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Earthquakes and Mental Health

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Earthquakes and Mental Health*

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Abstract

Earthquakes may seriously deteriorate mental health by generating fear and stress as a result of economic and human losses. However, mental health has also been found to improve as a result of greater social cohesion in affected communities after the event. We examine the short-run effects of earthquakes on a wide set of mental health outcomes in Ecuador. To this end, we combine hospital admissions, death records, and survey data with precise measures of local seismic activity to exploit the plausibly random spatial and temporal nature of earthquake intensity. We find that damaging earthquakes decrease the propensity to be admitted, the number of days of hospitalisation for mental and behavioural disorders, and deaths due to suicide. Estimates from nationally-representative surveys provide suggestive evidence of increased life satisfaction, trust, and religious observance, and thus provide a possible explanation for the fall in admissions and suicides after an earthquake.

JEL classifications: I15, Q54, O54
Keywords: Earthquake, Mental health, Ecuador

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1 Introduction

Not only do earthquakes cause considerable damage to physical infrastructure, resulting in human deaths and injuries, they also have substantial indirect, possibly negative (Koks et al., 2019; Inoue and Todo, 2019; Mao et al., 2020) or positive (Gignoux and Menéndez, 2016; Okazaki et al., 2019) economic impacts. People exposed to earthquakes also tend to be affected psychologically. Experiencing such events increases the propensity to develop mental and behavioural disorders by directly inducing fear or causing post-traumatic stress disorder (PTSD) (Galea et al., 2005; Norris et al., 2002). In addition, because of injuries sustained, the deaths of close ones, or losing belongings or employment, earthquakes might indirectly generate stress and sadness resulting in 'psychological poverty traps' (Ridley et al., 2020), and increase the risk to commit suicide (Chen et al., 2012; Lonnqvist, 2009). At the other end of the spectrum, because of the need to cooperate for survival (Diamond, 1997), natural disasters might have positive effects on mental health by renewing, re-enforcing cohesion within societies by strengthening cooperation and support networks (Gordon et al., 2011). The link between natural disasters and mental health is thus complex, multi-dimensional, and, ultimately, an empirical question.

There already exists a small, but growing, literature on the mental health effects of natural disasters, including earthquakes. For instance, White (2017) shows that hospital and emergency department visits increase with both extremely hot and cold days in California. Using data for the entire United States (US), Mullins and White (2019) confirm that hot temperatures increase emergency department visits due to mental illness, and deteriorate self-reported health. This result is echoed by Burke et al.'s (2018) analysis of depressive language used in social media during higher temperature episodes, even though mental health is found to improve at cold temperatures. In addition to higher temperatures, Obradovich et al. (2018) highlight that tropical cyclones worsen mental health in the US. With regard to earthquakes, in a study of 130 Californian survivors interviewed three months after an earthquake, only 13% met full PTSD criteria, and 48% met two out of three PTSD criteria (McMillen et al., 2000).

The empirical evidence on the role that natural disasters play in determining suicides is rather mixed. Using comprehensive data from multiple decades for the US and Mexico, Burke et al. (2018) show that deaths to suicide increase after higher temperature spells. Similarly, Carleton (2017) provides evidence that crop-damaging temperature levels increase suicide rates in India; Parida et al. (2018) find, for the same country, that suicides of farmers increase after droughts, but not following floods. When it comes to earthquakes, Chou et al. (2007) report an increase in male suicides as a result of earthquakes in Taiwan. In contrast, in the two years following the 1995 Great Hanshin-Awaji in Japan, the suicide rate dropped (Nishio et al., 2009), and did so similarly after the Northridge earthquake in California (Shoaf et al., 2004). No statistical association was found between earthquakes and post-disaster suicides in a panel of US counties (Krug et al., 1999; Shoaf et al., 2004). Additionally, the relationship between earthquakes and mental health might be delayed, and disorders appear, or worsen later in time. Indeed, a drop in non-fatal suicides has been observed in the direct aftermath of particularly damaging earthquakes, followed by a rise in suicides in the next months, as evidenced by a literature review on the psychopathological reactions of communities affected by earthquakes in Greece over 40 years (Madianos and Evi, 2010), and with almost 30 years of data from Japan (Matsubayashi et al., 2013).

