, 2002;). The peri-disaster risk factors are defined as the level of exposure to the event experienced, typically defined both by the proximity to the epicentre of the event and by the physical exposition (Goldman & Galea, 2014; McFarlane & Williams, 2012). The direct contact with particularly traumatic experiences such as severe injuries, building collapses, exposure to death and harm to others, has been widely evidenced as having a profound impact on mental health (Bonanno et al., 2010; Norris et al., 2002, 2009; McFarlane & Williams, 2012). The post disaster risk factors are determined by the presence of life stressors and by the social support received (Goldman & Galea, 2014). The types of stressors experienced can vary significantly in intensity and type, as they are influenced by the individual consequences encountered in the disaster aftermath (e.g traumatic injuries, loss of family members or friends, house collapsing) (Bonanno et al., 2010; Goldman & Galea, 2014; Norris et al., 2002). The second component of post disaster risk factors, social support, is defined by the interventions provided by the governments and local political forces to promote the safety and recovery of the populations' physical and mental wellbeing (Hidalgo & Baez, 2019; McFarlane &



Williams, 2012). Moreover, social support is also influenced by the sense of community and the strength of the relationships experienced in the aftermath of the disaster (Bonanno et al., 2010; Norris et.al, 2002).

Analysing the particular characteristics of pre, peri and post disaster risk factors when dealing with disaster management represents a priority, as these factors vary from each context and situation (IASC Guidelines, 2007). For such reason, understanding these factors creates the opportunity to plan and develop context-based interventions suitable to minimise and treat mental disorders (IASC Guidelines, 2007; McFarlane and Williams, 2012).

In order to prevent pre and peri disaster risk factors, the priorities are to develop context-based prevention programs aimed to optimize the security of the environments at risk, as to limit the damages caused by the event. These types of interventions will provide both physical protection and psychological reassurance for the populations involved, by decreasing the risk of experiencing traumatic consequences, and increasing the level of preparedness to cope with the disaster aftermath (Norris et al., 2002). Post disaster risk factors require efficient and immediate interventions, as to limit the impact of such unpredictable and devastating events on mental health. Research in the field has demonstrated that the priority is providing a safe living environment, structured to support victims with their medical and social needs, promoting calm and alleviating stress, and helping them return to pre-disaster functioning levels (Bryan & Litz, 2009). The psychological first aid (PFA) program has become the leading post-disaster intervention when dealing with these types of situations (Hobfoll et al., 2007; Vernberg et al., 2008). The goals of PFA are to secure health of survivors by providing a safe living space and basic necessities, to reduce acute stress by addressing post-disaster stressors and providing strategies aimed to limit stress reactions, and to help victims to access further psychological services structured to deal with psychiatric disorders (Goldman & Galea, 2012; Ruzek et al., 2007). The necessity to evaluate and treat severe forms of psychopathology is a crucial factor

in post disaster conditions, particularly the provision of adequate services and settings (Forbes, Creamer & Wade, 2012). As proposed by Forbes et al, evaluating symptoms and treating psychiatric conditions is the next priority, once primary survival needs and psychological support have been provided. The types of interventions required must involve a clinical evaluation of the symptoms and an implementation of specific psychological therapies provided by highly qualified specialists (psychologists and psychiatrists), allowing the survivors to receive adequate mental support needed for the particular conditions demonstrated (McFarlane & Williams, 2012).

It is clearly evident that understanding the context of psychopathologies in relation to natural disasters is crucial to effectively support mental health in post disaster situations. The efficient implementation of both prevention and post disasters interventions is related to the administrative and governmental management of the area affected, as well as the management of the resources and funds. Considering the characteristics of low- and middle-income countries as discussed, we can understand how dramatic the consequences on mental health can be for individuals living in such contexts when a natural disaster strike (Patel & Thara, 2003).

### **1.5 Posttraumatic Stress Disorder: definition and clinical characteristics**

According to the latest version of the Diagnostic and Statistical Manual of Mental Disorders PTSD is classified as an anxiety disorder, and its essential features include 4 main criteria for the description of the clinical symptoms (American Psychiatric Association, 2013). The 4 criteria specified by the DSM are respectively referred to: 1) exposure to a traumatic event that involved actual or threatened death or serious injury, 2) re-experiencing the event with distressing recollections and physical distress, 3) persistent avoidance of stimuli associated with the memories or experiences of the trauma, and 4) persistent symptoms of increased arousal. To be assessed, the symptoms reported must be present for more than 1

month from the traumatic experience. PTSD can be diagnosed in two different forms: acute and chronic PTSD; when the symptoms are present for less than 3 months, it is defined as “acute PTSD,” otherwise, it is called “chronic PTSD.” Furthermore, it is necessary that the disturbance experienced by the individual causes significant distress or impairment in social, occupational, interpersonal and other important areas of functioning.

The intensity and duration of the traumatic events lived are key factors influencing the frequency and intensity of the symptoms of PTSD (Javidi & Yadollahaie, 2011; Vieweg et al., 2006;). Following the definition as proposed by Vieweg et al., traumatic events can be re-experienced in various way, through recurrent and intrusive recollections of the event (images, thoughts and perceptions) or recurrent distressing dreams during which the event is replayed. In some instances, individuals can experience feelings as if the traumatic event were recurring (illusions, hallucinations, dissociative flashback episodes), and have intense psychological distress and reactivity when exposed to cues triggering memories of the traumatic experience. More often, stimuli associated with the trauma are persistently avoided through psychological efforts where the individual does not expose himself to thoughts, feelings or conversations about the traumatic event, avoiding activities, situations or people who arouse recollections of it. In addition, numbing of an individual’s general responsiveness can be observed (e.g. feeling of detachment from others, diminished interests on social activities, restricted range of affect and sense of foreshortened future). Finally, typical symptoms of increased arousal are characterized by sleeping disturbances, irritability and anger, difficulty in concentrating, hyper vigilance and exaggerated startle responses.

PTSD has been widely studied in the aftermath of horrifying traumatic events (e.g. disasters, war zone conflicts, accidents, serious disease or military combat). Previous meta-analysis reported PTSD prevalence at 19.7% in the aftermath of such events (Utzon-Frank et al., 2014). However, overall research reports PTSD prevalence ranging from 0 to 70 percent

after natural disasters, reporting lower rates than the figures documented after technological and human-made disasters (Neria, Nandi & Galea, 2008; Lowe, Bonumwezi, Valdespinoi-Hayden & Galea, 2019). As previously mentioned, higher rates of PTSD have been reported among specific groups, including individuals who were living in areas heavily affected by the disaster, bereaved individuals, women, individuals with pre-existing medical conditions and individuals with low socioeconomic status (Neria, Nandi & Galea, 2008; Lowe, Bonumwezi, Valdespinoi-Hayden & Galea, 2019). Moreover, there are few studies which provide comprehensive meta-analysis studying PTSD occurrence in the aftermath of natural disasters, reporting PTSD estimates at 15 percent after floods (Chen et al., 2015) and at 23 percent after earthquakes (Dai et al., 2016). This notable variability in reported prevalence estimates reflects how the characteristics and impact of natural disasters are extremely different from case to case.

This data underlines the alarmingly high prevalence of such a complex psychopathology in the aftermath of natural disasters, and reiterates the need to plan and deliver functional intervention aimed to support the ones affected by such disorder. The research in the field has shown that the symptoms of PTSD tend to decrease after 3 months from the experience of the event (Bonanno et al., 2010), and that efficient social and psychological support has a major impact on the possibility to recover, reducing the development of chronic and more complex forms (Bradley et al.; 2005). The necessity to promote safe environments aimed to prevent the traumatic outcomes of disasters, and to provide adequate post disasters psychological interventions is essential in this regard.

