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COMMENT

Echoes of the earthquake: evidence-based suggestions for the management of psychological consequences of earthquakes

Fabio Del Missier[a], Lucia Savadori[b], Alessandro Galvagni[c], Elena Pezzi[b], Giuseppe Scurci[b], Alessia Patacca[b], Mauro Dolce[d] and Daniela Di Bucci[e]

[a]Department of Life Sciences, University of Trieste, Trieste, Italy; [b]Department of Economics and Management, University of Trento, Trento, Italy; [c]Protezione Civile della Provincia Autonoma di Trento, Trento, Italy; [d]Department of Structures for Engineering and Architecture, University of Naples "Federico II", Naples, Italy; [e]National Civil Protection Department, Rome, Italy

ABSTRACT

Experiencing an earthquake can be a traumatic event, sometimes followed by another negative experience represented by post-earthquake temporary displacement. Both can have serious and lasting consequences on people's wellbeing, quality of life, and life satisfaction even years after the traumatic event. These consequences can hinder the recovery of individuals and communities affected by an earthquake. After summarizing our previous investigations of psychological consequences in individuals who faced different experiences in terms of temporary displacement from their home after an earthquake, we provide a new empirical contribution on the predictors and correlates of autobiographical memory of post-traumatic stress disorder (PTSD) symptoms in individuals who had or had not been displaced from their homes after three Italian earthquakes ($n = 340$). We also examined the association between the PTSD memory measure and measures of wellbeing, quality of life, life satisfaction, and event-related health impairment. Being female, having lower individual resilience and stronger place attachment, having been or still being displaced from home, and having higher current risk awareness were associated with higher scores on the PTSD memory measure. Higher scores were also associated with lower current wellbeing, lower current and expected quality of life, lower life satisfaction during displacement, and more severe perceived health consequences. The results suggest that experiencing an earthquake followed by prolonged displacement hinders recovery from the negative psychological effects of the disaster. Overall, the reviewed research suggests the need for tailored interventions at the individual, social, and management levels to prevent and manage the negative psychological consequences of earthquakes at different stages of the disaster risk management cycle.

List of abbreviations: C.A.S.E: Complessi Antisismici Sostenibili Ecocompatibili (Sustainable, Eco-Friendly, Earthquake-Resistant Complexes); DRM: Disaster Risk Management; M.A.P: Moduli Abitativi Provvisori (Temporary Housing Modules); Mw: Moment magnitude (earthquake magnitude); OSF: Open Science Framework; PTSD: post-traumatic stress disorder

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CONTACT Lucia Savadori lucia.savadori@unitn.it Department of Economics and Management, University of Trento, Via Inama 5, 38122 Trento, Italy.

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Introduction

The main aim of this paper is to offer evidence-based suggestions for potential interventions, to be applied at different stages of the disaster risk management cycle, to prevent and manage the negative psychological consequences of earthquakes. To this aim, we will first summarize the results of our previous investigations on the earthquake-related psychological consequences in individuals who faced different experiences in terms of temporary displacement from their home. Next, we will provide a new empirical contribution on the predictors and correlates of autobiographical memory of post-traumatic stress disorder (PTSD) symptoms in people affected by the three most recent strong Italian earthquakes. Finally, we will rely on our results and related empirical evidence to suggest examples of potential interventions.

Negative psychological consequences of temporary housing and their predictors

Research has reliably documented the negative psychological consequences of earthquakes, such as depression (e.g. Cénat and Derivois 2014; Önder et al. 2006), anxiety (e.g. Yıldırım et al. 2025), PTSD (Dai et al. 2016; Naeem et al. 2011), fear for the future (e.g. Salcioglu, Ozden, and Ari 2018), lower life satisfaction and perceived quality of life (Savadori et al. 2024; Sunarti et al. 2021). A specific aspect that contributes to these negative consequences is the displacement from damaged or collapsed homes. Displacement after a disaster can have adverse consequences mainly in relation to two aspects: the lower quality of the new temporary accommodation, and the disruption of the ordinary life activities and social relationships (Di Bucci et al. 2023). The quality of temporary housing encompasses various aspects, including appropriate privacy, space, thermal and acoustic insulation, light, quality of materials, and surroundings (Caia, Ventimiglia, and Maass 2010). Poor temporary housing quality can negatively affect life satisfaction (Di Bucci et al. 2023) and quality of life (Savadori et al. 2024). Moreover, the inappropriate placement of temporary housing may have a role in making more difficult the resumption of ordinary life activities related to education, work, socialization, health, and services (Félix, Branco, and Feio 2013). Additionally, a stronger attachment to the original place and community can make more painful the experience of displacement, negatively affecting quality of life (Savadori et al. 2024).