Strengthened social cohesion resulting from the willingness to help others in affected communities after a natural disaster could also lead to fall in suicides. In this regard, Gordon et al. (2011) have demonstrated that experiencing natural disasters reduces the desire to die associated with feelings of not belonging and being a burden on others, two key factors posited by Joiner's (2005) interpersonal-psychological theory of suicidal behaviour. Gordon et al. (2011) argue that working together ('pulling together') and supporting one another during a shared tragedy increase the sense of belongingness, and reduce perceived burdernsomeness. Using a sample of 210 undergraduate students in North Dakota in the aftermath of the 2009 Red River flood, their study confirms that during natural disasters, community members tend to join forces in volunteering. This, in turn, tends to uplift feelings of belongingness (lower levels of thwarted belongingness), and limit feelings of burdensomeness. As a matter of fact, disasters such as high-intensity earthquakes and storms, have been found to improve social cohesion in Chile (Calo-Blanco et al., 2017; García Hombrados, 2020), and Belgium (Méon and Verwimp, 2016). Earlier works point to improved group and family cohesion following earthquakes (Yacoubian and Hacker, 1989), tsunamis (Lindgaard et al., 2009; Hikichi et al., 2020), or hurricanes (Kaiser et al., 1996). Religious coping – individuals turning to religion to deal with unbearable, unpredictable life events – has also been evidenced to occur in the face of earthquakes at the international level (Bentzen, 2019).

In this paper, we explore the various mental health implications of natural disasters, particularly in the short-term, by studying earthquakes in Ecuador. Earthquakes in Ecuador arguably provide a particularly suited setting to assess the effect of natural disasters on mental health. Sitting between the Nazca and South American tectonic plates, the country faces a high seismic risk, as reminded by the 2016 7.8-magnitude Pedernales earthquake, responsible for more than 600 casualties, 28,000 injured, and USD3 billion destruction. However, while attention has largely focused on the biggest earthquakes, there are many smaller earthquakes. Parallel to this, statistics on behavioural disorders in Ecuador are alarming. For instance, mental, neurological, and substance use (MNS) disorders accounted for 19% of disability-adjusted life-years (DALYs) in 2019 in Ecuador – a stark increase compared to the previous decade. The country also tends to rank above the regional suicide average, with an adjusted suicide rate of 7.1 per 100,000 inhabitants, adding more than 10,000 years of premature years of life lost between 2001 and 2015 (Ortiz-Prado et al., 2017).

Our ability to assess empirically mental health responses to earthquakes in Ecuador with considerable precision rests on the existence of publicly available, high frequency, and localized data on the universe of hospitalisations and deaths, as well as nationally-representative surveys of life satisfaction, trust, and religious observance. We combine these with measures of local seismic activity constructed from comprehensive seismologic information on noticeable earthquakes. Importantly, while earthquakes might be considered more likely in some locations than others on a broader regional scale, at a more spatially disaggregated level, differences in occurrence and intensity are largely unpredictable. We use this plausibly as-good-as-random spatial and temporal variation in exposure to earthquakes across 220 Ecuadorian cantons that have similar historical, cultural roots, share the same formal institutions, and for which there were no pre-existing conflicts, to identify the causal effect of earthquakes on mental health. Using high frequency – daily – data allows us to explicitly disentangle any impacts in the very aftermath of an earthquake, i.e., implications that might be obscured in lower resolution temporal information.

Our results indicate that damaging earthquakes – events of intensity VIII or higher – improve mental health indicators in Ecuador in the short run. A one-unit increase in earthquake intensity significantly decreases the probability to be hospitalised to mental and behavioural disorders by 0.05 percentage points in the 14 days following an event, equivalent to a 15 percent decrease at the mean. The number of days of hospitalisation for mental and behavioural disorders consistently decreases, with a one-unit increase in earthquake intensity leading to a 0.01 day decrease in hospitalisation in the 21 days after an event. We also find evidence that deaths to suicide decrease by 0.41 percentage points in the seven days following a damaging earthquake, thus ruling out the possibility of a crowding out effect. Estimates from nationally-representative surveys provide suggestive evidence of increased life satisfaction, trust in the Church, community participation, and religious observance, in the 28 days following an earthquake. This likely confirms the role of social cohesion for the fall in admissions and suicides after an earthquake, consistent with previous studies (Bentzen, 2019; Calo-Blanco et al., 2017; García Hombrados, 2020; Yacoubian and Hacker, 1989). While we cannot reject the hypothesis that behavioural disorders might appear, or worsen, in the longer term, our findings lend support for natural disasters spurring processes that generate social connectedness in the immediate aftermath of a disaster.

The remainder of the paper is organized as follows. Section 2 presents the data, and section 3, our empirical strategy. Results are presented in section 4. Section 5 concludes.