The research has demonstrated that psychotherapy (e.g. trauma focused cognitive behavioural therapy and eye movement desensitization and reprocessing therapy), community-based interventions and psychoeducation are fundamental interventions to be applied when dealing with PTSD, and that pharmacological treatments can be provided with precaution

(Bradley et al., 2005; Bryant & Litz, 2009). In order to implement such rehabilitation programs, the presence of highly specialized psychologists and psychiatrists is required (IASC Guidelines, 2007; Mavranouzouli et al., 2020; Vieweg et al., 2006). For these reasons, the opportunity to protect individuals from developing PTSD and to efficiently treat symptoms will depend on the resources and services provided by each country when dealing with disasters' aftermath.

In the aftermath of natural disasters, promoting interventions aimed to provide efficient PTSD treatments result as one of the biggest challenges for LMIC. As previously discussed, the demographic characteristics of the people living in such contexts, as well as the limited resources provided by local governments, represent serious risk factors increasing the chances of developing PTSD. Not surprisingly, studies in the field have demonstrated that the rates of PTSD cases reported after disasters are much lower in high income countries than in LMIC (Patel & Thara, 2003). In LMIC, the need for understanding PTSD prevalence and course in the aftermath of natural disasters, as well as identifying high risk populations for developing such psychopathology, is a priority. In such types of environments, it is crucial knowing who to prioritize for receiving psychological assessment and support, as to maximise the efficiency of interventions.

## **1.6 The Present Review**

The aim of the current research is to expand the knowledge about PTSD in adult populations living in LMIC who experienced a natural disaster. The interest is to study both the general population and select subgroups identified by previous studies as most at risk to develop PTSD in such conditions.

Previous studies have reported that women, bereaved individuals and individuals with an education level lower than secondary schools appear to be most at risk to develop PTSD in

the aftermath of natural disasters (Kessler et al., 1995; Schnurr, Friedman & Bernardy, 2002; Galea, Nandi & Vlahov, 2005). Moreover, higher rates of PTSD have been reported in individuals assessed within the first year from the experience of the disaster (Chen & Liu, 2015; Dai et al., 2016). The focus of the current research is to consider these populations and provide more accurate information about vulnerable environments such as LMIC.

Existing literature consists of individual studies on PTSD prevalence after natural disasters, as well as systematic reviews and meta-analysis on PTSD prevalence for particular types of natural disasters (e.g. earthquakes, floods). However, no systematic reviews and meta-analysis were found which specifically examined natural disasters in LMIC. Therefore, a meta-analysis has been performed to provide useful information for future studies to expand current research, with particular interest for intervention programs. Providing accurate estimates of such a complex mental disorder could inform the decision of where and how to invest the resources needed, which is a priority when considering the limited opportunities demonstrated by LMIC.

### **1.6.1 General Aim:**

- Fill the gap: expand the knowledge on the topic, as no previous studies had conducted a meta-analysis evaluating PTSD prevalence in the aftermath of natural disasters occurred in LMIC.

### **1.6.2 Objectives:**

- Provide the pooled prevalence of PTSD in adult populations living in LMIC who experienced a natural disaster.
- Study particular “at risk” populations by analysing PTSD prevalence in 4 subgroups

according to: gender, bereavement, education level and time of assessment relative to the disaster

## **Chapter 2:**

### **Methods**

#### **2.1 Search Strategy**

The current research was conducted by following the format as proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Prisma Statement (Moher, Liberati, Tetzlaff, & Altman, 2009). The protocol has been developed, and it can be provided by the researcher if further details are required. The search strategy targeted articles reporting on the prevalence of Posttraumatic Stress Disorder (PTSD) in adult populations living in low and middle-income countries (LMIC) who experienced a natural disaster in the last 25 years.

The electronic database of PubMed, PsycINFO, Embase and Scopus were searched with the help of a logic grid, as to collect all the potential studies to be included in the meta-analysis. The keywords used included terms such as Natural Disaster, Posttraumatic Stress Disorder and Prevalence. Search terms were adjusted to each database by adding relevant thesaurus terms and adapting terms to account for adjacency operators, wildcards and truncation (see Appendix A for complete logic grid).

The articles obtained from the database search were screened using specific filters, referred to the language and the publication year of the study, in accordance with the eligibility criteria specified for the research. The studies detected were then collected through Endnote software (EndNote, 2020). Subsequently, the studies were moved to Covidence software, where each title and abstract were initially screened, and a full text review conducted (Covidence, n.d). The studies matching the eligibility criteria were identified and included in the meta-analysis. The references from each included study were then screened following the same procedure as above described.



In conclusion, a peer review with another student from the current Honours year was conducted, in order to screen the eligibility criteria for a random 20 % of the studies selected. The peer review resulted in a full percentage of agreement on the articles screened, demonstrating an optimal inter-rater reliability (100%, kappa= 1.00).

## 2.2 Eligibility criteria

The eligibility criteria were defined following the information specified in the PICO model, which was structured in accordance with the PRISMA recommendations (Moher, Liberati, Tetzlaff, & Altman, 2009). The table 1 shows the PICO model in details.

Table 1: *PICO model*

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**Population:** adults populations living in low- and middle-income countries who experienced a natural disaster in the last 25 years. The samples considered come from geographical areas severely affected by the event, where high numbers of deaths, physical injuries and buildings damaged were reported.

**Intervention/ Exposure:** the clinical evaluation of PTSD throughout validated psychometric tools and/or psychiatric interviews, in accordance with the diagnostic characteristics as defined by the 4<sup>th</sup> or further editions of the DSM.

**Outcomes:** the prevalence of PTSD, reported as the number of cases of PTSD and the total sample size for each study.

**\*Comparator:** the current analysis does not include any type of population comparator for the evaluation of PTSD.

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To be eligible for inclusion in the present research, studies needed to fulfil all the following criteria:

1. The study had to be published in English, or to have an English-language full-text version available.
2. The study had to be published on a scientific website or database.
3. The study had to be observational.

4. The study must have considered only populations living in low- and middle-income countries who experienced a natural disaster (The World Bank, 2020).
5. The study must have described a geographical area and a population severely affected by a natural disaster.
6. The study had to be conducted after the publication of the 4<sup>th</sup> edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM), in 1994 (American Psychiatric Association, 1994).
7. The study must have assessed PTSD by established and validated psychiatric interviews or psychometric tools exclusively structured for adult populations, according to the 4<sup>th</sup> or further editions of the DSM.
8. The study had to provide the prevalence of PTSD in the sample studied, or the data allowing such calculation.

The motivation behind using the publication of the 4<sup>th</sup> edition of the DSM as an inclusion criterion is inferred by the intention of avoiding unreliable and outdated methodologies used for the assessment of PTSD . The diagnostic characteristics of PTSD as described by the 4<sup>th</sup> and further editions of the DSM have been widely recognized throughout different cross-cultural settings and situations (American Psychiatric Association, 1994; American Psychiatric Association, 2013).

Moreover, the decision of using the term “prevalence” rather than “incidence” was inferred by the difficulty of finding articles reporting a study design which included persons screened for pre-disaster PTSD (Galea, Nandi & Vlahov, 2005; Neria, Nandi & Galea, 2008). Therefore, as the studies screened for the current meta-analysis were not consistently providing such information, it was not possible considering an accurate estimate of incidence.

### **2.3 Data extraction:**

The demographic characteristics and the data needed for the meta-analysis were extracted from each study and initially collected through Excel. The data retrieved from each study included:

1. The first author.
2. The year of publication.
3. The country where the natural disaster happened.
4. The type of natural disaster occurred.
5. The total number of victims reported.
6. The type of psychometric tool/psychiatric interview used to assess PTSD.
7. The time of assessment after the occurrence of the natural disaster.
8. The final number of participants of a survey (sample size).
9. The numbers of survivors assessed with PTSD.

Furthermore, for the studies reporting such information, the number of survivors assessed with PTSD and the total sample size were collected for each population of specific subgroups:

1. Gender (Male/Female).
2. Bereavement (Yes/No).
3. Time of PTSD assessment (Within 1 year/After 1 year).
4. Level of education (Primary education or lower/Secondary education or higher).