Di Bucci et al. (2023) analyzed life satisfaction of displaced people accommodated in temporary housing after three strong earthquakes that occurred in Italy in 2009 (Abruzzo), 2012 (Emilia), and 2016–2017 (Central Italy). Their measure of life satisfaction encompassed job prospects, educational opportunities, financial situation, personal safety, social life, outdoor activities, natural beauty, overall climate, and cultural opportunities. These authors considered, as potential predictors of life satisfaction during displacement, socio-demographic features, temporary housing type and quality, measures of social support and protection network, personal psychological resources and preparedness, and psychophysical health. The significant predictors of life satisfaction in the whole sample were earthquake preparedness, the specific earthquake experienced, quality of the protection network, temporary accommodation type and quality, and general health status. On the one side, these findings point to the need of appropriate structural and management interventions, involving the provision of high-quality temporary housing and the development of a strong protection network. On the other side, they suggest considering individual aspects by improving the level of personal preparedness and addressing health outcomes. Another significant insight from this research was that partly different predictors explained life satisfaction in the analysis of single earthquakes, pointing to the need to consider earthquake specificity and peculiarities and necessities of the local contexts (Félix, Branco, and Feio 2013).

Another relevant study for appraising the role of displacement and temporary housing was carried out by Savadori et al. (2024) on the same Italian earthquakes considered by Di Bucci et al. (2023). This study used a measure of perceived quality of life (Cantril Self-Anchoring Ladder) to compare three groups of individuals: those who had been displaced after the

earthquake but are no longer displaced, those who are still displaced, and those who have never been displaced. Participants' evaluations of quality of life were collected in reference to four time points: pre-earthquake (retrospective), during displacement (if applicable - retrospective), at the time of the survey (current), and in 10 years (prospective). In the non-displaced group, there was no significant variation in perceived quality of life. Those who were formerly displaced perceived a significant decline in their quality of life after the earthquake but a significant recovery after the conclusion of the displacement. Those who were still displaced at the time of the survey reported the lowest perceived quality of life both at the time of the survey, with no significant recovery over the years, and in their future estimates. The perceived decline in the quality of life in displaced participants was significantly predicted by the quality and type of temporary accommodation, place attachment, and perceived health impairment. The subsequent improvement in perceived quality of life was predicted by quality and type of temporary accommodation, risk awareness, and emotional well-being. These findings underscore the negative impact of temporary displacement on current and expected quality of life and the importance of the quality of temporary accommodation in the moderation of the negative effects of displacement.

Post-traumatic consequences of earthquakes and their predictors

An important facet of the negative psychological consequences of an earthquake is represented by the often observed occurrence of a post-traumatic stress disorder (PTSD), whose incidence varies with the degree of exposure to the disaster (e.g. Dai et al. 2016; Naeem et al. 2011), gender (e.g. Dai et al. 2016; Kun et al. 2009; Naeem et al. 2011), displacement or relocation (e.g. Kun et al. 2009), and exposure to death in family or friends (e.g. Cénat and Derivois 2014; Kun et al. 2009). A recent study on the devastating 2023 earthquakes in Turkey showed high levels of trauma exposure and PTSD among survivors and confirmed that significant risk factors include gender and exposure to death and traumatic events (Han Alpay et al. 2024). Another study in the same context highlighted the role of perceived social support and individual resilience in attenuating the traumatic experiences (Yıldırım et al. 2025).