2 Data

2.1 Administrative registries of hospitalisations and deaths records

We use administrative information on hospital inpatient (emergency and non-emergency) visits that took place in any health service institutions in Ecuador between 2012 and 2018. Each registry contains information on inpatients – canton of residence, date of birth, gender – and their hospitalisation – cause and date of admission, number of days hospitalised, and canton of the facility. Visits related to mental health are defined according to admission diagnoses. Diagnoses of hospital admissions are listed according to the International Classification of Diseases 10 (ICD-10), and provided at the three-digit level. Mental and behavioural disorders are listed from F00 to F99 as: (i) organic mental disorders, including symptomatic illnesses (F00-F09); (ii) mental and behavioural disorders due to psychoactive substance use (F10-19); (iii) schizophrenia, schizotypal, and delusional disorders (F20-29); (iv) mood (affective) disorders (F30-39); (v) neurotic, stress-related, and somatoform disorders (F40-48); (vi) behavioural syndromes associated with physiological disturbances and physical factors (F50-59); (vii) disorders of adult personality and behaviour (F60-F69); (viii) mental retardation (F70-79); (ix) disorders related to psychological development (F80-F89); (x) emotional and behavioural disorders that often appear in childhood and adolescence (F90-98); and (xi) mental disorders not specified (F99). As primary outcome of interest, we construct a binary variable taking value 1 if a respondent was hospitalised for any mental and behavioural disorders, and 0 otherwise. Binary variables are also generated for additional admission causes, thought to be related to mental and behavioural disorders: poisoning by drug, medication, and biological substance (T36-T50), and intoxication by non-medicinal substance (T51-T65). We construct corresponding variables measuring the number of days a patient was hospitalised for each admission cause.

We similarly process administrative information on deaths that occurred in Ecuador between 2013 and 2018. Each registry contains information on the deceased – date of birth, gender – and their death – cause of death, as per ICD-10 categories, canton of death occurrence, and date of death. Binary variables are constructed to indicate if a death occurred because of: (i) suicide (X60-X84); (ii) likely suicide (undetermined intent) (Y10-Y34); or (iii) mental and behavioural disorder (F00-F99). To assess the robustness of our empirical strategy, we also construct binary variables taking unity for hospital admission to injury (S00-T19), and death to natural disaster accident (X31-X39), and 0 otherwise.

It is important to note that hospital discharge data do not contain outpatient information. It follows that we cannot infer any conclusions about people who did not attend a health facility in Ecuador between 2012 and 2018.[1] Unique inpatient identifiers are not provided either. Data are thus processed at the individual hospital admission level, as pooled cross-sections, resulting in a dataset of 8,098,484 inpatient observations. Death registries are similarly processed at the deceased level. This leads to a death record database of 403,051 observations.

Summary statistics for outcome variables are reported in Table 1. Of all recorded inpatient visits, 7.68% were admitted for traumatic injuries between 2012 and 2018, while hospitalisations for mental and behavioural disorders, poisoning, and intoxication were all lower than 1%. In contrast, for the period 2013 to 2018, 1.53% of the deaths were suicides, and 0.92% were undetermined, i.e. resulting from external violent cause of death. Mental and behavioural disorders accounted for 0.28% deaths, and 0.22% were due to natural disaster accidents.

2.2 Survey data

Data on social cohesion are derived from the *Latinobarómetro* and the AmericasBarometer. The *Latinobarómetro* is an annual public opinion survey conducted across 18 Latin American countries since 1995; it interviews respondents about topics such as globalization, political institutions, and social capital, amongst others. The AmericasBarometer is a multi-country, regularly-conducted

[1] We use the 2012 and 2018 *Encuesta Nacional de Salud y Nutrición* (Ensanut) as a nationally representative source of information to assess the number of people who benefitted from health services in Ecuador during our period of analysis. According to Table A1, in 2012 (2018), 42.83% (22.83%) of the population reported having had a health condition; among those people, 51.87% (67.18%) sought professional assistance. This represented about 8 (11) million people who saw a doctor. This does not take into account the fact that an individual might go to the doctor more than once in a given year. As we infer from the Ensanut, the proportion of those who did not seek medical help could account for about 48.13% and 32.82% of the Ecuadorian population, in 2012 and 2018, respectively.

survey of democratic values and behaviours, initiated by the Latin American Public Opinion Project (LAPOP) in 2004, covering countries from North, Central, and South America, and the Caribbean. Both surveys use national probability samples of voting-age adults, so that observations are self-weighted to ensure nationally representativity. We process *Latinobarómetro* data collected in Ecuador in 2013 and from 2015 to 2018, and AmericasBarometer data gathered in Ecuador in 2014, 2016, and late 2018/early 2019. We process data at the respondent level, as pooled cross-sections. This results in two databases of 4,002 and 4,254 observations, respectively.

