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# The Impact of Earthquakes on the Mental Health of Children Living in Europe: a Systematic Review

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### **Abstract**

Earthquakes are the second deadliest natural disaster, and children exposed to them often experience various psychological health symptoms. This study investigates the consequences of earthquakes occurring in Europe on the mental health of children through a systematic review. The search identified 36 publications, of which 21 articles met the selection criteria and were included in the review. Reviewed studies indicated that children exposed to earthquakes commonly experience symptoms of PTSD, anxiety, and depression. The severity of these symptoms is influenced by factors such as proximity to the earthquake's epicenter and loss of loved ones. Coping mechanisms, such as emotional-focused coping skills and engagement in sports activities, play a role in promoting the psychological well-being of children affected by earthquakes. Gender differences are observed in certain studies, with females exhibiting higher rates of somatic symptoms, PTSD, depression, and anxiety than males, although these findings are not supported by all studies. Age differences are also evident, as children in middle childhood appear to be more vulnerable than children in other age groups. This study shows the lasting impacts earthquakes may have on children living in Europe and the need for appropriate support services in the aftermath of an earthquake. There are several limitations to be considered for future research to gain more insights into the consequences of earthquakes on children and how they cope.

*Keywords:* children, earthquakes, mental health, Europe

### **The Impact of Earthquakes on the Mental Health of Children Living in Europe**

Over the past years, there has been a global rise in the frequency of disasters; approximately 190 billion people worldwide are affected by disasters yearly (WHO, 2019; Sue et al., 2022). The consequences of these disasters involve the loss of family members, physical injuries, and forced migration (Brown et al., 2017). Among the victims, children constitute a significant proportion (Brown et al., 2017; Williams & McEwen, 2021). Children facing natural disasters encounter physical threats and lack coping skills, opportunities for community participation, and involvement in decision-making (Le Roux et al., 2022; Khalid et al., 2020). Consequently, children exposed to natural disasters often experience a range of heightened psychological health symptoms. These can include symptoms of depression, such as persistent feelings of sadness, loss of interest, and changes in appetite. They may also experience generalized anxiety, characterized by constant worrying, feeling tense or on edge, irritability, and difficulty concentrating. Additionally, posttraumatic stress disorder (PTSD) symptoms can emerge, including unwanted reexperiencing of the traumatic event, emotional numbing, avoidance of stimuli associated with the event, and heightened arousal. (Abel et al., 2021; Ehlers et al., 2000; Kar & Bastia, 2006; Navarro et al., 2016). The prevalence of mental health disturbances among affected children after a disaster ranges from 5% to 43% (Dyregrov et al., 2018).

Younger children's vulnerability to future stress and their early exposure to fragmentation and death in disasters may affect their personality development and lead to long-term consequences if not addressed (Daya et al., 2006). Maclean et al. (2016) found that children who experienced a natural disaster at five had an increased risk of mental health and substance use disorders in adulthood. Early exposure can also result in developmental delays. A study by Gomez and Yoshikawa (2017) revealed that preschool children who experienced an earthquake had lower performance in language and literacy assessments than unaffected

children. Moreover, parents' reports of stressors were negatively associated with language, literacy, and executive function outcomes in children, emphasizing the importance of parenting styles in the aftermath of a disaster for young children (Daya et al., 2006). Adolescents, on the other hand, exhibit higher rates of depression and posttraumatic stress compared to younger children in the aftermath of a disaster (Schwind et al., 2018; Sahin et al., 2007). They are also at greater risk of substance abuse, suicide, and exploitation following a disaster (Daya et al., 2006). Furthermore, experiencing traumatic events during adolescence, which is a critical period for identity formation, can have long-lasting effects on their personalities.

Earthquakes are humans' second deadliest natural disaster (Salcioglu & Basoglu, 2008). Their consequences extend beyond immediate physical damage due to their sudden occurrence, destruction, and aftermath (Turan et al., 2021). Similar to exposure to other natural disasters, children may experience stress reactions after an earthquake, and PTSD is commonly seen in children who have experienced one (Salcioglu & Basoglu, 2008; Turan et al., 2021). Other symptoms they may display are anxiety disorders, separation anxiety, school avoidance, enuresis (bedwetting), and psychosomatic problems, such as fatigue, insomnia, and migraines, resulting from earthquake exposure. Notably, earthquake-related fears and phobic avoidance tend to persist in children, with adolescents continuing to experience psychological consequences even years after the event, and PTSD prevalence remaining high 18 to 24 months post-disaster (Tanaka et al., 2016; Rezayat et al., 2020). Effective coping strategies, such as active or positive coping, can reduce PTSD symptoms, while passive or harmful coping strategies may exacerbate symptomatology (Powell et al., 2021). Maintaining typical roles, routines, and coping self-efficacy can help alleviate PTSD symptoms. Proximity to the earthquake and the severity of an earthquake are crucial factors that may influence the development of PTSD (Sahin et al., 2007), as well as parents' reactions and coping strategies

(Daya et al., 2006; Forresi et al., 2021; Maclean et al., 2016). Considering this context, it is essential to ensure that children receive the necessary mental health services after an earthquake, as not all can cope successfully (Dyregrov et al., 2018).