Although some studies documented the nonnegligible presence of PTSD even years after the event (e.g. Cénat and Derivois 2014; Önder et al. 2006), to our knowledge no study investigated the remembered experience of post-traumatic symptoms several years after the earthquake in relation to the displacement status of people affected. However, an autobiographical account of the earthquake as a traumatic experience, related to environmental and personal factors, may negatively affect wellbeing and quality of life after several years, and temporary displacement may contribute to the development of such traumatic memories. Thus, we filled this gap by analyzing the memory of PTSD symptoms in people affected by the same three Italian earthquakes studied by Di Bucci et al. (2023) and Savadori et al. (2024).

Our main hypothesis was that temporary displacement may not offer the adequate psychological conditions for trauma recovery after an earthquake (Kun et al. 2009; Savadori et al. 2024; Yokoyama et al. 2014) and may well represent another traumatic experience, thus making recovery even more difficult. Consequently, individuals who are still displaced or were displaced (vs. not displaced) from their home after an earthquake should remember the post-traumatic symptoms they experienced in the aftermath of the event as more severe and more frequent. In particular, individuals who are still displaced should expose the most traumatic memories. Moreover, we expected that significant predictors of PTSD detected in previous studies (e.g. gender, resilience, exposure to death) would also predict the remembered severity and frequency of PTSD symptoms. In addition, remembering the earthquake experience as more traumatic should be associated with lower current and future quality of life and current wellbeing, and with lower life satisfaction during displacement.

Methodological overview

The three earthquake contexts

We focused on three main seismic events occurred in Italy, each affecting distinct socio-geographical contexts: the 2009 Abruzzo earthquake (also known as L'Aquila earthquake), the 2012 Emilia earthquakes, and the 2016–2017 Central Italy sequence (Norcia). The 2009 Abruzzo earthquake (Mw 6.3) severely affected the urban area of L'Aquila, resulting in 309 fatalities and over 67,000 people displaced. Approximately 34,000 homes were rendered uninhabitable, and temporary housing included seismically isolated C.A.S.E. complexes and M.A.P. wooden prefabricated houses, as well as self-lodging grants. The 2012 Emilia earthquakes (Mw 5.9 and 5.7) impacted a quite densely inhabited and industrialized region of the Po Valley, causing 26 fatalities and the displacement of around 16,500 individuals. Temporary housing in this context mainly consisted of container modules, self-lodging grants, and rented accommodations. The 2016–2017 Central Italy sequence (Mw up to 6.5) struck a rural and mountainous area with low population density but widespread structural damage, causing 299 fatalities and affecting approximately 80,000 buildings, with consequent displacement of about 31,700 people. Temporary housing included prefabricated homes, and self-lodging grants. The distinct characteristics of each event—urban versus rural, concentrated versus dispersed damage—profoundly influenced both displacement patterns and recovery strategies.

Study sample

The study involved 340 adults who had experienced at least one out of the three main earthquakes mentioned in the previous paragraph. Participants were categorized into three groups based on their displacement status: currently displaced ($n = 98$), formerly displaced ($n = 163$), and non-displaced ($n = 79$). Currently displaced individuals were still living in temporary houses at the time of the study. Formerly displaced participants had returned to permanent houses. In contrast, non-displaced individuals suffered the earthquake, but their house remained usable. Demographic characteristics of the sample are presented in Table S1 of Supplementary Materials. The Ethical Committee of the University of Trento approved the research protocol (number 2020–039). Data is available at OSF (https://osf.io/v4uzc/?view_only=42a510ae41a24aa8a12b1d454df29473)

PTSD memory measure

Four items of the Davidson Trauma Scale (Davidson et al. 1997) relevant to the earthquake context were selected to create an indicator of remembered trauma. Each item was associated to a different cluster of symptoms according to Asmundson et al.'s four-factor model (Asmundson et al. 2000). The items measured physical distress from event-related memories (reexperiencing), avoidance of event-related thoughts and feelings (avoidance), difficulty imagining the future (numbing), and difficulty concentrating (hyperarousal) (see items 58a–58d of the questionnaire in Table S4 of Supplementary Materials). Participants rated retrospectively each item's frequency and severity on five-point scales, 5 to 12 years after the earthquake (data were collected in 2021), with a reference time frame of 2/3 months after the earthquake. A PTSD memory score was computed by multiplying the frequency and severity score for each item and then taking the average of these four values.

