



# Association of Optimism, Causal Thinking, and Karma Beliefs with PTSD and Depression 8 Years After the Tsunami in Sri Lanka

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## Abstract

In 2004, the Indian Ocean tsunami struck Asia and caused high mortality, displacement, and psychological trauma in Sri Lanka. Previous studies have found that optimism protects against PTSD and depression, whereas pessimistic causal thinking and karma beliefs are associated with depression soon after a trauma. The objective of this study is to examine whether these factors continue to be associated with psychological health among Sri Lankan coastal residents 8 years after the tsunami. A semi-structured survey was conducted in 5 coastal districts. Three hundred twenty-five participants had direct exposure to the tsunami whereas 105 were indirectly or non-exposed. Logistic regression models were used to examine the association between the three psychological predictors and health outcomes, adjusting for relevant covariates including exposure to the tsunami, gender, age, education, and health before the tsunami. Optimism showed an association with lower depression and better self-reported health. Belief in karma was associated with a higher risk of PTSD symptoms. Internal attribution style was associated with PTSD and depression as well. These findings suggest that optimism, causal thinking, and karma belief play a role in long-term psychological health after a disaster and should be studied further and targeted for interventions.

**Keywords** Attributional style · Karma · Posttraumatic stress disorder · Depression · Tsunami · Sri Lanka

## 1 Introduction

On Dec 26, 2004, the Indian Ocean tsunami caused by an undersea earthquake with a magnitude of 9 struck across countries in South, East and Southeast Asia, including Sri Lanka, Indonesia, India, Maldives, and Thailand (Lay et al., 2005). The tsunami caused more than 1 million people to lose their homes and 280,000 to lose their lives, making it one of the deadliest natural disasters in history (Morrow & Llewellyn, 2006). Sri Lanka, one of the major countries impacted by the tsunami, suffered approximately 23,000 injuries and 35,000 deaths, leading it to become the country with the second-highest number of casualties. About 800,000 people were directly affected by the tsunami, 1 million were displaced, and the financial cost was estimated to be \$1.5 billion (World Health Organization. Regional Office for South-East Asia, 2007).

Short-term and long-term psychological impact after a disaster is well documented (Newnham et al., 2022). Six months after the tsunami, we conducted a cross-sectional survey among survivors in temporary shelters in Sri Lanka and found a high prevalence of PTSD (56%) and depression (69%) (Ranasinghe & Levy, 2007). Eight years post-tsunami (2012), we found that the negative psychological impact remains, albeit attenuated. We carried out another cross-sectional survey study among Sri Lanka coastal residents which revealed that the prevalence of partial PTSD and depression were 10.5% and 18.8% among those who were directly exposed to the tsunami, while the corresponding prevalence was 1% and 11.4% among those who were indirectly or not exposed (Ranasinghe et al., 2022). Similarly, studies have shown the long-term prevalence of anxiety, depression and PTSD after the 2004 tsunami in Thailand and India (Kar et al., 2013; Piyasil et al., 2011). The factors that contribute to this long-term psychological toll following natural disasters, however, are not well understood. Identifying these factors is the goal of the current study.

Previously, we identified factors that contribute to the short-term psychological toll of the tsunami. We conducted a survey-based study 6 months after the Indian Ocean tsunami to investigate associations that attributional styles and causal thinking have with physical and psychological health measures (Levy et al., 2009). Study participants were residing in temporary shelters in five adjacent districts of southern Sri Lanka that were most affected by the tsunami. We found that pessimistic explanatory styles (internality, globality and stability) were associated with 30% higher odds of PTSD and 22% higher odds of poor health, and karma belief was strongly associated with poor health, adjusting for relevant covariates including magnitude of exposure, demographic factors, and social support.