In general, there is a higher prevalence of PTSD among women compared to men in general (Garza & Jovanovic, 2017). Moreover, studies have shown that following exposure to natural disasters, women tend to experience elevated rates of PTSD and depression (Aksaray et al., 2006; Steinglass & Gerrity, 1990; Tang et al., 2014). Several factors contribute to these rates, including differences in subjective experiences of the disaster, coping and recovery strategies, and socially constructed gender roles (Akerkar & Fordham, 2017; Aksaray et al., 2006; Daya et al., 2006). Subjective experiences may be associated with cultural reasons, limited access to information and resource, and the class status of women, with poor women being the most vulnerable and impacted compared to men (Enarson et al., 2007; Khalid et al., 2020; Sahin et al., 2007). As for coping and recovery strategies, men's mental health recovery strategies may align with notions of control, while women's strategies may rely on caring and feeling at home (Akerkar & Fordham, 2017). Women may also be more affected if displacement is necessary. Socially constructed gender roles may contribute to the emotional and material burden in these situations for women, as they are often assigned the primary responsibility for caring for those affected by disasters (Daya et al., 2006). Additionally, women survivors often face more challenging living conditions and higher levels of depression, which may further contribute to their increased risk of developing PTSD. Similarly, among children, girls tend to report higher rates of PTSD and other mental health disturbances following an earthquake than boys (Rezayat et al., 2020; Seddighi & Salmani, 2019), and in a study of Sahin et al. (2007), female adolescents showed a disadvantaged position in terms of their symptoms and future expectation compared to younger children and male adolescents, suggesting gender differences in the aftermath of a disaster.

Although Europe has been relatively less affected by natural crises, such as earthquakes, than other regions (Witt et al., 2021), it is still essential to understand the consequences for children exposed to earthquakes occurring in Europe. Over the last 25 years, several earthquakes have struck different European regions. For example, in 2009, the city of L'Aquila in Italy was struck by an earthquake magnitude of 6.3. This event resulted in the loss of 297 lives, 1.000 injuries, displacement of 66,000 people, and extensive destruction and damage to thousands of buildings (Walters et al., 2009). Similarly, three years later, in 2012, the Emilia region of Italy experienced two additional earthquakes measuring 6.1 and 5.8 in magnitude, leading to 27 fatalities and widespread damage (Pezzo et al., 2013). In 1999, the metropolitan area of Athens, Greece, was hit by a 5.9-magnitude earthquake. One hundred forty-three individuals died, 800 were injured, 100 buildings collapsed, and numerous others suffered severe damage. This catastrophe left approximately 100.000 people homeless (Papadopoulos et al., 2000). Iceland also faced two significant earthquakes in 2000, measuring 6.6 and 6.5 in magnitude. While no casualties occurred, the infrastructure, buildings, and dwellings sustained severe damage, with three individuals sustaining minor injuries (Sigbjörnsson & Ólafsson, 2002). Moreover, the Netherlands currently experiences the seismically induced earthquakes in Europe, resulting from gas extraction activities. Induced earthquakes have occurred in the Netherlands' northern region since 1986 (Spetzler & Dost, 2017). The frequency of seismic events in the gas field has gradually increased. These induced earthquakes lead to housing damage and conflicts between residents and institutions, potentially impacting psychosomatic health outcomes (Stroebe et al., 2020).

While the impact of earthquakes has been extensively studied, more research is still needed, specifically examining the experiences of children exposed to earthquakes in Europe. Given potential cultural variations and other influencing factors, such as the severity of the earthquake and gender, it is crucial to gain a deeper understanding of the consequences faced

by European children and their coping mechanisms in such events, as children's vulnerabilities are often overlooked in planning and relief efforts (Khalid et al., 2020). Furthermore, support services may only meet some of the specific needs of the different age groups of children. For instance, while support services may be suitable for younger children, they may prove inadequate for adolescents due to their different coping mechanisms (Daya et al., 2006). Understanding the psychological impact of earthquakes on children is essential for providing adequate support after such events. Thus, the current study aims to investigate the psychological effects of five distinct aforementioned earthquakes on children. Additionally, potential differences in gender and age groups will be explored.

## **Method**

### *Search strategy*

For this systematic review, the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines are utilized (Moher et al., 2015). For a comprehensive literature search, electronic databases including MEDLINE, Web of Science, CINAHL, PsychINFO, Cochrane Register of Controlled Trials (CENTRAL), Google Scholar, and EMBASE were used to identify records that met the aforementioned inclusion criteria published from the year 2000 or later, the limited time available for conducting this study led to the decision not to include studies published before the year 2000. The initial literature search identified the following specific search terms: (Earthquake OR disaster) and (children OR child OR adolescent OR teen OR student OR boy OR girl OR kid OR paediatric) and (psychiatry OR psychology OR mental OR mental health OR mental illness OR mental outcomes OR mental disorder OR depression OR anxiety OR stress OR posttraumatic stress OR PTSD OR well-being OR mood OR insomnia OR coping OR sleep OR eating disorder OR behavioral changes OR ADHD OR autism OR intellectual disability) and (Europe OR EU OR European countries). Boolean operators were appropriately combined with the search

terms, and the search was conducted in titles, abstracts, and keywords. Searches were limited by the following specifications: empirical research published in peer-reviewed journals or conference proceedings in the English language, full-length available peer-reviewed papers, publication dates after 2000, and the last date of the literature search (April 2023).

The selection process involved two reviewers who used Endnote desktop to store references and identify and remove duplicates. The reviewers reviewed both abstracts and full texts to find eligible studies. They separately evaluated the eligibility requirements of the research, taking into account the intervention type, sample population, and recorded outcomes. In case of any discrepancies, the two reviewers discussed and reached a consensus. If a resolution could not be reached, a third reviewer was consulted.