Predictor variables in regression models

We collected demographic variables including age, gender, education, income, and employment status. Psychosocial constructs such as resilience, place attachment, individual vulnerability

and preparedness, and risk perception were measured using validated scales. Event-related variables were also collected, including length of the displacement, social support, support from the protection network, exposure to death and suffering, and temporary house quality. Information on the variables used as predictors in the regression models in which the PTSD memory measure was the criterion variable can be found in Tables S2 and S3 of Supplementary Materials.

Key findings

Significant differences in memory of PTSD symptoms were observed across the groups of formerly displaced, currently displaced, and non-displaced individuals, $F(2, 297) = 18.7$, $p < .001$,$\eta^2_p = .112$ (see Figure 1). Currently displaced individuals reported the highest mean PTSD memory scores ($M = 11.95$, $SD = 5.26$), followed by formerly displaced individuals ($M = 10.43$, $SD = 4.85$), while non-displaced individuals had the lowest PTSD memory scores ($M = 7.44$, $SD = 4.50$). Post hoc comparisons using the Tukey test indicated that the PTSD memory scores of all groups significantly differed from each other ($p < .05$). These findings suggest that displaced participants held a more traumatic representation of the earthquake several years after the event than participants who did not leave their homes. Moreover, this representation was less traumatic in participants who eventually left their temporary houses than in participants who were still displaced at the time of the survey.

We carried out a first hierarchical regression, based on a layered model of earthquake-related variables (e.g. Di Bucci et al. 2023), to identify the significant predictors of PTSD memory scores. Due to the structural absence of values for some of our predictor variables in the nondisplaced group (e.g. nondisplaced participants have no values for some variables related to displacement), we could not include the displacement status variable in this first regression. The regression analysis indicated as significant predictors of the PTSD memory score the following variables: sex, resilience, place attachment, and current risk awareness (details in Tables S4 and S5, see also Figure S1 of Supplementary Materials).

These significant predictors were then employed in a second hierarchical regression, based on same layered model, in which we could also include the displacement status of respondents without facing problems with structural missing values (details in Tables S6 and S7 of Supplementary Materials). The final model of the second regression (Model 4), $F(6, 290) = 28.9$,

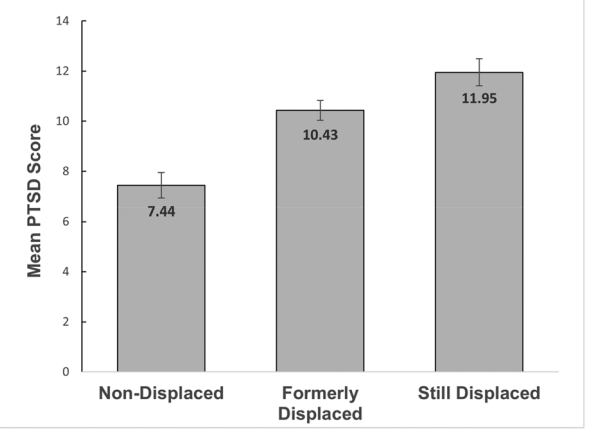

Figure 1. Mean PTSD memory scores by displacement status among people affected by the earthquakes. Error bars represent standard errors.