Karma, which is Sanskrit for “action” and refers to the belief prevalent in Hindu and Buddhist cultures that the current and past actions can determine the fate of the next life (Weiss, 1987) has been hypothesized to contribute to better long-term health. It has been argued that a belief in karma should build resilience, foster a sense of community, decrease selfishness, (Falk, 2021; Sun & Qi, 2023; White et al., 2019; Wiese, 2023), and decrease overconsumption when faced with mortality salience (Chen et al., 2019). On the other hand, karma has been found to be associated with more extensive traumatization. This could result from fatalistic understanding of negative circumstances discouraging coping behaviors, and encouraging an intrinsic

style of attribution of “bad karma” that associates self with the traumatic event. Long term, it could contribute to PTSD (Davidson et al., 2005).

It is not well documented which risk factors continue to operate beyond the initial phase of suffering from a natural disaster. The objective of the current study was to examine whether optimism, attributional style and karma belief are associated with long-term psychological health and self-reported health after the tsunami. Therefore, in a follow-up survey 8 years after the 2004 Indian Ocean tsunami, we collected three types of thinking style predictor variables: optimism (assessed through the Revised Life Orientation Test [LOT] score), pessimistic attributional styles (assessed by measures of internality, stability, and globality), and belief in karma in association with the tsunami (assessed through targeted questions). We also measured the outcome variables of PTSD, depression, and self-reported health, and the covariate of level of exposure to the tsunami 8 years earlier. We hypothesized that pessimistic attributional style and belief in karma would be associated with higher levels of PTSD/depression and worse health, whereas optimism would be associated with lower levels of PTSD-depression and better health among tsunami-exposed Sri Lankan residents.

## 2 Materials and Methods

### 2.1 Data Collection and Study Population

Eight years after the 2004 Indian Ocean tsunami, in 2012, we conducted a survey in the five coastal districts of Sri Lanka, the areas hardest hit by the tidal wave. Sri Lanka has a universal healthcare system with a comprehensive public health network. We used official data in identifying districts and communities to survey. Trained medical students in pairs visited households based on accessibility. One adult member from each household was enrolled after the informed consent. People who had self-disclosed cognitive issues or unable to understand the survey were excluded. Johns Hopkins School of Medicine Institutional Review Board and University of Colombo Faculty of Medicine Ethical Review Committee approvals were obtained. The questionnaire was translated from English to the local language Sinhala. A pilot study was conducted prior to the main study.

The study population included 430 adults over 16 years of age from the five coastal districts, Hambanthota, Matara, Galle, Kalutara, and Colombo. Demographic characteristics of the study population were described in detail in our previous paper (Ranasinghe et al., 2022). Briefly, the study population had a mean of 46.4 (SD 16.0) years of age, was 65.3% female. Overall, 82.8% were married, 91.2% self-identified as Sinhalese, 8.1% identified as Muslim, and 87.9% were Buddhist. Regarding exposure status, 325 had had direct exposure to the tsunami, and 105 people had not had direct exposure according to their self-report.

### 2.2 Predictors: Thinking Styles

Optimism was assessed with the Revised Life Orientation Test (LOT-R), a 10-item scale with choices from “Strongly Disagree (0)” to “Strongly Agree (4)”, with four

of the items being filler items only. The total score was summed across six non-filler items, ranging from 0 to 24 with a higher score representing more optimism. LOT-R has been shown to have high internal consistency (Cronbach's Alpha=0.78), test-retest reliability ( $\rho=0.56\sim 0.79$ ), and convergent and discriminant validity (Scheier et al., 1994).

We evaluated pessimistic attributional styles, including internality, stability, and globality, with these questions “Do you think it was due to your actions or someone, or something else’s will that led to you being subjected to the Tsunami?” (internality), “If you were affected by the Tsunami, how likely it is that the main cause you gave above will continue to affect you during your life?” (stability), and “Is the cause you gave something that only affects your experience of the Tsunami, or does it also affect other areas of your life?” (globality), which were adapted from the Attributional Style Questionnaire (Peterson et al., 1982). Participants responded on a scale of 1 to 6, with 6 consistent with highest intensity of these attributional styles; attributional styles were analyzed as continuous variables. Additionally, we further evaluated the stability of negative thinking by asking “How likely is that you will be affected by another Tsunami in the future?”, “How long do you think the effects of Tsunami will affect you in your life?” on a scale of 1 to 6, with 1 being “it will not happen” or “no longer at all”, and 6 being “it will definitely happen again” or “my entire life”.