Our variables of interest refer to life satisfaction, trust in people and community, and religious observance. Specifically, constructed binary variables take unity if a respondent:

- *Latinobarómetro*
  - is (quite) satisfied with their life; 0 if not very or not at all satisfied with their life;
  - believes the majority of people is trustworthy; 0, if thinks one is never careful enough in dealing with people;
  - thinks the Church is very or somewhat trustworthy; 0, if not trustworthy;
  - is very religiously observant; 0, if somewhat or not religiously observant
- AmericasBarometer
  - considers their economic situation to be better than or the same as 12 months ago; 0, if worse;
  - thinks people of their community are very to somewhat trustworthy; 0, if not trustworthy;
  - attends meetings of a community improvement committee or board at least once a week, month, or year; 0, if never;
  - considers religion to be very important in their life; 0 if somewhat, not much, or not at all important.

Table 1 indicates that, in the *Latinobarómetro* survey, across the 6-year period, 73.76% responded they were satisfied with their life. Only 19.54% trusted people in their community, while 74.76% considered the Church trustworthy, despite only 12.72% reported to be very religiously observant. In addition, in the AmericasBarometer data, 58.89% reported to have a better or similar economic situation. Trust in people is significantly higher than in the *Latinobarómetro*, reaching 57.24%. Community improvement meetings were joined by 37.24%, and a high 66.01% viewed religion as very important in their life.[2]

2.3 Seismic activity

We use harmonized data on seismic activity, namely the date, epicentre geolocation, and magnitude, from the United States Geological Survey (USGS). Earthquake events are selected when they occurred in the area covering Ecuador (geographic latitudes between -8.4 and 3.7 degrees and longitudes between -83.7 and 71.2 degrees), from 2010 to 2019.

The earthquake data are used to construct objective measures of how strong an earthquake is felt locally by individuals. While earthquake magnitudes measure the energy released at the epicentre, they might not reflect how (far) an earthquake is felt across the surface of the earth. However, this is essential since for any given combination of magnitude and distance to the epicentre, even areas far from an epicentre might be affected. For this reason, we calculate earthquake intensities. We quantify how much an earthquake is felt depending on quake magnitude, and the distance between its epicentre and each Ecuadorian canton centroid.

To measure intensity, we use the Medvedev-Sponheuer-Karnik (MSK) scale, which is similar to the Modified Mercalli Intensity scale used in the US. We determine the intensity of an event, occurring at epicentre location k, on date t, felt in the centroid of canton c, by using Beauval et al.'s (2010) attenuation function that has been estimated for earthquakes in Ecuador. Accordingly, the relationship between event magnitude, epicentre location, and intensity at a

2 Discrepancies between these two databases are likely explained by differences in data collection dates, geographical coverage within the country, and survey question framing.

certain location is given by:

$$intensity_{kct} = -0.85 + 2.41 \cdot M_{kt} - 5.39 \cdot log_{10}\Delta_{h,kc} \quad (1)$$

where $intensity$ measures the seismic activity of an earthquake occurring at epicentre k, on date t, felt in the centroid of canton c. M is the moment magnitude of an earthquake occurring at epicentre k, on date t. Δ_h is the hypocentral, or slant, distance between epicentre k and the centroid of canton c. The resulting $intensity$ measures are normalized to 0 when values are negative. Finally, the values are used to calculate the maximum seismic activity for every existing canton-date combination.

We merge the resulting database with hospital discharges, death records, and survey data by assigning the maximum seismic intensity felt in canton c at time t to (i) the date of hospital admission of an inpatient, and their canton of residence, (ii) the date of passing of a deceased, and the canton of death occurrence, and (iii) the date of survey data collection, and a respondent's canton of residence, respectively.

Figure 1 displays the epicenters of the 193 earthquake events retained following this procedure that are used to conduct our study. Sample-specific earthquake intensities are reported in Table 1. The corresponding figures for earthquake intensities are comparable in their means, while maxima are higher for larger samples – inpatient visits and death registries – as expected.[3]

3 Empirical strategy

To identify the impacts of earthquakes on mental health, we estimate a series of linear probability models with pooled cross-sections, as specified below:

[3] See Table A2 for descriptive statistics of non-null MSK intensities by data sources.

$$Y_{ict} = \alpha + \sum_{j=1}^{J} \beta_j intensity_{j,ct} + \delta X_{ict} + \theta_{dow} + \theta_{month} + \theta_{year} + \theta_c + u_{ict} \quad (2)$$

where Y is the outcome of interest in canton of residence (or death occurrence) c, at time t, alternatively for hospital admissions, deaths, or survey respondent life satisfaction, interpersonal trust, or religious practices. $intensity$ measures the maximum seismic activity individual i felt in canton c from j days prior to date t. We assign maximum seismic activity to the exact date of these events at the daily level. We use four time-windows to determine the time sequence j: 7 days prior to and including date t, 8 to 14 days, 15 to 21 days, and 22 to 28 days prior to date t. X is a vector of control variables, such as gender, age, and squared age. The main specification also includes a rich set of fixed effects: day-of-week, month, year, and canton indicator variables. Standard errors are clustered at the canton level.