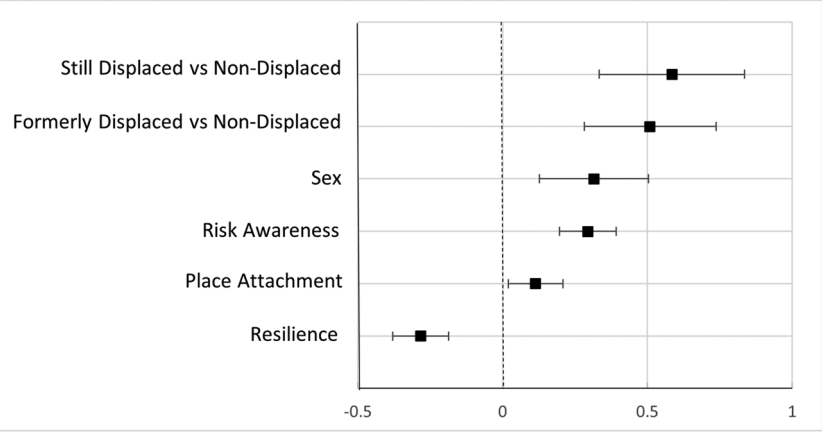

Figure 2. Standardized beta coefficients and 95% confidence intervals from the final regression model predicting the PTSD memory score among people affected by the earthquakes. All predictors shown were statistically significant at $p < .05$. Positive values indicate a positive association between the predictor and the PTSD memory score, and negative values a negative association.

$p < .001$, explained a substantial proportion of variance in PTSD memory scores, $R^2 = .374$, *adjusted* $R^2 = .361$. All predictors in the final model were statistically significant (see Figure 2 for standardized coefficients and their 95% confidence intervals).

Being female was associated with higher PTSD memory scores compared to being male, $B = 1.63$, $SE = 0.50$, $t = 3.29$, $p = .001$. Resilience was a negative predictor of PTSD memory score, $B = -1.30$, $SE = 0.22$, $t = -5.81$, $p < .001$, indicating that greater individual resilience was associated with lighter remembered PTSD symptoms. Place attachment was positively associated with PTSD memory scores, $B = 0.55$, $SE = 0.23$, $t = 2.40$, $p = .017$, indicating that greater place attachment was associated with PTSD symptoms remembered as more severe and frequent. Displacement status was also a significant predictor. Compared to nondisplaced individuals, formerly displaced participants reported significantly higher PTSD memory scores ($B = 2.63$, $SE = 0.60$, $t = 4.40$, $p < .001$), as did those still displaced ($B = 3.02$, $SE = 0.66$, $t = 4.59$, $p < .001$). Additionally, current risk awareness was positively associated with PTSD memory scores ($B = 1.03$, $SE = 0.17$, $t = 5.93$, $p < .001$), suggesting that higher current perceptions of risk were related to worse remembered PTSD symptoms.

Correlation analysis was conducted to assess the association between the PTSD memory measure and measures of wellbeing, quality of life, perceived health impairment, and life satisfaction during displacement, and to show the extent to which the memory of PTSD symptoms is related to other variables known to be affected by the earthquake and displacement (e.g. Di Bucci et al. 2023; Savadori et al. 2024). The PTSD memory score was significantly and negatively associated with well-being, quality of life, and life satisfaction, and positively associated with health impairment, highlighting the negative association of remembered trauma with other psychological consequences of the earthquake (see Table S8 in Supplementary Materials).

Together, these findings indicate that the extent to which the autobiographical memory of an earthquake is remembered as a traumaticexperience is predicted by individual variables (resilience, place attachment, risk awareness) and event-related variables (displacement). Moreover, the PTSD memory scoreis negatively associated with self-reported current wellbeing and current and expected quality of life. This suggests that integrated interventions at different levels could be useful to prevent and cope with the traumatic dimension of the event, and possibly reduce its long-term negative consequences (see Table 1).

Table 1. Summary of individual and environmental factors predictive of psychological consequences of earthquakes and potential related interventions.