Lastly, we assessed the belief in karma by asking “Why do you think the Tsunami occurred? (options: God’s will, karma, natural reasons, supernatural forces, a sign of end of the world, no opinion, or other)”, “What would have prevented the Tsunami from happening? (options: supernatural powers, God, good Karma, scientists, no one, no opinion, other)”, and “Why do you think you were affected or not affected by the Tsunami? (options: God’s will, my karma, bad/good fortune, unknowable reasons, no opinion, other)”, with one of the choices for each question being karma. Belief in karma was defined as 1 if the participant selected karma as a response to any one of the above questions, and was defined as 0 if karma was not selected in all three questions.

### 2.3 Outcomes

Our psychiatric outcomes consisted of depression and partial PTSD. Depression was evaluated with the 20-item Center for Epidemiological Studies-Depression (CES-D) scale. Each item was rated from “Rarely or none of the time (less than 1 day) (0)” to “Most or all of the time (5–7 days) (3)”. The total depression score was summed across items, with a score of or over 16 classified as having depression, which yields a sensitivity of 0.95 and a specificity of 0.70 with high reliability (Cronbach’s alpha=0.85) (Carleton et al., 2013; Radloff, 1977; Thomas et al., 2001).

Partial PTSD was measured with the 17-item PTSD Symptom Scale (PSS), with 5 items on reexperiencing symptoms, 7 items on avoidance symptoms, and 5 items on hyperarousal symptoms (Foa et al., 1993). Each item was rated from “Not at all” to “5 or more times per week/very much”. PSS has been shown to have high internal reliability (Cronbach’s Alpha=0.86), high interviewer-rater reliability ( $\rho=0.93$ ), and high validity ( $\rho=0.87$ ) compared to the gold-standard Clinician-Administered PTSD Scale (Foa & Tolin, 2000). Full-criteria PTSD was not used here due to the low num-

ber of participants fulfilling the criteria ( $N=9$ ). Partial PTSD has been defined as sub-threshold presentation of PTSD symptoms, and has been shown to be prevalent and have a significant impact on an individual's well-being that rivals full PTSD (Kulka et al., 1990; Weiss et al., 1992). In this study, we defined partial PTSD as the presence of one or more symptoms in each of the three symptom groups (Stein et al., 1997).

Our physical health outcome consisted of poor self-reported health, which was evaluated with a single question on the scale of 1 (excellent), 2 (very good), 3 (good), 4 (fair), and 5 (poor). Poor health was dichotomized as choosing 5 (poor current health) or choosing 1–4 (non-poor current health), consistent with our previous studies (Levy et al., 2009; Ranasinghe et al., 2022).

## 2.4 Covariates

Age, gender, education level, self-reported health before the tsunami, and exposure to the tsunami were considered covariates. We evaluated participants' exposure to the tsunami with the following 15 items as a response to the question "experience on the day of the tsunami": (1) serious injury or threat to one's own life; (2) death of family member; (3) serious injury or threat to family member's life; (4) death of close person; (5) serious injury or threat to close person's life; (6) death of a person not close to oneself; (7) serious injury or threat to other's life; (8) destruction of family house or property; (9) destruction of other's homes or property; (10) damage to other's homes or property; (11) damage to private property; (12) damage to public property; (13) minor injury; (14) contact with tsunami water; (15) fear of death. Participants were classified as directly exposed (DE) to the tsunami if they selected at least one out of items (1), (2), (3), (4), (5), (8), (13), (14). Otherwise, they were classified as indirectly or non-exposed (INE) (Heir et al., 2011).