### *Eligibility*

To be included, studies needed to report on the psychological impact of earthquakes occurring in Europe on "children," defined as individuals under 18 years old. All geographical European countries were included, except for transcontinental European countries (Azerbaijan, Kazakhstan, Russia, and Turkey). This exclusion is also due to the limited time available to conduct this research. Furthermore, this review included qualitative studies, quantitative studies, observational studies (including case-control, cohort, and cross-sectional studies), and clinical trials (including randomized and non-randomized controlled trials) that investigate the impact of both natural and man-made crises in European countries on the psychological health of children. Additional excluded publications were non-original studies, studies published in non-peer-reviewed journals, and studies that are not in the English language, as the reviewers do not master other languages and to keep the search small. In addition, it is essential to note that this study only included studies conducted in English to maintain a manageable scope for the review, and the reviewers were not proficient in other languages. Conference abstracts without corresponding full-length peer-reviewed papers and



unpublished research such as dissertations and theses will also not be considered for inclusion. Additionally, studies that do not report on the psychological impact of crises on children will be excluded.

#### *Data Extraction and Quality Appraisal*

Each study was extracted into an Excel spreadsheet. The two reviewers individually performed the data retrieval. Through conversation, an agreement was achieved. The following data was extracted from the qualified studies:

- Study characteristics: study design, year of publication, and geographical location of study conduct.
- Participant characteristics: sample size, age (e.g., mean with standard deviation, range), gender, measurement methods, and measurement time.
- Study characteristics: the aim of studies, psychological health, results.

Two reviewers conducted a quality appraisal of the selected papers using the Cochrane Collaboration's Risk of Bias (CCRB) tool (Higgins et al., 2011; Institute, 2017) was used to measure the risk of bias for selected articles with randomized designs, evaluating bias in five dimensions, including selection bias, performance bias, detection bias, attention bias, and reporting bias. The assessment of the Critical Appraisal Skills Programme (CASP) checklist was utilized to evaluate the risk of bias in qualitative studies, which is recommended by the Cochrane Collaboration for qualitative literature (Hannes, 2011). This tool comprised ten questions, nine addressing quality and one addressing 'value.'

For each reviewed study, the type of study, country of the earthquake, sample size, age of participants, the study's time frame concerning the earthquake, and the measures to assess the impact on the children were entered into a table. In addition, a summary of the findings related to the earthquake's impact on the children appears in the table.

#### *Data synthesis*

Given the heterogeneity and variation of the reviewed studies, particularly concerning the wide range of disasters examined, a statistical aggregation of the data was not used in this systematic review. Instead, a narrative synthesis approach was employed. A narrative synthesis is an approach to systematic reviews that relies mainly on words and text to summarize and explain findings (Popay et al., 2006). While it is typically considered a "second-best" approach to synthesis in systematic reviews, it is a crucial method for interpreting findings and is widely used in policy and practice. This approach explored the psychological consequences for children exposed to a crisis. Three steps were followed to conduct a narrative synthesis (Popay et al., 2006):

1. Develop a theory of the different psychological consequences, why, and for whom.
2. Creating a preliminary synthesis of the results obtained from the included studies
3. Analyzing the data to identify any relationships that may exist
4. Evaluate the strength and reliability of the synthesis.

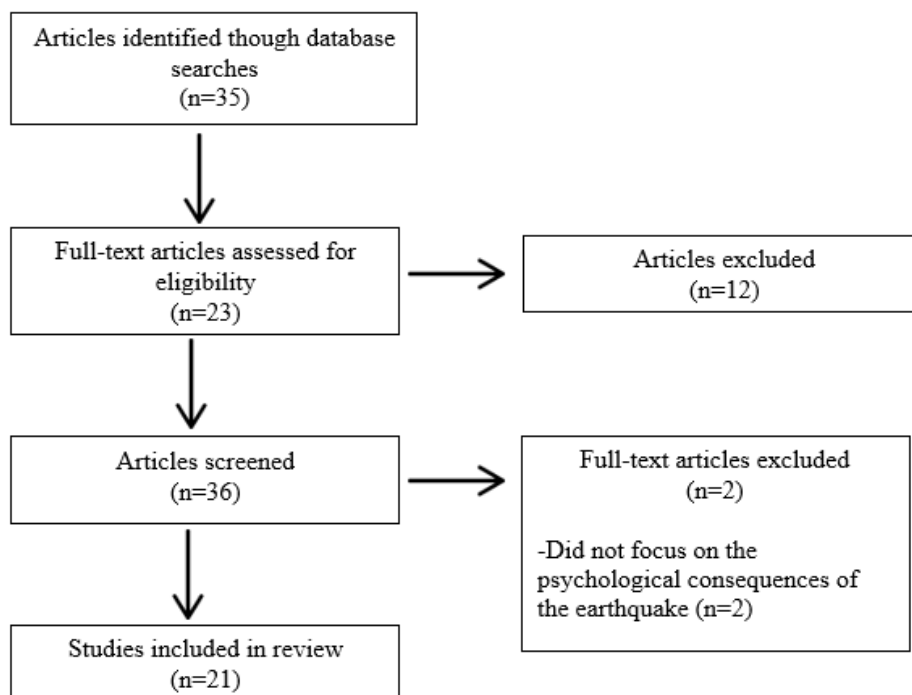
The initial step of this process is critical to understanding the study's findings and assessing their generalizability. The second step involves developing a preliminary synthesis that specifically identifies the impact the crises have on children's psychological health. The third step involves exploring relationships within the data to understand better the effect of the different types of crises on children and how and if they differ. Finally, in the fourth step, the robustness of the synthesis will be assessed to determine the strength of the evidence for concluding the identified psychological consequences. Three methods were utilized to develop the preliminary synthesis: textual descriptions, grouping and clusters, and tabulation. Textual descriptions were used to create a descriptive paragraph of the included studies. Grouping and clusters were used to categorize studies according to their types, contexts, and outcomes, which aided in analyzing and identifying patterns. Additionally, tabulation was utilized to summarize key findings in a table to aid data analysis.