Factor	Consequence	Reference	Potential intervention	Numbers in Figure 3
Personal factors				
Gender	Being female (vs. male) → • More negative PTSD memory	Current study	• Consider gender-specific aspects in prevention and in post-event psychological treatment or support	• 1
Place attachment	Stronger place attachment → • Bigger decline in quality of life after displacement • More negative PTSD memory	Savadori et al. (2024) Current study	• Avoid breaking community relationships during displacement • Minimize the time of displacement and reconstruction • Handle the loss feeling with psychological support	• 2 • 3 • 4
Resilience	Stronger resilience → • Less negative PTSD memory	Current study	• Build individual and community resilience *via* preventive psychological and social interventions	• 5
Individual preparedness	Better preparedness → • Higher life satisfaction	Di Bucci et al. (2023)	• Increase individual and community preparedness *via* preventive interventions	• 6
Current risk awareness	More risk awareness → • More negative PTSD memory	Current study	• Handle excessive post-event worries by psychological support, especially in displaced individuals	• 7
Pre-event risk awareness (retrospective)	More risk awareness → • Smaller improvement in quality of life from the displacement period	Savadori et al. (2024)		
Perceived health impairment	Stronger perceived health impairment → • Bigger decline in quality of life after displacement	Savadori et al. (2024)	• Address physical and psychological outcomes *via* appropriate medical and psychological treatment/support, especially in displaced individuals	• 8
General health status	Better health status → • Higher life satisfaction	Di Bucci et al. (2023)		
Emotional wellbeing	Better emotional wellbeing → • Bigger improvement in quality of life from the displacement period	Savadori et al. (2024)		
Environmental factors				
Specific earthquake	Type of earthquake → • Differences in life satisfaction	Di Bucci et al. (2023)	• Consider the specificities of the earthquake, place and local communities in planning interventions	• 9
Displacement status	If displaced → • If still displaced (vs. formerly displaced) smaller improvement in quality of life from the displacement period • More negative PTSD memory vs. nondisplaced	Savadori et al. (2024) Current study	• Minimize the time of displacement • Offer specific practical and psychological support to displaced persons	• 10 • 11

(*Continued*)

Table 1. Continued.

Factor	Consequence	Reference	Potential intervention	Numbers in Figure 3
Type of temporary house	Better type of temporary house → • Higher life satisfaction (tents vs. containers/ modules) • Smaller decline in quality of life after displacement and smaller improvement from the displacement period	Di Bucci et al. (2023) Savadori et al. (2024)	• Take care of the type and quality of provided temporary houses • Locate temporary houses to foster a prompt resumption of ordinary life and social activities	• 12 • 13
Quality of temporary house	Better quality of temporary house → • Higher life satisfaction • Smaller decline in quality of life after displacement and smaller improvement from the displacement period	Di Bucci et al. (2023) Savadori et al. (2024)		
Protection network	Stronger support from protection network (family, friends, institutions, …) → • Higher life satisfaction	Di Bucci et al. (2023)	• Strengthen protection network and community relations before the event	• 14

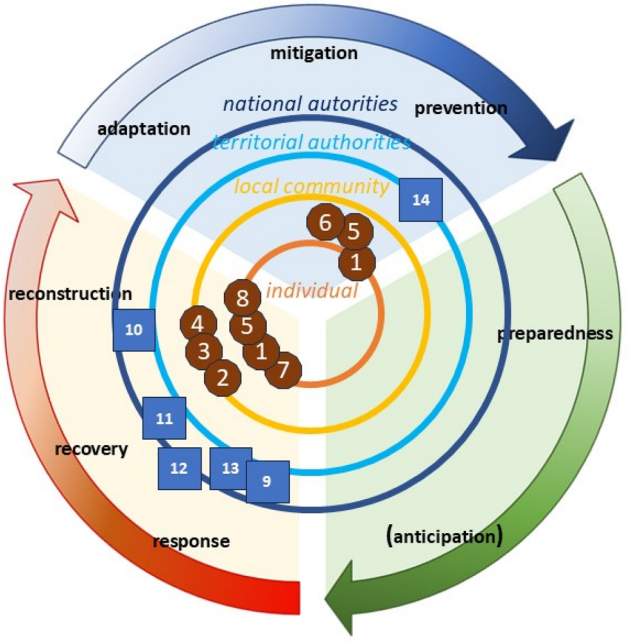

Figure 3. DRM cycle in its most comprehensive definition (modified from (DiBucci et al. 2022)). Numbers are referred to Table 1. Brown: interventions related to personal factors. Blue: interventions related to environmental factors.