## 2.5 Statistical Analysis

Causal thinking was compared according to exposure status (DE vs. INE) with unpaired t-test and Pearson's Chi-squared test. We examined the mean and standard deviation (SD) for continuous variables and count and percentage for categorical variables. Simple logistic regression was used to identify whether optimism (i.e., LOT score), attributional styles (i.e., internality, stability, globality), belief in karma, perceived likelihood to be affected by another tsunami, or perceived length of effect of the tsunami were associated with psychological health outcomes (i.e., PTSD, and depression) and self-reported health. Multiple regression models were further used to examine the association after adjusting for the covariates. The covariates were selected based on the initial analysis of the survey and their predictive effects on outcomes from literature (Ranasinghe et al., 2022). P-values < 0.05 were considered statistically significant. Statistical analyses were performed with R version 4.0.2 (R Core Team, Vienna, Austria).

### 3 Results

#### 3.1 Predictors by Exposure to Tsunami

In 325 DE and 105 INE individuals in the study population, there was no significant difference in age and gender between the two groups (Table 1). For education, more DE individuals finished 10 years of school or above. No significant difference was shown in self-reported health before the tsunami between DE and INE (3.0 vs. 2.9,  $p=0.09$ ). The prevalence of Buddhists was higher among INE (96.2%) than DE (85.1%). We saw no significant difference in optimism scores between groups (DE: 14.2 [SD 2.6] vs. INE: 14.6 [2.5],  $p=0.14$ ). The mean scores of internality, stability, and globality in DE were 2.0, 3.7, and 3.8, respectively, which were not significantly different from those in INE, which were 2.0, 3.4, and 3.6, respectively. In regard to belief in karma, there was no significant difference between groups (DE:

**Table 1** Life orientation test scores, karma belief and attributional styles by exposure status

	Direct exposure (DE) (N=325)	Indirect or no exposure (INE) (N=105)	p-value
Age	46.9±15.8 [17–80]	44.7±16.5 [17–92]	0.22
Gender			0.19
M	118 (36.5%)	30 (28.8%)	
F	205 (63.5%)	74 (71.2%)	
Education			0.02
Below Grade 5	59 (18.3%)	19 (18.1%)	
Grade 5–10	59 (18.3%)	34 (32.4%)	
10–12 years of school	85 (26.3%)	19 (18.1%)	
12 years of school and above	120 (37.2%)	33 (31.4%)	
Self-reported health before the tsunami	3.0±0.8 [1–5]	2.9±0.8 [1–5]	0.09
Religion			0.003
Buddhist	275 (85.1%)	101 (96.2%)	
Muslim	32 (9.9%)	2 (1.9%)	
Catholic/Christian	16 (5.0%)	1 (1.0%)	
Hindu	0 (0%)	1 (1.0%)	
Frequency of religious activity			0.02
Never or ≤1/month	124 (38.2%)	28 (26.7%)	
Several times/month	77 (23.7%)	39 (37.1%)	
Several times/week or daily	124 (38.2%)	38 (36.2%)	
Life Orientation Test score	14.2±2.6 [6–20]	14.6±2.5 [6–22]	0.14
Belief in karma	91 (28.0%)	40 (38.1%)	0.07
Internality	2.0±1.5 [1–6]	2.0±1.3 [1–6]	0.99
Stability	3.7±1.4 [1–6]	3.4±1.2 [1–6]	0.08
Globality	3.8±1.4 [1–6]	3.6±1.2 [1–6]	0.22
Perceived likelihood to be affected by another tsunami	2.6±1.1 [1–5]	2.3±0.8 [1–6]	0.002
Perceived length of effect of the tsunami	3.4±1.7 [1–6]	1.9±1.0 [1–6]	<0.001

Note: Data are presented as N (%) for categorical variables; Mean±SD for continuous variables. Range is shown as [min–max]

28.0%, INE: 38.1%). Additionally, DE individuals showed a significantly higher score compared to INE individuals when asked about their perceived likelihood to be affected by another tsunami (2.6 vs. 2.3), and perceived length of effect of the tsunami (3.4 vs. 1.9).