### **2.4 Quality Assessment:**

The quality of each eligible article was assessed using the evaluation criteria for prevalence and incidence studies as proposed and recommended by Loney (Loney et al., 2010). The choice of using such quality assessment tool was motivated by the specificity of

the criteria reported. Moreover, different studies published on scientific databases have used the same quality evaluation criteria in their meta-analysis of prevalence or incidence (Chen & Liu, 2015; Dai et al., 2016). The evaluation criteria used consist of eight items namely:

1. Participants (random sample or population).
2. Description of the study procedure.
3. Adequate sample size ( $\geq 300$ ).
4. Efficient and validated diagnostic tools.
5. Unbiased appraisal of the outcome.
6. Adequate response rate ( $\geq 70\%$ ).
7. Subgroup analysis.
8. Detailed description of the participants.

The quality score of each article is equal to the numbers of items satisfied. Each item is worth 1 point. Thus, the total quality scores of the included articles range from 0 to 8 points.

## **2.5 Statistical analysis:**

### **2.5.1 Combined prevalence calculation:**

The number of PTSD cases and the total sample size from each original study were collected through Excel, as to calculate the pooled PTSD prevalence and the heterogeneity statistics. Subsequently, the statistical software R version 3.6.3 was used to analyse the data retrieved (R Core Team, 2019). In order to calculate the pooled prevalence, an initial transformation of each study's proportions was performed using the Freeman-Turkey transformation of the inverse hyperbolic sine function, as to allow an accurate estimate of the pooled effect size. The Freeman-Turkey transformation method is recommended when high variability between studies proportions is reported, assumption matching the case of the data

collected for the current meta-analysis. The pooled prevalence of the transformed proportions was subsequently calculated using a random effects model. The choice of using a random effects model was motivated by the large between-study variability demonstrated both by the different effect sizes and by the particular demographic characteristics reported by the included studies (e.g. geographical area, cultural background, levels of exposure, number of victims, etc.; see Table 1 in the 3.1 section of the results for details). The characteristics as described in the Table 1 underline a large probability of reporting heterogeneity between studies. Therefore, using a fixed effect model as to combine together the prevalence from different studies would have resulted inappropriate.

### **2.5.2 Heterogeneity calculation:**

Heterogeneity was assessed by using three different statistics:

1. The Q statistics, which reflects a formal Chi-squared test with a statistic Q under the null hypothesis that all studies share the same true effect. The Q-test and its p-value serve as a test of significance against the null hypothesis ( $H_0: \tau^2 = 0$ ). If the value obtained is above the critical Chi-squared value, and a significant p. value is reported, the null hypothesis can be considered as rejected, and it is therefore possible to conclude that the effect sizes are heterogeneous (Borenstein et al., 2009).
2. The Tau-squared statistics, which reflects the amount of true heterogeneity on an absolute scale (Borenstein et al., 2009). That is, the total amount of systematic differences in effects across studies.
3. The I-squared statistics, which reflects the ratio of between-study variance to the observed variance. It is assumed that I-squared values of 25, 50 and 75% indicate low, medium and large heterogeneity respectively (Higgins et al., 2003).

### **2.5.3 Publication bias and Sensitivity analysis:**

Publication bias and sensitivity analysis were conducted by using the statistical software R version 3.6.3 (R Core Team, 2019). In order to verify whether publication bias might have had an influence on the validity of the pooled prevalence, a funnel plot was created to inspect visually the presence of publication bias. Subsequently, a linear regression method was used to test for asymmetry between studies. The Egger's regression test was used to detect the risk of publication bias by calculating asymmetry between studies: asymmetry test was considered statistically significant when  $p \leq 0.05$ . A significant result on the Egger's regression test demonstrates the presence of publication bias.

Sensitivity analysis was conducted as to investigate the influence of low-quality studies on the stability of the pooled prevalence. Such analysis involved re-running of the meta-analysis, but removing the studies reporting a quality score equal to or lower than 4 points. The choice of setting the cut-off score at 4 point was taken in accordance with previous studies published on scientific databases which used the same methodology (Chen & Liu, 2015; Dai et al., 2016).

### **2.5.4 Subgroup analysis**

Subgroup analysis were carried to evaluate the combined prevalence of the following categorical variables: gender, bereavement, time of PTSD assessment and level of education. The statistical software R version 3.6.3 was used to calculate the combined prevalence and the heterogeneity statistics for each variable (R Core Team, 2019). The statistical analysis followed the same procedure as described in the 2.5.1 section of the methods, both for combining each study's prevalence and for the heterogeneity statistics calculation. In addition, a comparison of the PTSD cases/total sample size proportions between each subgroup's population was done by carrying out a Chi-squared significance test. Data analysis was performed with SPSS Statistics for Windows 26.0 (SPSS) software (IBM Corp.,

2019). The results reporting a Q-value above the critical Chi-squared value and a significant p. value ( $\leq 0.05$ ) informed a significant difference between the variables analysed.

## **Chapter 3:**

### **Results**

#### **3.1 Literature Search and Study Characteristics**

The literature search provided an initial aggregate of 853 articles to be screened. As a final result of the screening process, 38 independent studies met the inclusion criteria specified, and were subsequently included in the present meta-analysis. The Figure 1 shows the screening process in details.