### Articles included

The initial search identified 35 publications that were potentially relevant to the study. After screening the titles and abstracts, 12 articles were excluded as they needed to meet the criteria for the study. The complete reports of the remaining 23 articles were thoroughly reviewed. Upon further examination, two articles were excluded as they primarily focused on interventions rather than exploring the psychological consequences of the earthquake on children. As a result, 21 articles were included in the review (see Figure 1).

**Figure 1**

*Prisma Diagram*



### Results

The review included a total of twenty-one studies representing various study designs. The studies were conducted in four different countries, capturing diverse earthquake events (see table 1). Nine of the included studies were conducted more than one year after the earthquake to assess the long-term psychological effects of earthquakes on children. This allowed for a deeper understanding of the enduring impact of earthquakes on the participants'

psychological well-being. The sample sizes across the studies varied, ranging from twenty to 2291 participants. The age range of the participants was generally between three and eighteen years old, except for one study that included individuals up to twenty years old. To facilitate analysis and interpretation, the included studies classified participants into three distinct age groups: early childhood (0-6 years old), middle childhood (7-11 years old), and adolescence (12-18 years old). This stratification allowed for a comprehensive exploration of the psychological consequences experienced by children and adolescents across different developmental stages following earthquakes.

### *Symptoms*

Several studies have consistently reported a high prevalence of posttraumatic stress disorder (PTSD) symptoms among children directly or indirectly exposed to earthquakes (Dell'Osso et al., 2011; Giannopoulou et al., 2020; Kolaites et al., 2003; Groume & Soureti, 2010; Zijlstra et al., 2002; Forresi et al., 2021; Carmassi et al., 2020; Dell'Osso et al., 2014; Vaccarelli, 2015; Feo et al., 2014). These symptoms often include perceiving the event as an extreme stressor, anxiety, and depressive symptoms. The severity of PTSD symptoms in children was found to be influenced by the proximity to the earthquake's epicenter; studies conducted by Roussos et al. (2005), Groume and Soureti (2010), and Forresi et al. (2019) revealed a positive association between proximity to the epicenter and higher PTSD symptomatology. Additionally, children who experienced more frequent post-earthquake difficulties at home also exhibited higher scores of PTSD and depression (Roussos et al., 2005; Groume & Soureti, 2010; Forresi et al., 2019). Coping mechanisms were identified as essential factors in the psychological well-being of earthquake-affected populations. Stratta et al. (2014) found higher levels of emotional-focused coping skills among individuals impacted by the earthquake, which served as a mediator between life stress and suicidal ideation. Engagement in sports activities emerged as a protective factor for adolescents exposed to

earthquakes. Valenti et al. (2012) reported that adolescents involved in sports demonstrated better adaptive responses to earthquake exposure than those not engaged in sports.

### *Age and Gender*

Several studies have examined gender differences in mental health outcomes following earthquakes. According to the results, females exhibited significantly higher rates of somatic symptoms, which may be associated with their elevated PTSD rates, partial and full-blown PTSD, scored higher on the Depression Self-Rating Scale, and had higher anxiety symptoms than males (Dell'Osso et al., 2011; Giannopoulou et al., 2020; Groome & Soureti, 2003; Roussos et al., 2005). In examining the resilience of adolescents, Stratta et al. (2013) found that female adolescents exhibited lower resilience scores and utilized problem-focused coping strategies to a lesser extent than their male counterparts. On the other hand, several studies did not identify significant gender differences in their outcomes (Vaccarelli, 2015; Feo et al., 2014; Valenti et al., 2012; Stratta et al., 2014; Forresi et al., 2019; Kolaites et al., 2003; Groome & Soureti, 2010).

Regarding age differences, three studies found that the younger children in their study experienced more severe posttraumatic stress (PTS) and anxiety symptoms and that younger children were more affected by earthquake-related fears, darkness, nightmares, and monsters compared to older children (Giannopoulou et al., 2006; Groome & Soureti, 2003; Vaccarelli et al., 2015). The younger children in these studies were all in middle childhood and compared to adolescents. The findings of Groome and Soureti (2003), who discovered that nine-year-old children residing in the most damaged districts exhibited more severe PTS symptoms than fourteen-year-olds, also found a reverse effect for children living in the least damaged district. Feo et al. (2014) reported a lower prevalence of mental health symptoms in preschool children than in older children. Children in middle childhood, aged 6-10 years old, exhibited a higher burden of psychiatric symptoms, such as anxiety, PTS, and depressive

symptoms, compared to younger (3-5 years old) and older children (11-14 years old). However, Forresi et al. (2019) did not find indications of increased symptomatology in either primary school children or adolescents based on their developmental period. Furthermore, Raccanello et al. (2017) found that older children, particularly girls, demonstrated a better understanding of emotions.

### *Predictors*

Bereaved students exhibited significantly higher rates of PTSD and PTS symptoms compared to non-bereaved students (Dell’Osso et al., 2011). The study also found that emotional problems stemming from the loss, rather than the loss itself, were predictive of delayed onset PTSD. Proximity to the earthquake's epicenter and the severity of damage to homes and districts were identified as important predictors of higher or more severe PTSD symptoms (Groome & Soureti, 2010; Kolaites et al., 2003; Forresi et al., 2019; Roussons et al., 2005). Other predictors of PTSD symptoms following an earthquake included parental psychopathology, disaster-linked life events, subjective earthquake-related experiences, pre-existing health problems (e.g., autism and depression), economic disruption, and relocation (Dell’Osso et al., 2011; Forresi et al., 2019; Roussons et al., 2005; Valenti et al., 2011; Bodvarsdottir et al., 2003). On the contrary, Feo et al. (2014) found that parents' level of education played a protective role in children's mental health.