### 3.2 Logistic Regression

As predicted, in univariate analysis, optimism was significantly associated with lower odds of depression ( $p < 0.001$ , OR=0.70 (0.62, 0.78)) and poor health ( $p < 0.001$ , OR=0.78 (0.69, 0.88)) (Table 2). Belief in karma led to an OR of 2.05 for partial PTSD ( $p = 0.04$ , 95% CI (1.01, 4.13)). Among attributional styles, internality was significantly associated with partial PTSD ( $p = 0.007$ , OR=1.33 (1.07, 1.64)) and depression ( $p = 0.004$ , OR=1.28 (1.08, 1.52)), and globality was associated with poor health ( $p = 0.04$ , OR=0.77 (0.60, 0.99)). We found no association between stability or globality with depression or partial PTSD. Additionally, perceived likelihood to be affected by another tsunami was significantly associated with partial PTSD ( $p < 0.001$ , OR=2.05 (1.53, 2.78)) and depression ( $p < 0.001$ , OR=1.64 (1.30, 2.08)), and perceived length of effect of the tsunami was significantly associated with partial PTSD ( $p < 0.001$ , OR=1.86 (1.51, 2.36)), depression ( $p < 0.001$ , OR=1.43 (1.24, 1.66)) and poor health ( $p < 0.001$ , OR=1.41 (1.19, 1.68)).

Multivariate logistic regression showed consistent results after adjusting for gender, age, education, self-reported health before the tsunami, and exposure to the tsunami (Table 3). A higher optimism score was associated with lower odds of experiencing depression ( $p < 0.001$ , OR=0.72 (0.64, 0.81)) and poor health ( $p = 0.003$ , OR=0.82 (0.72, 0.93)). People with a belief in karma were more likely to have partial PTSD ( $p = 0.02$ , OR=2.35 (1.12, 4.93)). Internality was consistently associated with partial PTSD ( $p = 0.009$ , OR=1.35 (1.08, 1.68)) and depression ( $p = 0.04$ , OR=1.21 (1.01,

**Table 2** Univariate logistic regression: Association of Life orientation test scores, karma belief and attributional styles with PTSD, depression, and poor health

	Partial PTSD		Depression		Poor Health	
	Pr(> z )	OR (CI)	Pr(> z )	OR (CI)	Pr(> z )	OR (CI)
Life Orientation Test score	0.13	0.90 (0.79,1.03)	<0.001	0.70 (0.62,0.78)	<0.001	0.78 (0.69,0.88)
Belief in karma	0.04	2.05 (1.01,4.13)	0.11	1.53 (0.90,2.58)	0.93	0.97 (0.47,1.88)
Internality	0.007	1.33 (1.07,1.64)	0.004	1.28 (1.08,1.52)	0.13	1.17 (0.95,1.43)
Stability	0.25	1.18 (0.89,1.57)	0.89	1.01 (0.82,1.25)	0.31	0.87 (0.67,1.13)
Globality	0.93	1.01 (0.77,1.33)	0.07	0.83 (0.68,1.01)	0.04	0.77 (0.60,0.99)
Perceived likelihood to be affected by another tsunami	<0.001	2.05 (1.53,2.78)	<0.001	1.64 (1.30,2.08)	0.33	1.15 (0.86,1.53)
Perceived length of effect of the tsunami	<0.001	1.86 (1.51,2.36)	<0.001	1.43 (1.24,1.66)	<0.001	1.41 (1.19,1.68)

P: p-value, OR: odds ratio, CI: confidence interval

**Table 3** Multivariate logistic regression: Association of life orientation test scores, karma belief and attributional styles with PTSD, depression, and poor health