The parameter of interest, β_j, quantifies the average effects of past earthquake exposure on the outcome Y. Arguably, β_j allows us to capture the causal effect of earthquake intensity on mental health for a number of reasons. First, $intensity$ is only constructed on the basis of the physical features of an earthquake event, and not on any ex-post damage assessment that may correlate with other factors associated with mental health. Second, currently in Ecuador there is no reliable method to accurately predict earthquakes in a short time-space window that would allow for evacuations or any other short-term response (Nandan et al., 2021). Third, although at a broader regional level certain areas differ in their seismic hazard due to their location relative to active faults (Valentini et al., 2017), amongst other factors, the actual location of the epicenter is at best predictable at a few hundred kilometers (Sarlis et al., 2015), i.e., far beyond our spatial unit of analysis. Fourth, even if some local areas were more likely to experience earthquakes, or to be damaged given a certain earthquake intensity (because of, for instance, building quality, or people making location decisions accordingly), in short enough time windows, such aspects should be absorbed by the canton fixed effect c.[4] In fact, in Ecuador, no reliable, official information is provided that would enable the population to forecast the location and strength of an earthquake in deciding where to (re)locate. Finally, it might be argued that victims are forced to leave their communities as a result of the damages caused by earthquakes. However, evidence from rural Ecuador indicates that adverse environmental conditions do not mechanically lead to out-migration, and might even decrease migration – in other words, rural households tend to adapt to environmental disasters (Gray and Bilsborrow, 2013). In the unlikely scenario earthquake victims did relocate, the fact that we assigned seismic activity according to an inpatient's canton of *registered* residence, ensures correct measure of earthquake exposure since canton registration would not change quickly in a situation of emergency such as an earthquake. In this sense, selective migration is not expected to bias our estimates.

We first examine whether seismic activity per se affects behavioural disorders, disregarding earthquake intensity categories. We then assess whether intensity scales matter, by setting to 0 events with an intensity strictly lower than VIII in the MSK scale – 'damaging' earthquakes. This is done because earthquakes of intensities VIII or more entail serious damages such as furniture being overturned, older structures partially collapsing, as well as many people finding it difficult to stand, to all surface and underground structures completely destroyed (XII).

4 Results

We primarily focus on measures of hospital admissions and deaths (Tables 2 to 7) as they come from administrative sources, and represent the universe of occurrence of mental health events in the Ecuadorian population, and are measured similarly, allowing for direct comparability. In contrast, survey data results on life satisfaction, interpersonal trust and religious observance (Table 8) are derived from nationally representative samples, and interpreted as supplementary evidence.

[4] Results hold when including province-by-year and canton-by-month fixed effects, and are available on request.

4.1 Main findings

Table 2 presents baseline estimations of equation (2) for hospital admissions. The dependent variables are binary, equal to 1 if the admission corresponds to the column-specific cause, and 0 otherwise – mental and behavioural disorders in column (1), poisoning by drug, medication, and biological substance in column (2), intoxication by non-medicinal substance in column (3), and injuries in column (4). Results in all columns include day-of-week, month, year, and canton fixed-effects, distance between canton of residence and canton of health unit, as well as inpatient's gender, age and squared age. Panel A presents equation (2) estimates for all earthquake intensities; Panel B, for intensities strictly above IV, that is for largely observed earthquakes; Panel C for intensities strictly above VI, strong earthquakes; and Panel D, for intensities strictly above VIII, damaging earthquakes. All values of intensities below the specified thresholds are set to 0. Note that, for readability purposes, earthquake intensity variables were rescaled (divided by 100).

While column (1) in Panel A, Table 2, suggests that being admitted for mental and behavioural disorders is not significantly related to seismic intensity in the 28 days following an earthquake, Panel (D) indicates that a one-unit increase in the intensity of damaging earthquakes – with intensities VIII or higher – significantly decreases the probability to be hospitalised for mental and behavioural disorders by 0.05 percentage points. This is equivalent to a 6.53 (-0.000477/0.0073) percentage point decrease at the estimation sample mean, in the 14-day window following an earthquake. This is a first indication that larger earthquakes do impact on mental health of those exposed, albeit favourably, while lower intensity earthquakes seem neutral to our measure of hospital admission in the short run. These result are supported by estimates in columns (2) and (3), showing that a one-unit increase in damaging earthquake intensity decreases the likelihood of hospital admission by almost 0.01 percentage points for poisoning in the seven days following an earthquake; and by 0.05 percentage points for intoxication in the 14-day window following an earthquake, corresponding to 6.09 and 10.89 percentage point decreases at the estimation sample mean, respectively.