Discussion

In this paper, we summarized the results of our previous work on the long-term psychological consequences affecting individuals displaced after an earthquake and we provided novel evidence on the autobiographical memory of the earthquake as a traumatic experience. From this work, it is possible to identify individual and environmental factors that are predictive of these

consequences and suggest interventions targeting these factors. Table 1 summarizes these factors and some examples of related interventions. These interventions are also projected onto the phases of the Disaster Risk Management cycle in Figure 3.

The results summarized in Table 1 suggest five general considerations. First, a combination of long-term preventive actions and post-event actions (e.g. strengthening individual and community resilience and offering psychological support to displaced individuals; see also Salcioglu, Ozden, and Ari 2018; Yıldırım et al. 2025) may have more potential than brief actions limited to the post-event stage. This also means that these actions need to be appropriately planned, coordinated, and deployed over the entire cycle of disaster risk management (Figure 3).

Second, interventions with positive psychological consequences may not be limited to effective treatment addressing mental health problems (e.g. Woods et al. 2025), but they may include structural measures (e.g. providing high quality temporary houses), management measures (e.g. minimizing the time of temporary displacement, strengthening the protection network), and measures targeting physical health (e.g. addressing consequences for physical health). When planning and implementing these measures, their psychological consequences should be appropriately considered. Interestingly, in our studies, although the different measures of psychological outcomes were correlated with each other, their predictors partly varied with the outcome measure. This suggests that different facets of the psychological consequences of an earthquake may be related to partly different individual and environmental factors. An integrated approach that combines different interventions in a meaningful way can therefore better cover more psychological facets.

Third, some interventions need to be tailored to the specific earthquake, community, and individual. Each earthquake has its own specificity (e.g. Di Bucci et al. 2023), and some groups of people or even specific individuals may need support tailored to their needs (e.g. Savadori et al. 2024). Overlooking the specific needs of local communities may lead to intervention failures (e.g. Félix, Branco, and Feio 2013). Thus, participatory approaches may be better suited to meet the real needs of the population and strengthen community resilience and preparedness.

Fourth, although scholars and professionals are aware of the need for an integrated approach to disaster prevention and management, the level of preparedness of the population is not always adequate (e.g. Di Bucci et al. 2023), and this may also apply to public administration. Therefore, it may be useful to increase efforts to raise awareness among the population and stakeholders about the fundamental role of long-term planning and prevention measures in disaster management (Figure 3), including measures to prevent the psychological and mental health consequences.

A fifth consideration, related to the previous one, specifically concerns risk perception and awareness. We observed that higher current risk awareness was associated with memory of worse PTSD symptoms. This association may be related to increased worry and anxiety after the experience of an earthquake (e.g. Nakayachi, Yokoyama, and Oki 2015). On the one hand, increased risk awareness may promote better preparedness, given that heightened risk perception seems to be associated with the implementation of some mitigation actions (Ozdemir and Yilmaz 2011). On the other hand, heightened risk perception can have negative consequences on quality of life and psychological wellbeing. Indeed, Savadori et al. (2024) reported that a greater retrospective evaluation of pre-event risk awareness was related with a smaller improvement in citizens' quality of life from the displacement period, and Cui and Han (2019) found that the perceived likelihood of future earthquake was a mediating factor of the negative impact of earthquake experience on quality of life. Thus, it seems important to foster a well calibrated risk perception in the population and increase preparedness through appropriate interventions and informative campaigns, taking into account socio-demographic factors such as education (Beck et al. 2012, 2019). Moreover, excessive post-event worries may need to be attenuated by psychological support, especially in displaced individuals.

Finally, it should always be noted that field studies of earthquakes have often various limitations, including lack of pre-disaster assessments, retrospective evaluations, prevalence of cross-sectional designs, samples that are not always representative of the populations of interest, and heterogeneity of methods and instruments used. Thus, their conclusions need to be strengthened by replications and converging evidence. In addition, while the results obtained in the studies of earthquakes may be useful to promote our understanding of potential consequences of other types of disasters and to suggest possible interventions, their generalizability to other disaster situations needs to be adequately assessed through conceptual replications.

Disclosure statement

Lucia Savadori reports financial support was provided by European Union. Daniela Di Bucci reports a relationship with Italian Civil Protection Department that includes: employment. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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