	Partial PTSD		Depression		Poor Health	
	Pr(> z )	OR (CI)	Pr(> z )	OR (CI)	Pr(> z )	OR (CI)
Life Orientation Test score	0.20	0.91 (0.80,1.05)	<0.001	0.72 (0.64,0.81)	0.003	0.82 (0.72,0.93)
Belief in karma	0.02	2.35 (1.12,4.93)	0.24	1.41 (0.80,2.47)	0.61	0.82 (0.39,1.75)
Internality	0.009	1.35 (1.08,1.68)	0.04	1.21 (1.01,1.45)	0.22	1.16 (0.92,1.46)
Stability	0.36	1.15 (0.86,1.53)	0.83	0.98 (0.79,1.21)	0.19	0.83 (0.63,1.09)
Globality	0.91	0.98 (0.74,1.31)	0.03	0.79 (0.64,0.97)	0.007	0.67 (0.50,0.90)
Perceived likelihood to be affected by another tsunami	<0.001	1.94 (1.41, 2.65)	<0.001	1.55 (1.22,1.98)	0.39	1.15 (0.84,1.58)
Perceived length of effect of the tsunami	<0.001	1.85 (1.44,2.36)	<0.001	1.37 (1.16,1.62)	0.001	1.41 (1.14,1.74)

Note: Multiple regression models were adjusted for gender, age, education, health before the tsunami, and exposure

P: p-value, OR: odds ratio, CI: confidence interval

1.45)). Globality was negatively associated with poor health ( $p=0.007$ ,  $OR=0.67$  (0.50, 0.90)) and depression ( $p=0.03$ ,  $OR=0.79$  (0.64, 0.97)). A consistent association was shown between perceived likelihood to be affected by another tsunami and partial PTSD ( $p<0.001$ ,  $OR=1.94$  (1.41, 2.65) and depression ( $p<0.001$ ,  $OR=1.55$  (1.22, 1.98)). Also, perceived length of effect of the tsunami was also associated with partial PTSD ( $p<0.001$ ,  $OR=1.85$  (1.44, 2.36)), depression ( $p<0.001$ ,  $OR=1.37$  (1.16, 1.62)) and poor health ( $p=0.001$ ,  $OR=1.41$  (1.14, 1.74)) after adjusting for covariates. No other association was found in the rest of the variables.

## 4 Discussion

This study found that optimism, attributional style, and karma beliefs were associated with self-reported health, partial PTSD and depression eight years after the 2004 Indian Ocean tsunami among Sri Lankan coastal residents. Specifically, we found that optimism was associated with lower odds of depression and poor self-reported health, and belief in karma was associated with higher odds of PTSD. Internality was associated with long-term PTSD and depression symptoms. On the other hand, globality had a negative association with depression and poor health. A higher perceived likelihood to be affected by another tsunami and a longer perceived length of effect of the tsunami were associated with poor mental and physical health. It was also found that participants who were directly exposed to the tsunami were more likely to think that they would be affected by another tsunami and the tsunami would have a longer effect on their life.

Our finding that optimism, reflected by LOT scores, was correlated with lower odds of depression and poor subjective health 8 years after the tsunami is consis-



tent with previous theories related to how optimism operates and empirical findings conducted with other populations (Scheier & Carver, 1992). Neurology studies have found that the same brain area is associated with lower depression and maintaining optimism, which provided a physiological foundation for this association (Wu et al., 2015). Previous studies have also found that optimism reduced the risk of developing PTSD among many trauma-affected populations including adults who suffered from childhood maltreatment, and former refugees (Acquaye, 2017; Chen et al., 2021; Rauch et al., 2013). Although we did not find a significant association between optimism and partial PTSD, this might be due to the small sample size with partial PTSD or a waning effect of both optimism and PTSD over 8 years.