To assess the consistency of the above results, we run the same specification, changing the dependent variable to hospitalisation for injuries. In contrast to the three first columns, column (4), Panel C, reassuringly evidences an increase in the propensity of hospitalisation for injuries in the seven days following an earthquake, by up to 1.06 percentage points – a 13.82 percentage point increase at the mean – for intensity VI earthquakes. The general picture that emerges from inpatient data is that hospital admissions to mental disorders, poisoning, and intoxication decrease, but only because of larger intensity earthquakes. In contrast, injury-related admissions increase by all types of earthquakes, but only in the very short aftermath of an event.

In order to exclude a possible crowding out effect of mental health hospitalisations by admissions for injuries, we undertake a number of checks using alternative measures of mental health distress. In Table 3, we focus on baseline estimations of equation (2), relying on the length of the stay in hospital upon admission. We set to 0 earthquake intensities strictly lower than intensity VIII, that is we assess the effects of damaging earthquakes exclusively. Similar to results in Table 2, column (1) indicates that the number of days of hospitalisation for mental and behavioural disorders significantly decreases with the frequency of earthquake exposure. A one-unit increase in intensity decreases hospital stays by almost 0.01 day in the 21 days following an earthquake. Although effects are small in magnitude, they are highly significant. Similarly, columns (2) and (3) evidence significant shortened stays for poisoning and intoxication. In contrast, in column (4), the relationship between length of hospitalisation for injuries and damaging earthquake intensity, albeit positive, is not statistically strong.

In Table 4, the baseline equation (2) is re-estimated for damaging earthquakes, using death records. Column (1) presents estimates for death to suicide; column (2), undetermined intent of external violent deaths; column (3), mental and behavioural disorders; and column (4), natural disaster accidents. Column (1) is consistent with a decrease in suicides for all considered windows, where a one-unit increase in intensity of damaging earthquakes significantly decreases the probability to die to suicide by 0.41, 0.14, 0.19, and 0.21 percentage points in the 7-, 14-, 21-, to 28-day windows following an earthquake, respectively. These are equivalent to 26.94 to 9.34 percentage point decreases at the estimation sample mean. Similarly, column (2) indicates that a one-unit increase in intensity of stronger earthquakes significantly decreases the probability to die to undetermined violent intent by almost 0.20 percentage points in the very short run (7-day window) after an earthquake. In column (3), deaths to mental disorders also decrease significantly up to 28 days after an earthquake – albeit marginally insignificant for the 8-14 day window. A one-unit increase in the intensity of stronger earthquakes significantly decreases the probability to die due to mental and behavioural disorders by about 0.02 percentage points in the 7, 15-21, and 28-day windows, corresponding to a 7.14 percentage point decrease at the mean. In contrast, and as expected, column (4) suggests that a one-unit increase in earthquake intensity significantly increases the probability to die by accident resulting from a natural disaster by 9.08 percentage points in the 7-day window following an earthquake. These results are robust to further robustness checks. Table A3 presents estimates of a placebo test in which specification (2) is estimated with inpatient data, for causes of hospital admission that should not, a priori, be related to earthquakes: neoplasms (C00-D48), endocrine and metabolic illnesses (E00-E90), genito-urinary track illnesses (N00-N99), and skin and subcutaneous tissue illnesses (L00-L99). Reassuringly, coefficient estimates are small in magnitudes, and none is statistically significant.

In Table A4, we re-estimate specification (2) with inpatient data, excluding hospitalisations that are shorter than two days. This is because of possible reporting inconsistencies, where health units might have differing admission practices, leading to gaps in reported data. Recording is expected to increase in quality the longer hospitalisations are (Williams et al., 2016). Baseline results presented in Table 2 hold – estimated coefficient magnitudes become even larger.

Table A5 presents effects associated with damaging earthquakes that occurred up to two years before admission dates, to explore possible non-monotonic impacts of damaging earthquakes on mental health. In fact, evidence from Greece and Japan indicates that areas affected by strong earthquakes experience an increase in suicide rates in subsequent years, despite suicide rates temporarily declining one or two years after the disaster (Madianos and Evi, 2010; Matsubayashi et al., 2013). Column (1) highlights the persistence of a decrease in hospital admissions for mental and behavioural disorders in response to damaging earthquakes up to one year and three months, at least. Looking at alternative mental health indicators – poisoning in column (2), and intoxication in column (3) – estimated effects seem to fade away after a month after exposure to a damaging earthquake.