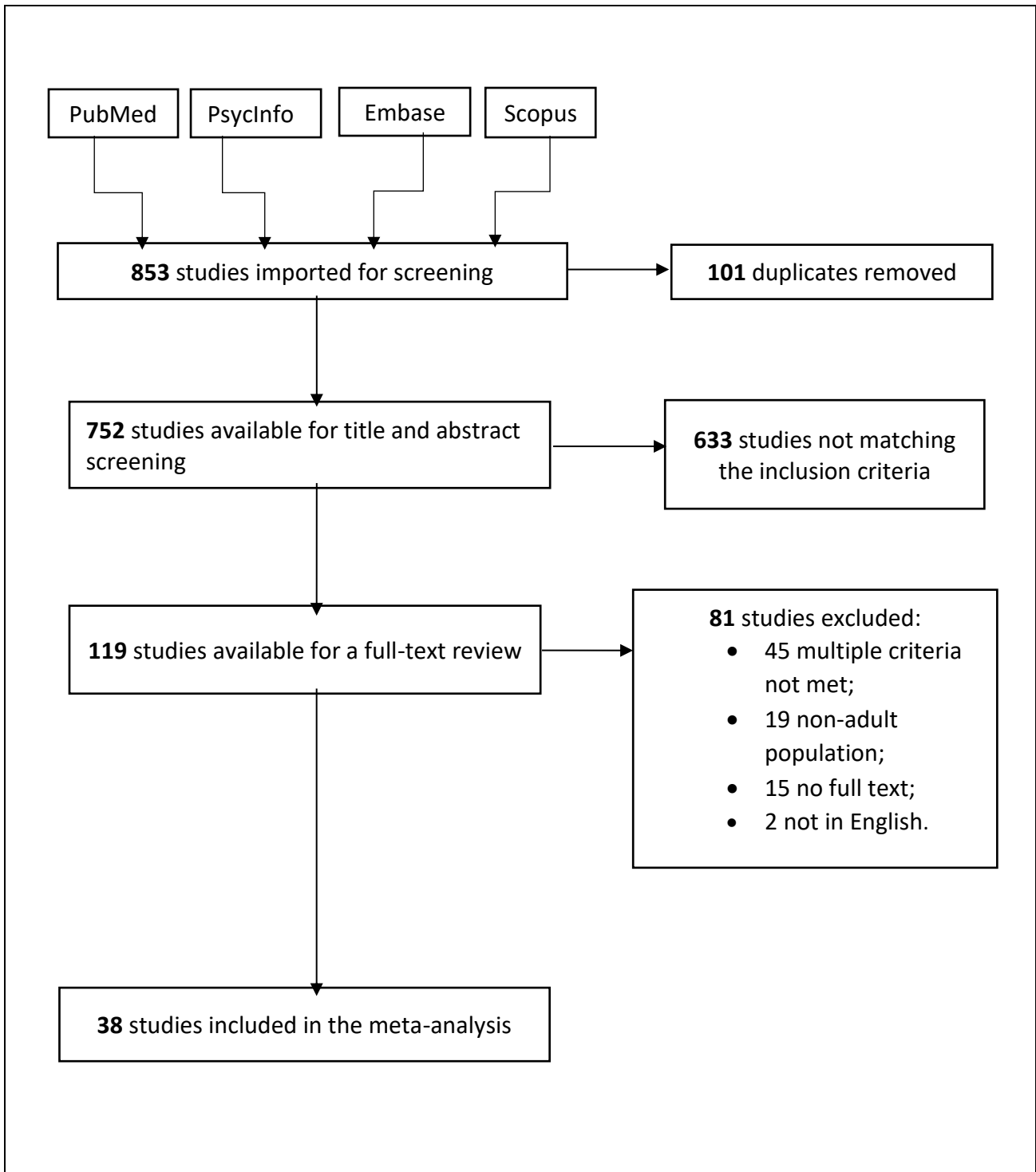


Figure 1: *The study screening process*

The majority of the studies were conducted in Asia (Nstudies= 26, n= 12717), followed by Latin America (Nstudies = 7, n= 6517), Europe (Nstudies = 4, n= 2553) and Africa (Nstudies = 1, n= 846). The most occurring types of natural disaster reported were earthquakes (N= 28), followed by tsunami (N= 4), hurricanes (N= 3), floods (N= 2) and landslides (n= 1). All the studies included were structured following a cross-sectional design. The assessment of PTSD varied across studies in terms of assessment tools utilized and time of assessment reported (range = 1 month - 17 years after the event). A total of 18 different assessment tools were utilized. In 34 studies PTSD was assessed by using self-report questionnaires, while in the other 4 PTSD was assessed through clinical and psychiatric interviews. The PCL (PTSD Checklist) was the assessment tool mostly utilized in the articles included (Nstudies = 14). The Table 1 shows the characteristics of each study included in details.

**Table 2:** Characteristics of the studies included in the systematic review and meta-analysis

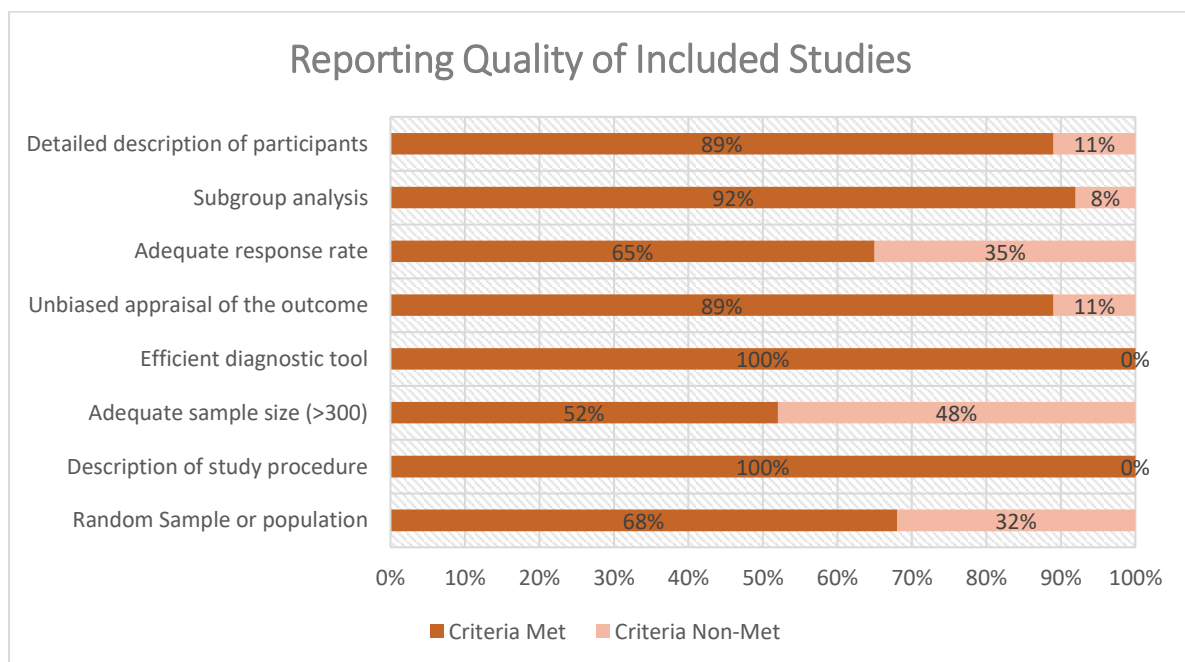
<i>Author</i>	<i>Publication Year</i>	<i>Country</i>	<i>Type of Disaster</i>	<i>N. of Deaths</i>	<i>PTSD Assessment tool</i>	<i>Time of assessment (months after the disaster)</i>	<i>Victims with PTSD</i>	<i>Total sample Size</i>
1) Adhikari et.al	2019	Nepal	Earthquake	8702	PCL-5	10	70	291
2) Ali et.al	2011	Iran	Earthquake	87,000	DTS	30	124	300
3) Asnakew et.al	2019	Ethiopia	Landslide	113	PCL-C	13	310	846
4) Basoglu et.al	2004	Turkey	Earthquake	18,000	TSSC	14	120	530
5) Cairo et.al	2010	Peru	Earthquake	596	PCL-C	5	75	298
6) Cenat et.al	2014	Haiti	Earthquake	222,000	IES-R	30	352	1355
7) Cerda et.al	2013	Haiti	Earthquake	222,000	PCL	3	323	1315
8) Chan et.al	2011	China	Earthquake	69,227	IES-R	7	135	243
9) Chan et.al	2016	Philippines	Cyclone	6300	PCL-C	2-4	18	192
10) Cheng et. al	2015	China	Earthquake	69,227	SCID	12	72	182
11) Chou et. al	2005	Taiwan	Earthquake		MINI	4-6	35	442
12) Caldera et.al	2001	Nicaragua	Hurricane	2000	HTQ	6	29	496
13) Dahal et.al	2018	Nepal	Earthquake	8702	PCL-C		99	535

14) Dai et.al	2017	China	Flood	4150	PCL-C	17years	31	325
15) Flores et.al	2014	Peru	Earthquake	596	PCL-c	4years	156	1012
16) Guo et.al	2017	China	Earthquake	69,227	IES-R	8years	161	1369
17) Hashmi et.al	2011	Pakistan	Earthquake	79,000	PCL	6	186	361
18) Hollifield et.al	2008	Sri Lanka	Tsunami	31,187	PSS-SR	12	19	89
19) Kilic et.al	2003	Turkey	Earthquake	18,000	TSSC	18	116	430
20) Kohn et.al	2005	Honduras	Hurricane	2000	CIDI	2	85	800
21) Kumar et.al	2007	India	Tsunami	280,000	HTQ	2	40	314
22) Kun et.al	2009	China	Earthquake	69,227	HTQ	3	203	446
23) Kun et.al	2013	China	Earthquake	69,227	HTQ	4	436	922
24) Kuo et.al	2007	Taiwan	Earthquake		DTS-C	12	45	272
25) Lai et.al	2004	Taiwan	Earthquake	2000	DTS/MINI	10	26	252
26) Onder et.al	2006	Turkey	Earthquake	15,226	TSSC	36	131	683
27) Rafiey et.al	2019	Iran	Earthquake	306	NSESSS-PTSD	36	224	600
28) Ranasinghe et.al	2007	Sri Lanka	Tsunami	35,000	PSS-I	6	147	264
29) Seyedin et.al	2017	Iran	Flood		PTSS-10	3	256	400
30) Tural et.al	2004	Turkey	Earthquake	15,226	PTSD-SS	3-11	231	910
31) vanGriensven et.al	2006	Thailand	Tsunami	5395	HTQ	2	77	1061
32) Wang et.al	2011	China	Earthquake	4821	PTSD-SS	1	257	409
33) Xu et.al	2011	China	Earthquake	69,227	PCL-C	12	226	704
34) Zhang,L; et.al	2015	China	Earthquake	69,227	PCL-C	5years	63	684
35) Zhang,W; et.al	2015	China	Earthquake	69,227	PCL-C	36	37	360
36) Zhang et.al	2011	China	Earthquake	69,227	PCL-C	12	311	1195
37) Zhang et.al	2012	China	Earthquake	2698	PCL-C	4	170	505
38) Zuniga et.al	2019	Mexico	Earthquake	467	DTS	3	532	1539