In this study, there were mixed associations between the three components of pessimistic attributional style. We found a tendency to make internal attributions for the tsunami predicted long-term PTSD and depression. Additionally, perceived likelihood to be affected by another tsunami and perceived longer length of the effect of the tsunami was associated with presence of partial PTSD, depression, and poor health. This association is consistent with our earlier finding that six months after the tsunami a pessimistic explanatory style, which includes a tendency to make internal attributions, was associated with a 1.22 times higher risk of PTSD (Levy et al., 2009). Similar results have also been described in previous studies. Young hurricane survivors with a pessimistic explanatory style reported more and longer symptoms of PTSD (Goldwater, 1993). Stability was associated with PTSD among women who suffered domestic violence (Zinzow & Jackson, 2009). Pessimistic attributional style was also commonly found to be associated with depression (Hu et al., 2015; Sanjuan et al., 2008; Sweeney et al., 1986), and it was also a risk factor for poor health in our previous study (Levy et al., 2009). However, there were mixed results for the other components of attributional style. The association with stability was not detected in this study. Furthermore, on the contrary, a tendency for the tsunami to have a consistent effect on other aspects of life, globality, was associated with lower odds of depression and poor health. These mixed findings could be because the effect of attributional styles on health might have worn off over the long period of time and potentially confounded by other environmental stressors and life events. There may have been a component of confounding by indication, as this analysis was cross-sectional and did not take into account psychiatric interventions individuals may have had for the 8 years after the tsunami.

Karma belief was found to be significantly associated with PTSD symptoms, which is consistent with a previous study among violence survivors (Davidson et al., 2005). An association was also found between karma belief and explanatory styles with PTSD among Chinese Buddhists which supported our finding that both karma belief and pessimistic explanatory styles were risk factors for PTSD (Liu et al., 2017). While karma belief was associated with poorer short-term self-reported health in our previous study (OR=2.78), no association was found with long-term depression and health. This could be because in the short term, survivors thought their life was determined by karma which may have discouraged healthy behaviors, while in the long term, survivors realized their survival was a sign of good karma so the effects on healthy behaviors and pessimistic thought patterns might have been lifted. This could also be because karma belief was not adequately captured through

our questionnaire since we didn't specifically ask for karma belief but asked for participants' perceived reason for the tsunami and dichotomized their responses if karma was mentioned as a response. Therefore, the number of participants with karma belief might be underestimated in this study.

A strength of the current study is that it is one of the first to examine the long-term effect of optimism and causal thinking on psychological health outcomes after a natural disaster. We were able to compare determinants of self-reported psychological and physical health in a similar population immediately after and 8 years after the same natural disaster, then compare how optimism and causal thinking impacted those who had direct exposure and those who did not have direct exposure, but lived nearby, to the same natural disaster. However, there were also limitations in this study. Firstly, this study was a cross-sectional study, so causality could not be established between the risk factors and outcomes. Secondly, the psychological outcomes were assessed through a questionnaire rather than a formal physician evaluation. However, we used validated psychometric screening tools to capture PTSD symptoms and depression. Thirdly, as this study was a follow-up cross-sectional study done on similar, but not the same, populations as the prior study, we could not directly compare changes in health in individuals immediately after the tsunami and 8 years thereafter.

In conclusion, in our study population that survived a tsunami, greater levels of optimism and lower levels of internality and karma beliefs were associated with better long-term psychological health. With the associations found in this study, interventions, such as cognitive-behavioral training, to promote optimism and adaptive attributional style thinking could be protective in improving psychological outcomes when facing disasters (Proudfoot et al., 2009). For a country with a majority of Buddhists like Sri Lanka, the long-term impact of karma beliefs on mental health should be studied further. Considering that karma has many nuanced ideas associated with it and previous studies have found that a belief in karma is sometimes associated with health benefits and sometimes associated with worse health, there may be advantages to developing interventions that draw on the dynamics that allow for it to lead to health benefits, such as strengthening the belief that "good" karma has allowed them to survive. Combined efforts from psychological health professionals and other stakeholders may work together to design creative and culturally appropriate interventions to promote a positive mindset to improve short-term and long-term health following natural disasters. Studies that further examine the association between optimism, causal thinking, karma belief, and long-term psychological health after other types of natural disasters could also expand the beneficial implications of the current study.

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## Declarations

**Ethics Approval** Johns Hopkins School of Medicine Institutional Review Board and University of Colombo Faculty of Medicine Ethical Review Committee approvals were obtained.

**Consent to Participate** Informed consent was obtained from all individual participants included in the study.

**Conflict of Interest** The authors certify that they have no affiliations with any organization or entity with any financial or non-financial interest in this research that could be construed as a potential conflict of interest.

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