To summarize thus far, results yield four important findings. First, exposure to damaging earthquakes does not lead to PTSD diagnoses up to 28 days following an earthquake. Rather, they support a reduction in hospitalisations to mental and behavioural disorders in the immediate aftermath of a disaster. Second, the decrease in hospital admissions and length of hospitalisation to mental and behavioural disorders is not explained by a corresponding increase in admissions to injuries. Third, the improvement in mental health is confirmed by significant decreases in deaths to suicides. The order of magnitude of the estimated suicide response to damaging earthquakes is larger than the effect on admissions to behavioural disorders. This is particularly informative as death registry indicators are less likely biased by measurement errors. Fourth, in contrast to previous works, it is not clear whether, in the setting of our analysis, there is presence of non-linearities in the effect of earthquake events on the mental health measures we considered. Albeit counter-intuitive, these results are in line with a surge in social cohesion and community participation that have been shown to buffer cognitive and mental decline following disasters (e.g. Gordon et al., 2011; Hikichi et al., 2020; Kaiser et al., 1996).

4.2 Heterogeneous effect analysis

Baseline estimates show that damaging earthquakes reduces hospitalisations and deaths to mental disorders and suicides. Still, these estimates are average effects – they might hide differences in the mental health response to earthquakes. It has indeed been documented that people are not equal when it comes to mental health disorders (Currin et al., 2011), nor in their propensity to help-seeking attitudes (Mackenzie et al., 2006). In the Americas, for instance, women are more likely depressed and anxious than men. In contrast, men are more prone to substance addiction, self-harm, and suicide. And, while the elderly are, organically, more prone to disorders such as dementia, Alzheimer, or depression, the 15-49 year-old category display the greatest amount of years lived with disability because of depression, and thus the highest number of years of life lost (PAHO, 2018)

Table 5 presents estimates of equation (2) with hospital discharges for damaging earthquakes by gender. Columns (1)-(3) confirm baseline decreases for hospital admissions to mental disorders, poisoning, and intoxication for both men and women. They also indicate that the effect is more immediate, and statistically stronger for women, even if of lower magnitude.

Results from estimates of equation (2) with hospital discharges for damaging earthquakes by age categories are given in Table 6. As expected, column (1) highlights some heterogeneity, with patients aged 61 years old or more driving results unearthed in Table 2. For instance, Panel D indicates that a one-unit increase in earthquake intensity significantly decreases the probability to be hospitalised for mental and behavioural disorders by 0.05 percentage points in the 7-28-day windows following an earthquake, for the elderly. The decrease in the propensity to be admitted for poisoning and intoxication, on the other hand, is essentially driven by the 18-40 and 41-60 year-old categories, as evidenced by Panels B and C.

We also explore whether there are differences in the mental health consequences of earthquakes across the variety of behavioural disorders. Presence of heterogeneity in diagnoses in response to environmental changes has indeed been found elsewhere in the literature. For instance, heatwaves were shown to induce hospital admissions particularly for mental retardation, and organic mental disorders in Vietnam (Trang et al., 2016); and weather temperature increases, to result in emergency department visits for mood, self-harm, and anxiety disorders in the US (Mullins and White, 2019). Table 7 presents estimates of equation (2) with hospital admissions for damaging earthquakes breaking up mental and behavioural disorders into 10 subcategories. We generate a series of binary variables specific to each disorder as specified by the columns of the table. In line with existing evidence, we find that hospital admissions are differently related to earthquakes depending on the type of diagnosis. The decrease in the likelihood to be admitted for mental and behavioural disorders appear mainly driven by psychoactive substance use, in column

(2), and mood disorders, in column (4). To a lower extent, baseline results are explained by delusional, stress-related, organic disorders, and physical factors, in columns (3), (5), (1) and (6), respectively.

4.3 Social cohesion

Table 8 presents estimations of equation (2) for social cohesion indicators relying on survey data. As it is difficult to ensure precise measure of social cohesion, we present a range of estimates. While possible reporting errors should call for caution in interpreting these results, survey data estimates suggest that the relationship between earthquake and mental health is explained by improved social cohesion in affected communities.

Panel A reports results obtained from five successive waves of *Latinobarómetro*, examining the impact of an earthquake prior to a respondent's interview date on life satisfaction, interpersonal trust, trust in the Church, and religious observance. Column (1) indicates a marginally significant increase in life satisfaction in the 7-day window following an earthquake. While there is no visible association with interpersonal trust, column (3) shows that a one-unit increase in earthquake intensity increases trust in the Church by 3.44 to 6.41 percentage points in the 7- to 28-day windows following an earthquake.

Panel B depicts results obtained from three successive waves of AmericasBarometer, assessing the effect of an earthquake prior to a respondent's interview date on their current economic situation, interpersonal trust, participating in solving community problems, and religious observance. Although column (1) shows that interviews report worsened economic situation in the 7-day window following an earthquake, their economic situation appears to quickly improve, in the 21-day window following an earthquake. In line with *Latinobarómetro* data, no significant relationship is evidenced with regard to interpersonal trust. Nonetheless, column (3) demonstrates an increase in the propensity to participate in community organisations by 14.74 percentage points in the 28-day window following an earthquake, and in religious observance by 2.79 percentage points in the direct aftermath of an earthquake.