### 3.2 Reporting Quality of Included studies

Reporting quality across the included studies was high, with an average raw score of 6.57 (SD = 1.06, range 4 – 8) and percentage score of 82.23% (range 50% - 100%; refer Table 3 and Appendix B for details). More specifically, about 2/3 of the studies structured the population sampling through randomized techniques (Criterion 1; 68% fulfilled), while all the studies described the study procedure in details (Criterion 2: 100% fulfilled). However, only half of the studies met the minimum sample size required (Criterion 3: 52% fulfilled). All the studies used efficient and validated tools for PTSD assessment (Criterion 4: 100% fulfilled), with most of them demonstrating a reliable capacity of providing unbiased appraisal of the outcome (Criterion 5: 89% fulfilled). About 2/3 of the studies reported a response rate greater than 70% (Criterion 6= 65% fulfilled), and the majority of the studies reported subgroup analysis (Criterion 7= 92% fulfilled). In conclusion, most of the studies reported a detailed description of the participants and their demographic characteristics (Criterion 8= 89% fulfilled).

**Table 3:** Reporting quality of the included studies



### 3.3 Meta-Analysis

#### 3.3.1 Combined prevalence of PTSD

A total number of 22931 survivors of natural disasters were available for this systematic review and meta-analysis, with a median sample size of 603 survivors per study (range = 89 – 1539). The total number of survivors assessed with PTSD reported by the included studies was 5928. The prevalence of PTSD among survivors ranged from 7.2% (vanGriensven et al., 2006) to 64 % (Seyedin et al., 2017), and the heterogeneity test showed that the studies were highly and significantly heterogeneous (I-Squared = 98.8%, tau<sup>2</sup> = 0.03, p<0.001). Therefore, the decision of using a random effects model to assess the combined prevalence of PTSD as specified in the section 2.5.1 of the methods was supported by the high degree of heterogeneity obtained. As a result, the combined prevalence of PTSD among natural disaster survivors living in LMIC was 25.68% (95% confidence interval: 20.57 – 31.15 %). The Forrest plot in Figure 2 reports the characteristics of such analysis in details.

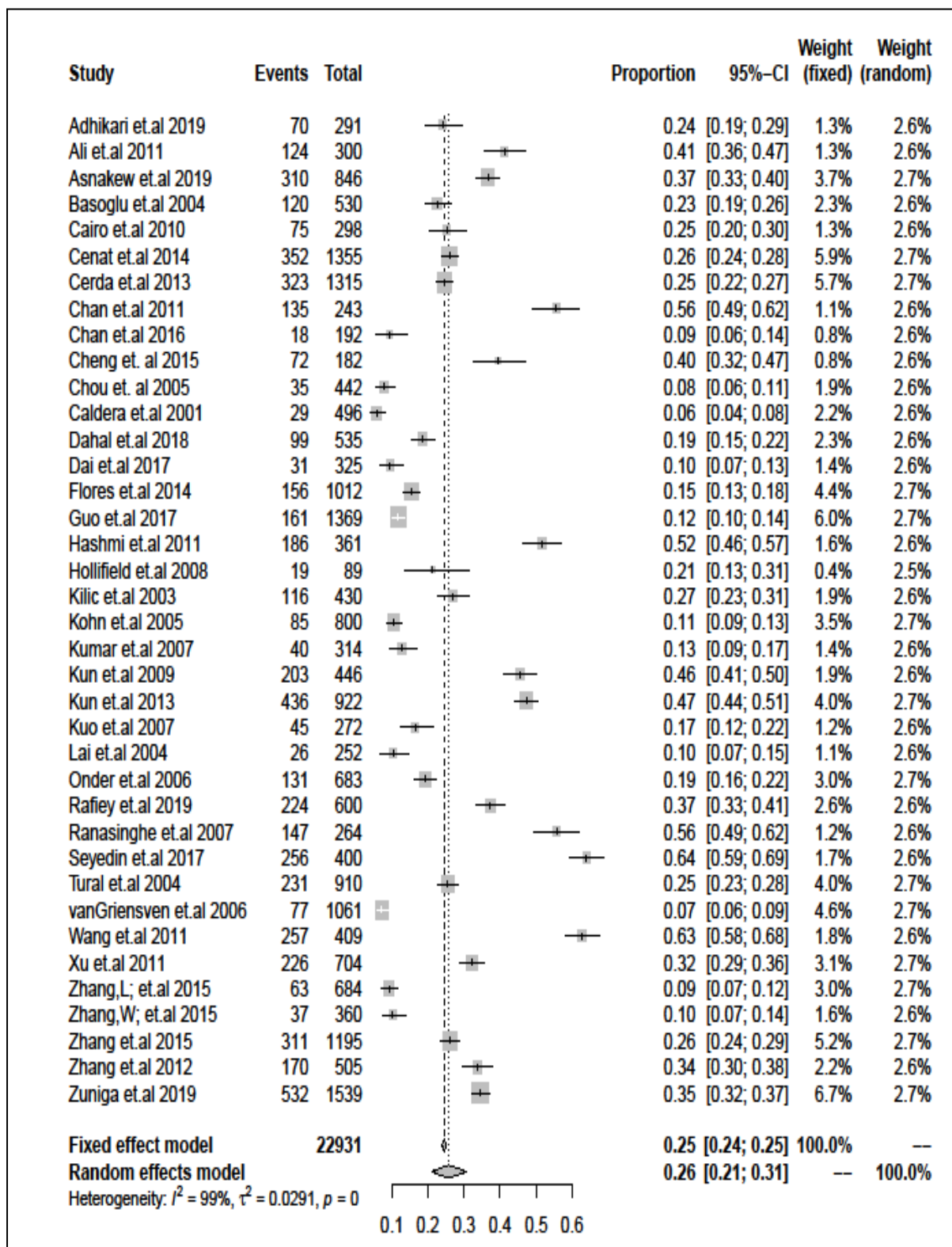


Figure 2: Forrest plot of the main study

### 3.3.2 Publication bias analysis:

Publication bias was assessed by using a linear regression analysis. A funnel plot was initially produced and inspected, reporting an overall symmetrical distribution of the studies and therefore a negligible possibility for publication bias (Figure 3). Subsequently, the Egger's regression test was performed, and a non-significant result confirmed the absence of asymmetry ( $z = 0.48$ ,  $p = 0.62$ ). Therefore, both the funnel plot inspection and the Egger's test score demonstrated a low risk of publication bias for the included studies.