### *Short-term vs. long-term*

Both Roussons et al. (2005), examining short-term effects, and Groome & Soureti (2010), examining long-term effects, highlight the contribution of proximity to the epicenter in the manifestation of higher PTSD symptoms. Additionally, findings from various studies indicate that younger individuals are more susceptible to PTSD symptoms and are more vulnerable to the lasting negative impact of trauma (Feo et al., 2014; Giannopoulou et al., 2020). Furthermore, studies investigating either short-term or long-term effects consistently

report the presence of PTSD symptoms following earthquakes, with studies on long-term effects often reporting higher percentages of individuals experiencing PTSD or PTSD symptoms (Feo et al., 2014; Dell'Osso et al., 2011; Dell'Osso et al., 2014; Forresi et al., 2019; Kolaites et al., 2003).

#### *Natural vs. unnatural*

One study investigated the effects of man-made earthquakes caused by gas extraction in Groningen (Zijlstra et al., 2022). Despite the differences in the earthquake source, this study suggests that people's perception of earthquakes remains unaffected. The continuous nature of the earthquakes in Groningen poses challenges for recovery from the stressors experienced by adolescents during such seismic events.

#### *Measures*

Of the included studies, thirteen were cross-sectional studies, two were observational studies, two were intervention studies, one was a qualitative study, one was a cohort study, one was a pre-post study, one was a field study, and one was a longitudinal study, as shown in table 1.

Various measures have been utilized to assess the impact of earthquakes on children's psychological well-being. Researchers have employed several self-report instruments to evaluate the psychological effects of earthquakes on children. One such instrument, the Trauma and Loss Spectrum Self Report (TALS-SR), has been utilized in four studies conducted by Carmassi et al. (2020), Dell'Osso et al. (2011), Dell'Osso et al. (2014), and Stratta et al. (2014). In addition, the Moods Spectrum-Self Report (MOODS-SR) has been employed in two articles by Dell'Osso et al. (2014) and Carmassi et al. (2020). Furthermore, the Resilience Scale for Adolescents (READ) has been utilized in two separate studies conducted by Stratta et al. (2014) and Stratta et al. (2013). The Impact of Event Scale-revised (IES) was used in two different studies conducted by Dell'Osso et al. (2011) and Groome and

Soureti (2010). Other measures employed in assessing the impact of earthquakes on children included the Child Behavior Checklist (CBCL) (Feo et al., 2014), the Strengths and Difficulties Questionnaire (SDQ) (; Forresi et al., 2019), the UCLA PTSD-index for DSM-IV (Feo et al., 2014; Dell'Osso et al., 2011; Roussons et al., 2005), the Symptom Checklist-90 (SCL-90) (Forresi et al., 2019; Forresi et al., 2021), the Minnesota Multiphasic Personality Inventory-Adolescents (MMPI-A) (Valenti et al., 2012), The Brief Cope (Stratta et al., 2013), The Vineland Adaptive Behavior Scales (VABS) (Valenti et al., 2011), the Child PTSD Reaction Index (CPTS-RI) (Bödvarsdóttir et al., 2013), the Trauma Symptom Checklist (TSC) (Bödvarsdóttir et al., 2013), the Crisis Support Scale (CSS) (Bödvarsdóttir et al., 2013), the Depression Self Rating Scale (DSRS) (Roussons et al., 2005), the Earthquake Exposure/Experience Questionnaire (Giannopoulou et al., 2020), The Children's Depression Inventory (CDI) (Giannopoulou et al., 2020), the Screen for Child Anxiety Related Emotional Disorders (SCARED) (Giannopoulou et al., 2020), the Revised Children's Manifest Anxiety Scale (RCMAS) (Groome & Soureti, 2010), and the Earthquake Trauma Exposure Scale (Groome & Soureti, 2010).

Moreover, researchers have also utilized qualitative methods such as focus groups, semi-structured interviews, and interviews to gain deeper insights into children's experiences in the aftermath of earthquakes. Zijlstra et al. (2020) and Raccanello et al. (2017) employed these qualitative approaches in their studies to capture nuanced information. Additionally, Vaccarelli (2015) employed a research tool to assess participants' thoughts, representations, and ideas of the city before and after the earthquake, providing a comprehensive understanding of the participants' perspectives.



**Table 1***Study Characteristics*

Authors	Sample Size	Age/ Grade	Country/ Event	Method	Measurement Method	Outcomes
Feo et al. (2014)	2291	3-14 years old	Italy, L'Aquila 2009	Cohort study, 12-17 months after earthquake	Child behavior checklist (CBCL), the Youth Self Report (YSR)	Identification of high-risk populations, specifically children aged 6-10 residing in the epicenter, exhibiting elevated rates of psychiatric symptoms following earthquakes, highlighting the importance of targeted public health interventions in complex emergencies.
Forresi et al. (2019)	682 children, 1162 parents	9-14 years old	Italy, Emilia 2012	Epidemiological cross-sectional study, 2 years after earthquake	University of California at Los Angeles Posttraumatic Stress Disorder Reaction Index for DSM-5 (UCLA PTSD-index for DSM-IV), Strengths and Difficulties Questionnaire (SDQ), Symptoms Checklist-90 (SCL-90)	Youths may experience PTSD symptoms alongside behavioral and emotional challenges, making long-term monitoring and interventions crucial
Vaccarelli (2015)	310	7-13 years old	Italy, L'Aquila 2009	Cross-sectional study, 3 years after the earthquake	Research tool to study: feelings an recurrent thoughts; representation and the idea of city before and after the earthquake; future expectations	Children experiencing a catastrophic event, coupled with the challenges of urban life, undermines their connection with the city and alters their overall perception of their living environment.

Dell'Osso et al. (2011)	457	last year high school students	Italy, L'Aquila 2009	Cross-sectional study, 3 years after earthquake	Impact of Event Scale-revised (IES), Trauma and Loss Spectrum-Self Report (TALS-SR)	Adolescents who survived the L'Aquila earthquake displayed high rates of post-traumatic spectrum symptoms, with a stronger association between experiencing the loss of a close friend or relative during the earthquake and elevated PTSD rates along with more severe symptoms.
Dell'Osso et al. (2014)	475	Last year high school students	Italy, L'Aquila 2009	Cross-sectional study, 3 years after earthquake	Moods Spectrum-Self Report (MOODS-SR), Trauma and Loss Spectrum Self Report (TALS-SR)	A significant correlation between mood disorders and PTSD, specifically linking lifetime depressive and manic symptoms with PTSD was found. The study emphasizes the impact of PTSD on the frequency of traumatic exposures and maladaptive behaviors.
Valenti et al. (2012)	149	14-18 years old	Italy, L'Aquila 2009	administration: 02-2009, few months after the earthquake follow-up	Minnesota Multiphasic Personality Inventory-Adolescents (MMPI-A)	Incorporating sports as a coping strategy can help address the psychological changes in adolescents and mitigate the earthquake-induced effects on their personalities, emphasizing the importance of relevant social policies.
Stratta et al. (2014)	343	17-18 years old	Italy, L'Aquila 2009	april, 2011.	Resilience Scale for adolescents (READ), Coping Orientation to Problems Experienced Inventory (Brief	Adolescents exposed to traumatic events may exhibit externalizing problems and maladaptive behaviors, as evidenced by the

					Cope), Trauma and Loss Spectrum Self Report (TALS-SR)	positive correlation between emotion-focused and problem-focused scores.
Carmasi et al. (2020)	450	Last year high school students	Italy, L'Aquila 2009	Cross-sectional study, 3 years after earthquake	Trauma and Loss Spectrum-Self Report (TALS-SR), Mood Spectrum Self-Report (MOODS-SR)	Survivors with PTSD had significantly higher rates of MOODS-SR somatic symptom endorsement compared to those without, with females reporting higher rates. However, further analysis confirmed that PTSD had a significant effect, and the presence of MOODS-SR somatic symptoms was associated with re-experiencing and maladaptive coping TALS-SR domains.
Stratta et al. (2013)	471	17-18 years old	Italy, L'Aquila 2009	Cross-sectional study, 2 years after earthquake	Resilience Scale for adolescents (READ), Coping Orientation to Problems Experienced Inventory (Brief Cope)	Males exposed to the earthquake exhibited consistently higher READ factor scores and preferred problem-focused coping strategies, suggesting an interaction that aligns with a potential resilient "protective mechanism" for males.
Valenti et al. (2011)	60	Younger than 18 years old	Italy, L'Aquila 2009	Longitudinal study, 1.5 years after earthquake	Vineland Adaptive Behavior Scales (VABS)	Participants who were exposed to the earthquake experienced a significant decline in adaptive behavior in the initial months. Nevertheless, immediate and intensive post-disaster intervention showed

						promising signs of partial recovery in adaptive functioning among children and adolescents with autism.
Dell'Osso et al. (2011)	512	Last year high school students	Italy, L'Aquila 2009	Cross-sectional study, 10 months after earthquake	Trauma and Loss Spectrum-Self Report (TALS-SR), Impact of Event Scale (IES)	Adolescents who survived the April 2009 L'Aquila earthquake experienced elevated rates of full or partial PTSD, with a higher impact observed among women.
Forresi et al. (2021)	843 children, 1162 parents	9-15 years old	Italy, Emilia 2012	Cross-sectional study, 2 years after earthquake	Questionnaire on traumatic exposure, University of California at Los Angeles Posttraumatic Stress Disorder Reaction Index for DSM-5 (UCLA PTSD-index for DSM-IV), Symptom Checklist-90-Revised (SCL-90-R)	Earthquake exposure, past trauma, and parental internalizing symptoms individually predicted PTSD in offspring from high-impact areas, while an interaction between earthquake exposure and parental depression or anxiety was also observed, whereas in low-impact areas, youth PTSD was solely predicted by earthquake exposure, and a significant reverse pattern was found with offspring PTSD explaining parental psychopathology.
Raccanello et al. (2017)	127	Second grade and fifth grade	Italy, Emilia 2012	Cross-sectional study, 2 years after earthquake	Semi-structured interview	Exposure to the earthquake did not affect the understanding and regulation of emotions, but the comprehension varied by class level and gender, with children who experienced the earthquake

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						demonstrating more complex, frequent, and intense knowledge of earthquakes, emotional language, and associated emotions as they grew older.
Bödvar sdóttir et al. (2013)	140	10-15 years old	Southwe st Iceland, 2000	Cross- section al study, three months after earthqu ake	Child PTSD Reaction Index (CPTS-RI), Trauma symptom Checklist (TSC), Crisis Support Scale (CSS), Demographic and Stressor questions	Immediately after the earthquake, exposed children reported more emotional support compared to controls, which was not the case at three months post-earthquake; additionally, exposed children who desired but did not receive crisis intervention had significantly higher PTSD symptoms than other groups.
Zijlstra et al. (2022)	27	12-20 years old	Netherla nds, Groninge n since 1986	Qualitat ive study, 2022	Qualitative analysis	Anxiety and feelings of endangerment in adolescents were influenced by both personal experiences and the impact of earthquakes on their social environment, including building restoration, while various sources of support were mentioned to cope with the negative consequences; lack of trust in the government emerged as a significant theme, highlighting relevant needs for policymakers in the Netherlands, with adolescents in the gas extraction area of Groningen facing