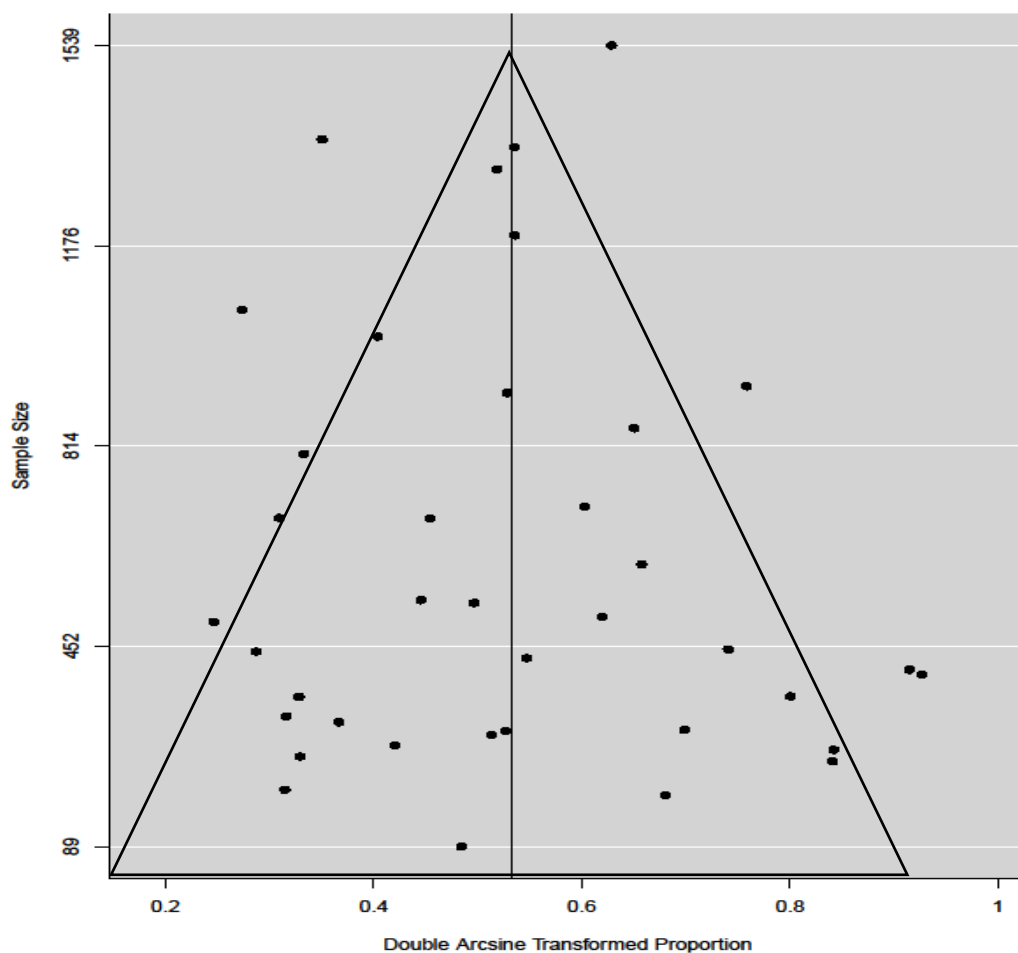


Figure 3: *Funnel plot of the included studies*

### **3.3.3 Sensitivity Analysis**

After excluding articles with a quality evaluation score equal to or lower than 4 points (Nstudies = 2), the combined prevalence of PTSD was 25.85% (95% CI: 20.58-31.49 %). The small increase of 0.17% reported after excluding low quality articles indicates low sensitivity and therefore credible results.

### **3.3.4 Subgroup Analyses**

Subgroup analyses were performed with respect to gender, bereavement, time of PTSD assessment and educational level. The results indicated that the studies included in each subgroup population were highly heterogeneous, supporting the decision of using a random effects model to combine PTSD prevalence as specified in the 2.5.1 section of the methods. The results showed that the pooled prevalence of PTSD among female survivors was higher than that of male survivors. Besides, the combined prevalence of PTSD for bereaved individuals was higher than that of non-bereaved ones. In addition, the combined prevalence of PTSD for survivors assessed within 1 year from the occurrence of the natural disaster was higher than that of survivors assessed 1 year after. In conclusion, the combined prevalence of PTSD among survivors with educational level at most primary school was higher than that of survivors with educational level higher than primary school. The results of the Chi-squared test showed that PTSD prevalence was significantly different according to gender, bereavement and time of assessment ( $P < 0.05$ ). No significant difference in PTSD prevalence was observed between different education levels ( $p = 0.457$ ). The Table 3 shows the details of subgroup analyses.



**Table 4:** Subgroup analyses results

Group	Number of studies	Prevalence % (95% CI)	P value (heterogeneity*)	I Squared (%)	P value (interaction **)
Total	38	25.68 (20.57 - 31.15)	< 0.001	98.8	
<b>Gender</b>					<0.000
Male	26	17.46 (12.82 – 22.63)	< 0.001	96.6	
Female	26	29.83 (23.35 – 36.75)	< 0.001	97.9	
<b>Bereavement</b>					<0.000
Yes	14	34.90 (24.25 – 46.36)	< 0.001	97.5	
No	14	18.50 (11.55 – 26.63)	< 0.001	98	
<b>Assessment time</b>					<0.000
Within 1 Year	20	28.65 (19.96 – 38.23)	< 0.001	99.6	
After 1 Year	18	24.47 (18.64 – 30.80)	< 0.001	98.4	
<b>Educational level</b>					<0.457
Primary school or below	18	25.12 (17.92 – 33.06)	< 0.001	97.72	
Secondary school or above	19	19.37 (12.71 – 27.02)	< 0.001	98.12	

\*p values for heterogeneity across studies were computed using Cochran's Q test

\*\*p values for comparison between subgroups were computed using the Chi Squared test with one degree of freedom

## **Chapter 4:**

### **Discussion**

#### **4.1 Key findings**

##### **4.1.1 Main Study:**

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. The current meta-analysis showed that one quarter of the adult population living in LMIC who experienced a natural disaster in the last 25 years have been assessed with PTSD diagnosis (25.68%, 95% C.I: 20.57 – 31.15 %). The results obtained provide further evidence with respect to what reported by previous articles studying PTSD prevalence in the aftermath of natural disasters (see section 1.5 of the introduction for details). These numbers underline the central role played by PTSD in such circumstances, confirming and expanding the information reported by previous studies describing the course and characteristics of such psychopathology.

Therefore, PTSD can be identified as one of the biggest threats for the health of adult individuals living in LMIC who experienced a natural disaster. In such regard, the results obtained provide further evidence about the crucial need for psychological intervention in such conditions.

##### **4.1.2 Subgroup Analysis:**

The results obtained from the subgroups analysis provide further evidence about particular individuals who appear to be more at risk to develop PTSD in the aftermath of natural disasters. Specifically, women, bereaved individuals and individuals assessed with PTSD within the first year from the occurrence of the disaster were found to be significantly more threaten by PTSD. Such results provide accurate information identifying those

survivors who appear to be in particular need for receiving mental health support, informing where to invest the available resources. If we take into consideration the limited opportunities experienced by LMIC to provide efficient intervention in post disaster environments, prioritizing those population who are reported being more at risk to develop PTSD become a necessity.

Therefore, the results of the present meta-analysis show that bereaved individuals appear to be almost twice at risk for developing PTSD (34.90%, 95% CI:24.25-46.36 %) than non-bereaved ones (18.50%, 95% CI: 11.55-26.63 %), as well as women (29.83 %, 95% CI: 23.35-36.75%) when compared with men (17.46%, 95% CI: 12.82-22.63%). Those results clearly identify these two categories as highly vulnerable, requiring particular attention when prioritising post disaster interventions in LMIC.

Moreover, the information provided by the analysis of individuals assessed before and after one year from the occurrence of the disaster confirms what previously discussed about the role played by PTSD in LMIC. Although a significant difference between individuals assessed within the first year (28.65%, 95% CI: 19.96-38.23 %) and those assessed after 1 year from the occurrence of the disaster (24.47%, 95% CI: 18.64-30.80 %) was found, the results provided show how chronic forms of PTSD appear to be a serious complication in LMIC, as a quarter of the population reports chronic forms of PTSD after one year from the experience of the trauma. As discussed in the section 1.5 of the introduction, extensive knowledge has been provided about how chronic and untreated forms of PTSD represent an extreme risk for mental health, compromising the possibilities for recovering a normal psychological functioning and lifestyle over time. These results demonstrate both the burden experienced by LMIC in dealing with PTSD and the crucial need for an efficient implementation of interventions on a longitudinal perspective.