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						inhibitions in expressing anxiety and fear.
Roussos et al. (2005)	1937	9-8 years old	Greece, Athens 1999	School-based observational study, 3 months after earthquake	Questionnaire on traumatic exposure, University of California at Los Angeles Posttraumatic Stress Disorder Reaction Index for DSM-5 (UCLA PTSD-index for DSM-IV), Depression Self-Rating Scale (DSRS)	High rates of severe to mild PTSD symptoms and a significant proportion of depression in the exposed group were found. The importance of post-earthquake difficulties at home and subjective earthquake-related experiences in predicting the severity of PTSD was highlighted. Girls scored higher on PTSD and depression measures.
Vezzali et al. (2014)	517	7-12 years old	Italy, Emilia 2012	Field study, 6 months after earthquake	Questionnaires based on common ingroup identity model	Perceiving the earthquake as a threat was associated with stronger ingroup-outgroup connections and increased willingness to support outgroup victims among majority children, while immigrant children showed no such associations.
Giannopoulou et al. (2020)	517	9-17 years old	Greece, Athens 1999	Cross-sectional study, 6-7 months	Post-Traumatic Stress Disorder Reaction Index for Children (CPTSD-RI)	Greater perceived threat during the earthquake predicted the severity of PTSD symptoms, post-earthquake adversity

				after earthquake		level predicted depression severity, and female gender predicted the severity of anxiety symptoms.
Kolaitis et al. (2003)	163	Fourth, fifth, and sixth grade	Greece, Athens 1999	Cross-sectional study, 6 months after earthquake	Earthquake Exposure/Experience Questionnaire, Children's Depression Inventory (CDI), Screen for Child Anxiety Related Emotional Disorders (SCARED extended version), Impact of Event Scale (IES), State and Trait Anxiety Inventory (STAI), Strengths and Difficulties Questionnaire (SDQ)	The earthquake-exposed group exhibited a high prevalence of severe to mild PTSD symptoms, along with a significant proportion meeting criteria for depression compared to the control group, with severe or moderate PTSD symptoms correlating with higher depression scores. The association between PTSD symptoms and anxiety was specifically linked to the "avoidance" factor of the anxiety questionnaire, and the most affected subgroups were children who were alone during the earthquake and those who sustained injuries.
Groome & Soureti (2010)	178	9-14 years old	Greece, Athens 1999	Observational/correlational study, 5 months after earthquake	Impact of Events Scale (IES), Revised Children's Manifest Anxiety Scale (RCMAS), Earthquake Trauma Exposure Scale	Age did not have a direct impact on anxiety or PTSD symptoms, but significant interactions between age and other variables were found, with the youngest children in the closest region to the epicenter reporting the highest PTSD and anxiety symptom scores, while the older

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children in the furthest region reported the highest scores.

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### **Discussion**

This systematic review aimed to determine the effects of earthquakes in Europe on the mental well-being of children who have experienced such events. The review aimed to explore the various factors related to the impact of earthquakes on children, including age and gender. The findings indicate that the most prevalent symptoms observed in children exposed to an earthquake are PTSD, anxiety, and depression. Although these symptoms are present in both the short- and long-term following an earthquake, more children experience PTSD or PTS symptoms over the long term. These results are consistent with previous literature, suggesting that exposure to earthquakes can have a lasting impact on children's mental well-being.

According to the results, children in middle childhood tend to be more affected by earthquakes than in adolescence. They reported more PTSD and anxiety symptoms, which are seen in both the short- and long-term aftermath of an earthquake. The study by Feo et al. (2014) reported that three to five years old showed fewer psychiatric symptoms than six to ten years old, indicating that children in early childhood may be less affected compared to children in middle childhood. These findings align with previous research that suggests that younger children are more susceptible to the adverse psychological effects of earthquakes (Seddighi & Salmani, 2019; Schwind et al., 2018). Incorporating these findings into support services and individuals' efforts is crucial to effectively assist children across various age groups. Specifically, it is important to recognize that children in middle childhood exhibit



greater vulnerability compared to adolescents, highlighting their heightened need for support in the aftermath of an earthquake.

However, this review lacks research on the consequences for children under six, leading to almost no information on the consequences of earthquakes on children in early childhood. Apart from Feo et al. (2014) and Valenti et al. (2011), all studies include children aged five years or older. With the current literature available, it is difficult to draw conclusions on children in early childhood in this review. This is a limitation, as this review aimed to investigate potential differences in impact and coping of the different age groups. The distinction in needs between younger children and adolescents in the aftermath of an earthquake has been acknowledged (Daya et al., 2006), and a similar differentiation may exist between early and middle childhood due to their distinct developmental stages. Although young children in early childhood may have trouble expressing their emotions, it is important to investigate the consequences they face in the aftermath of earthquakes. Neglecting their specific needs and failing to provide adequate support could have long-term repercussions on their mental health and overall development throughout their lives (Daya et al., 2006; Gomez & Yoshikawa, 2017). Therefore, further exploration is necessary to comprehend the consequences experienced by early childhood children exposed to earthquakes in Europe.