In conclusion, the pooled prevalence of PTSD reported in individuals with an education level lower than secondary school (25.12%, 95% CI: 17.92-33.06 %) was higher than the one reported by individuals with education level at secondary school or higher (19.37%, 95% CI: 12.71-27.02 %). However, no statistically significant difference was reported between such categories. This result shows how educational level appears to play a secondary role influencing PTSD course for individuals living in LMIC who experienced a natural disaster.

#### **4.2 Limitations**

The goal of this research was to expand the knowledge of PTSD in the aftermath of natural disasters occurring in LMIC, as to suggest directions for future research and interventions. However, there were particular decisions made and limitations of the literature included that influenced the conclusions drawn.

First, the definition of LMIC as proposed by the World Bank included countries from different economic backgrounds, such as high middle income, low middle income and low income. Therefore, variability in terms of levels of poverty and availability of resources is likely describing the different contexts considered. Such variability could have influenced the course of PTSD between higher income countries and lower income ones within the group of LMIC.

Second, a wide range of PTSD studies with notable differences in assessment tools and sampling methods were included. In addition, the majority of the included studies (n=34) identified PTSD by self-reporting questionnaires rather than using clinical interviews conducted by professional psychiatrists, as a consequence of which the pooled prevalence of PTSD could have been overestimated.

Third, one of the biggest limitations is the fact that the included studies come from very different cultural background. Multiple cross-cultural factors could have limited the validity of the instruments applied and the capacity of providing reliable assessments of PTSD, as these instruments were primarily designed to assess psychopathology in high income countries. Without appropriate validation of assessments instruments in the particular cultural context, it is difficult to define whether specific instruments reflect systematic bias when used in a different setting than the one for which they were validated.

Fourth, given the complexity of defining traumatic event exposure, included studies are likely describing individuals who experienced different levels of exposure to the various natural disasters considered, potentially influencing the variability in PTSD prevalence reported between studies.

Fifth, high degrees of heterogeneity between studies have been reported for both the general population and each subgroups' populations. The limitations previously described, in addition with the wide demographic differences as reported in the Table 1 of the 3.1 section of the results, provide a rationale for such levels of heterogeneity. Explaining heterogeneity is a challenge that no previous meta-analysis has managed to accomplish when studying PTSD occurrence in the aftermath of multiple natural disasters happened in different environments.

Such information, in addition with the results provided by the current meta-analysis, underline how the particular characteristics demonstrated by each context and population involved in such events uniquely defines the course of PTSD. For this reason, caution should be used when interpreting the results provided by the current meta-analysis.

### **4.3 Strength**

The literature search for the current review found no evidence of existing meta-analysis that investigated the prevalence of PTSD among adult survivors of natural disasters

occurred in LMIC. Therefore, this is probably the first meta-analysis investigating PTSD prevalence for such population and types of traumatic events. The current meta-analysis has proved to be comprehensive in studying PTSD prevalence both considering a variety of contexts and types of natural disasters. The 38 included studies accounted for 22.931 natural disasters survivors and considered 15 different LMIC and 5 types of natural disasters. It is therefore understood that the results obtained could reflect the actual prevalence of PTSD after natural disasters for adults individual living in LMIC, expanding the knowledge about the topic.

The reported quality of the included studies was high, with an average score of 6.5 out of 8, informing a negligible risk for systematic errors and bias within the data retrieved. No risk for publication bias, as well as low sensitivity after excluding articles with the quality evaluation score equal or lower to 4 points, were reported. The statistical analysis used, as well as the software and the interpretation for the results provided, followed the guidelines as proposed by the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019), as well as the examples provided by previous meta-analysis published on scientific databases (Chen & Liu, 2015; Dai et al., 2016).

These results, in accordance with the systematic process used to conduct the research, can be considered as important factors in supporting the reliability and generalizability of the results obtained, despite the limitations previously exposed.

#### **4.4 Recommendations for Future Research**

The information provided by the current meta-analysis should be considered as to expand the knowledge about two major topics regarding the course of PTSD in the aftermath of natural disasters occurred in LMIC. On one hand, post-disaster intervention research should further explore which types of interventions provide optimal outcomes in LMIC, and

whether results vary depending on what types of characteristics. On the other, further evidence about the vulnerability reported by particular populations will help for a better understanding of where and how to implement functional interventions.

#### **4.4.1 Post-Disaster Intervention Research**

As described in section 1.5 of the introduction, several studies have demonstrated that the leading evidence-based psychological treatments for PTSD are EMDR (eye movement desensitization and reprocessing therapy) and TF-CBT (trauma focused -cognitive behavioural therapy), followed by combined somatic/cognitive therapies and self-help therapies with support (Mavranezouli et al., 2020).

However, few studies have reported about the implementation and efficacy of such interventions in contexts such as LMIC, especially when dealing with post disaster environments. The variety of social, cultural and health backgrounds describing LMIC represent a crucial factor determining the need for exploring extensively the relationship between therapeutical interventions and psychological outcomes observed. All the therapies above mentioned require highly specialized healthcare professionals as to deliver the treatments. Such factor can represent an issue for LMIC, where the possibility to access these types of services is reported to be limited in post disaster conditions, as well as the cultural acceptance of the delivery of particular therapeutical techniques (Bonanno et al., 2010; Weiss et al., 2003). Therefore, future studies should explore the efficacy of the therapies above mentioned in LMIC considering a cross-cultural perspective, as to provide further evidence about how and where to invest the economic resources as to promote efficient psychological treatments.

Previous studies have also reported the fundamental role played by social cohesion and social support as mediating factors increasing individual resilience to cope with disasters'

aftermath, as well as the impact that preparedness trainings has in reducing the risk for developing PTSD (McGuire et al., 2018; Welton-Mitchell, James & Khanal, 2018). Future studies should explore deeper the efficacy of community-based interventions in LMIC, as these types of interventions are reported having significant positive outcomes in reducing the impact of PTSD in communities affected by disasters (Goldman & Galea, 2014; IASC Guidelines, 2007; Welton-Mitchell, James & Khanal, 2018). These types of interventions could potentially meet the needs reported by LMIC, as the resources needed for the implementation are less demanding when compared with individualized therapeutical programs. In addition, such types of interventions could be implemented for the communities affected both as prevention and post disaster programs. Examples of community-based interventions enhancing preparedness to cope with disaster's aftermath, as well as social cohesion and social support, can be found in the literature (IASC Guidelines, 2007; Pan American Health Organization, 2012). The MHDP is an example of a community-based intervention which reported remarkable results, utilized in the aftermath of natural disasters happened in LMIC such as Haiti and Nepal (James, Welton – Mitchell & TPO Nepal, 2016).

However, minimal information about the techniques used and the results obtained when dealing with the course of PTSD in the aftermath of natural disasters occurred in LMIC are present in the literature. Therefore, future research should explore more in depth such topic.

#### **4.4.2 Evidence on Vulnerability:**

The present meta-analysis showed how women, bereaved individuals and individuals assessed within the first year from the occurrence of the disaster can be considered as extremely vulnerable population when dealing with PTSD in the aftermath of natural disasters happened in LMIC.



Previous research widely recognized how high levels of exposure (e.g. traumatic injuries, loss of the house and personal belongings, witnessing death), pre-existing health conditions and cumulative experience of disasters appeared to be constant factors influencing the course of PTSD both in LMIC and HIC (Bonanno et al., 2010; Goldman & Galea, 2014).

However, a broad range of potential risk factors could be evaluated as to expand the knowledge about those populations who would require particular needs for interventions. For example, previous studies have reported that children appear to be particularly threatened by PTSD in the aftermath of disasters (Bonanno et al., 2010; Goldman & Galea, 2014).

However, no previous studies analysed comprehensively such population when considering natural disaster occurring in LMIC. In addition, few studies explored the course of PTSD using longitudinal designs. As the results from the current meta-analysis underlined, long term forms of chronic PTSD severely threaten individuals living in LMIC in the aftermath of natural disasters. Therefore, future studies should explore more in depth the trajectories of PTSD over time, so as to understand if particular populations can be considered as more likely either to recover from psychopathology or to report chronic forms. In addition, further studies should investigate the role played by protective factors previously found as associated with lower risk for PTSD by considering LMIC, as well as the type of interventions which could enhance such factors. Examples of these protective factors are social support, social cohesion, gratitude, self-esteem, religiosity and adaptive coping strategies (Bonanno et al., 2010).

Expanding the knowledge in such areas could significantly improve the understanding and identification of the social targets needed to be prioritize for interventions. Developing a more accurate knowledge would help maximising the delivery of the limited resources usually available in LMIC. The benefits for the community affected by such events and challenging consequences could significantly improve if guided by this information.

#### **4.5 Conclusion:**

The results obtained confirm that PTSD represents one of the most serious and complex health problems for individuals involved in natural disasters. Moreover, the present findings identify that individuals living in LMIC are particularly threatened by this disorder. These findings also identify particular populations who are most in danger of developing PTSD in the aftermath of natural disasters, primarily women, bereaved individuals and individuals assessed within 1 year from the experience of the disaster.

The information reported expands the knowledge about the course of PTSD in the aftermath of natural disasters, providing accurate summaries and estimates of the psychopathology for specific populations “at risk”. In addition, the present findings offer new pathways for future research, and provide evidence-base and case for targeted interventions to prevent and reduce PTSD in the aftermath of natural disasters.

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*Note:* References marked with an asterisk denote studies included in the meta-analysis

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## Appendices

### Appendix A: Logic grids with Boolean Operators

PubMed

	PTSD	AND →	Prevalence	AND →	Natural disasters
OR →	“Stress disorders, post-traumatic” [mh]  Post-traumatic stress disorder*[tiab]  PTSD[tiab]  Post traumatic stress[tiab]  Posttraumatic stress[tiab]  Traumatic stress[tiab]	OR →	“Prevalence”[mh]  Prevalence[tiab]	OR →	'Natural disaster'/exp  ‘Natural disaster*’:ti,ab  ‘Earthquake’/exp  Earthquake*:ti,ab  ‘Avalanche’/exp  Avalanche*: ti,ab  ‘Hurricane’/exp  Hurricane*:ti,ab  Flood*:ti,ab  ‘Drought’/exp  Drought*:ti,ab  ‘Landslide’/exp  Landslide*: ti,ab  ‘Tsunami’/exp  Tsunami:ti,ab  ‘Tornado’/exp  Tornado*:ti,ab  ‘Wildfire’/exp  Wildfire*:ti,ab

## Ovid PsycInfo

	PTSD	AND →	Prevalence	AND →	Natural Disaster
OR →	Posttraumatic stress disorder.sh Posttraumatic stress disorder\$.ti Posttraumatic stress disorder\$.ab PTSD.ti PTSD.ab Post-traumatic stress.ti Post-traumatic stress.ab Traumatic stress.ti Traumatic stress.ab Posttraumatic stress.ti Posttraumatic stress.ab	OR →	Prevalence.ti Prevalence.ab	OR →	Natural disasters.sh Natural disaster\$.ti Natural disaster\$.ab Avalanche\$.ti Avalanche\$.ab Flood\$.ti Flood\$.ab Wildfire\$.ti Wildfire\$.ab Drought\$.ti Drought\$.ab

## Embase

	PTSD	AND →	Prevalence	AND →	Natural Disaster
OR →	'Posttraumatic stress disorder'/exp  'Posttraumatic stress disorder*':ti,ab  PTSD:ti,ab  'Post-traumatic stress':ti,ab  'Traumatic stress':ti,ab  'Posttraumatic stress':ti,ab	OR →	'Prevalence'/exp  Prevalence:ti,ab	OR →	'Natural disaster'/exp  'Natural disaster*':ti,ab  'Earthquake'/exp  Earthquake*:ti,ab  'Avalanche'/exp  Avalanche*:ti,ab  'Hurricane'/exp  Hurricane*:ti,ab  Flood*:ti,ab  'Drought'/exp  Drought*:ti,ab  'Landslide'/exp  Landslide*:ti,ab  'Tsunami'/exp  Tsunami:ti,ab  'Tornado'/exp  Tornado*:ti,ab  'Wildfire'/exp  Wildfire*:ti,ab



## Scopus

	PTSD	AND →	Prevalence	AND →	Natural Disaster
OR →	"Stress disorders, post-traumatic"  "Post-traumatic stress disorder"  "Post traumatic stress"  "Posttraumatic stress"  "Traumatic stress"			OR →	"Natural disaster"  Earthquake  Avalanche  Hurricane  Flood  Drought  Landslide  Tsunami  Tornado  Wildfire

## Appendix B: Quality assessment - Items met by each included study

+ = item met; \ = item not met

	1)Random sample or population	2)Description of study procedure	3)Adequate sample size (≥300)	4)Efficient diagnostic tool	5)Unbiased appraisal of the outcome	6)Adequate response rate (≥70%)	7)Subgroup analysis	8)Detailed description of participants	Total Score
1) Adhikari et.al	+	+	+	+	+	+	+	+	8
2) Ali et.al	\	+	+	+	+	+	+	+	7
3) Asnakew et.al	+	+	+	+	+	+	+	+	8
4) Basoglu et.al	+	+	+	+	+	+	\	+	7
5) Cairo et.al	+	+	\	+	+	\	+	+	6
6) Cenat et.al	\	+	+	+	+	\	+	+	6
7) Cerda et.al	+	+	+	+	+	+	+	+	8
8) Chan et.al	\	+	\	+	+	+	+	+	6
9) Chan et.al	\	+	\	+	\	\	+	+	4
10) Cheng et. al	\	+	\	+	\	\	+	+	4
11) Chou et. al	+	+	+	+	+	\	+	+	7
12) Caldera et.al	+	+	\	+	+	+	+	+	7
13) Dahal et.al	+	+	\	+	+	+	+	+	7
14) Dai et.al	+	+	+	+	+	\	+	+	7
15) Flores et.al	+	+	+	+	+	+	+	+	8
16) Guo et.al	\	+	+	+	+	\	+	+	6
17) Hashmi et.al	+	+	+	+	+	\	+	\	6
18) Hollifield et.al	+	+	\	+	+	+	+	\	6
19) Kilic et.al	+	+	+	+	+	+	+	+	8
20) Kohn et.al	+	+	+	+	\	\	+	+	6
21) Kumar et.al	+	+	\	+	+	+	+	+	7
22) Kun et.al	+	+	\	+	+	+	+	+	7
23) Kun et.al	+	+	\	+	+	+	+	+	7
24) Kuo et.al	\	+	\	+	+	\	+	+	5
25) Lai et.al	+	+	\	+	+	+	+	\	6
26) Onder et.al	+	+	\	+	+	+	+	+	7
27) Rafiey et.al	+	+	\	+	+	+	+	+	
28) Ranasinghe et.al	\	+	\	+	+	+	+	+	6

29) Seyedin et.al	+	+	\	+	\	\	+	+	5
30) Tural et.al	+	+	+	+	+	+	+	+	8
31) vanGriensven et.al	+	+	+	+	+	\	+	+	7
32) Wang et.al	+	+	+	+	+	+	+	+	8
33) Xu et.al	\	+	+	+	+	+	+	+	7
34) Zhang,L; et.al	+	+	+	+	+	\	+	+	7
35) Zhang,W; et.al	+	+	\	+	+	+	+	+	7
36) Zhang et.al	\	+	+	+	+	+	+	+	7
37) Zhang et.al	\	+	\	+	+	+	\	+	5
38) Zuniga et.al	\	+	+	+	+	+	\	\	5
<b>Total percentage of criteria met</b>	<b>68%</b>	<b>100%</b>	<b>52%</b>	<b>100%</b>	<b>89%</b>	<b>65%</b>	<b>92%</b>	<b>89%</b>	