Studies exploring gender differences in the context of earthquake-induced mental health outcomes for children showed inconsistent results. In general, the studies that suggest a difference in gender report that females show more PTSD symptoms, anxiety, and depression than males. Furthermore, males show more resilience than females and show more problem-focused coping, which may cause resilience to act as a buffering intervention after exposure to an earthquake (Stratta et al., 2014). There were, however, also studies that did not report any gender differences. This is in line with the study by Kar and Bastia (2006), who also mentioned the controversy in the literature on gender differences; some report that females are

more likely than men to report symptoms of anxiety and posttraumatic stress, while others fail to demonstrate these differences. It is important to investigate the differences, as there is not one conclusion in this systematic review. However, it seems that the consequences do not necessarily need to be different for females and males, but that their coping strategies differ, resulting in other symptomology (Akerkar & Fordham, 2017). Furthermore, different factors may influence how boys and girls react to the earthquake. It is important to address this and implement it in support services, especially for children, as good support afterward may help prevent the development of further PTSD, anxiety, and depression symptoms. It is also important for children to be able to process their trauma.

Additional factors and predictors that contribute to PTSD symptoms in children are discussed in the results section. These predictors are largely consistent with previous literature and may shed light on the variations observed in gender differences across different studies, as mentioned in the article by Kar and Bastia (2006). The identified predictors include proximity to the epicenter, loss of loved ones, pre-existing health problems, and subjective earthquake-related experiences. These findings align with previous research by Aksaray et al. (2006), Tang et al. (2014), and Salçioğlu & Basoğlu (2008), who conducted a comprehensive review of studies investigating the effects of earthquakes worldwide. The earthquakes investigated in this review had different magnitudes; some made more victims than others. The severity of an earthquake plays a crucial role in the aftermath and subsequent impact. The reviewed studies focused on only five earthquakes in Europe, but it is important to acknowledge that numerous earthquakes have occurred in Europe over the past decades with different magnitudes and impacts. Therefore, further exploration of the consequences of earthquakes in Europe, even in cases of smaller-scale events, would be valuable. Such research would enhance the understanding of the specific services and interventions needed for different types of earthquakes across Europe.

The results of Zijlstra et al. (2022) showed that the personal impact of seismic-induced earthquakes is similar to natural earthquakes because of the constant stressors children are exposed to due to the gas extraction in Groningen. This gradually affects their mental health and has individual, social, and economic consequences. This is in line with the research of (Stroebe et al., 2021), which focused on adults affected by the seismic-induced earthquakes in Groningen. However, these studies are the only two in this systematic review investigating the impact of seismic-induced earthquakes in Europe. Conclusions on the effects of unnatural earthquakes in Europe cannot be drawn as there is a lack of research available concerning this specific type of earthquake.

#### *Limitations and future directions*

A limitation of the systematic review was the heterogeneity of methodologies employed across the included studies. Variations in study design, measurement tools, and sample characteristics may have influenced the consistency of the findings. Furthermore, the reliance on self-report measures for assessing symptoms raises concern regarding recall biases and subjective interpretation of the experiences. It is important to consider these methodological limitations carefully when interpreting the results and drawing conclusions.

Another limitation of this study is its reliance on a single qualitative study (Zijlstra et al., 2022). While the quantitative studies provided valuable insights into the consequences of earthquakes on children, they may need more contextual information to interpret the findings comprehensively. Additional qualitative studies should be conducted to gain a deeper understanding of the psychological impact, coping mechanisms, and subjective experiences of children in the aftermath of an earthquake. Combining quantitative and qualitative approaches would enable researchers to analyze and interpret the results more effectively. Furthermore, this study focused specifically on seismic-induced earthquakes, and it would be beneficial to include qualitative studies on other earthquakes as well, as most earthquakes in Europe are

natural. Therefore, future investigations should incorporate quantitative and qualitative studies to ensure a more holistic understanding of the subject matter.

Seismic-induced earthquakes may have distinct impacts due to constant stressors, and further research is needed to better understand the consequences of such earthquakes, particularly on children, as only one study investigated the impact of seismic-induced earthquakes on children in this review. Moreover, the existing literature primarily focuses on adolescents and adults (Stroebe et al., 2011; Zijlstra et al., 2022), with limited attention given to children under twelve. Gaining insights into the perspectives of younger children and comprehending the unique effects of these earthquakes on them is crucial for providing targeted assistance and support that aligns with their specific needs.

The inconsistent findings regarding gender differences following an earthquake highlight the need for further research. Future research should clarify the potential differences between boys and girls and explore the underlying mechanisms that contribute to these differences. Moreover, focusing on the coping styles boys and girls adopt after experiencing an earthquake might be interesting, as they seem different for both boys and girls. This might help better understand the potential differences and how support services could improve their services. Furthermore, future research should aim to include children in early childhood in their studies to gain more insight in the consequences for that age group.

Additionally, one study focused on the impact of earthquakes on children with autism and their mental health, revealing their unique reactions compared to non-autistic children. This was the only study focusing on children with different characteristics and it emphasizes the necessity for additional research encompassing children with varying attributes, such as disabilities, races, and ethnicities. Understanding how these factors interact with childhood experiences in such circumstances is crucial for developing more effective strategies for support and intervention. By acknowledging the diverse identities of children, a deeper

comprehension of the intricate dynamics at play can be achieved, resulting in the ability to provide the essential support for every child.

### **Conclusion**

In conclusion, this systematic review indicates that earthquakes have a significant and lasting impact on the mental well-being of children in Europe, with symptoms such as PTSD, anxiety, and depression being common. Middle childhood appears to be a particularly vulnerable period, while limited research exists on the effects on younger children. Gender differences in symptomology and coping strategies require further investigation for tailored support services. Factors such as proximity to the epicenter, loss of loved ones, pre-existing health problems, and subjective experiences contribute to the severity of symptoms. However, more research is needed to understand the effects of earthquakes, including unnatural ones, and to incorporate qualitative studies for a comprehensive understanding. Particular attention should be given to the experiences of children with autism and other characteristics, as the current literature is limited. By addressing these gaps in knowledge, appropriate interventions can be developed to support children's mental well-being after earthquakes.

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