5 Concluding remarks

We have presented causal evidence of a robust negative relation between earthquake intensity and mental well-being. Our findings show that damaging earthquakes improve mental health in the short run by decreasing hospital admissions and length of hospitalisation to mental and behavioural disorders. The identified link is consistent across gender, age, diagnoses, and exposure windows. The decrease in deaths to suicides, as well as the boost in various social cohesion indicators following the occurrence of damaging earthquakes we estimated suggest that our results might be explained by improved social connectedness, at least in the direct aftermath of a disaster, in line with previous studies (e.g. Bentzen, 2019; Calo-Blanco et al., 2017; García Hombrados, 2020; Yacoubian and Hacker, 1989).

One should note that the nature of data did not allow us to explore whether behavioral disorders after an earthquake appear, or worsen, in the longer term. It might also be argued that our findings result in part from limited, or bad quality screening of mental disorders,[5] and the low propensity to seek mental health care in the Ecuadorian population.[6] Empirically, these aspects would lead to measurement errors in the dependent variables, and decrease the precision of our estimates.

Finally, we believe that more research is needed to fully understand the relationship between earthquake and mental health. As mental disorders might be unobserved, but prevalent in our setting, future research might seek to explore how to improve mental health disorder screening in emergency as well as non-emergency settings to anticipate and address the possible need for mental health and humanitarian services. A direct intervention that we can infer from our work is for practitioners to set in place interventions strengthening cohesion within affected communities as a means to relieve mental and behavioural disorders associated with earthquakes.

[5] With 0.20% of per capita gross domestic product dedicated to mental health spending in 2015, Ecuador tends to allocate funding to specialised neuropsychiatric care, away from community-based mental health services. The disproportion between the share of the total burden caused by mental disorders, and the share of health expenditures devoted to mental health leads to the mental health burden being 13.9 times the spending (PAHO, 2018).

[6] See footnote 2.

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Figure 1: Earthquake epicenters, Ecuador, 2012-2018

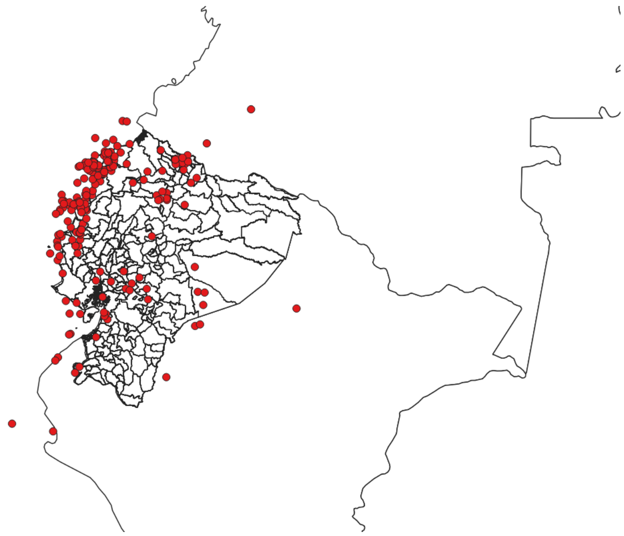

Table 1: Summary statistics

Hospital discharges 2012-2018					Death records 2013-2018					*Latinobarómetro* 2013-2018					AmericasBarometer 2014-2019				
Variables	Mean	SD	Min	Max	Variables	Mean	SD	Min	Max	Variables	Mean	SD	Min	Max	Variables	Mean	SD	Min	Max
MSK intensity					*MSK intensity*					*MSK intensity*					*MSK intensity*				
7-day	0.0972	0.5050	0	10.1750	7-day	0.1176	0.6031	0	9.2412	7-day	0.1813	0.6500	0	4.1045	7-day	0.3799	1.0267	0	4.2065
8-14-day	0.0862	0.4777	0	10.1750	8-14-day	0.0932	0.4961	0	10.1750	8-14-day	0.1574	0.5917	0	4.1045	8-14-day	0.1766	0.6754	0	5.8470
15-21-day	0.0877	0.4840	0	10.1750	15-21-day	0.0938	0.5026	0	10.1750	15-21-day	0.2806	0.8660	0	5.9262	15-21-day	0.0028	0.0760	0	3.1041
22-28-day	0.0870	0.4821	0	10.1750	22-28-day	0.0936	0.5022	0	10.1750	22-28-day	0.0957	0.4909	0	5.9262	22-28-day	0.0161	0.1430	0	1.3110
Admissions for					*Deaths for*														
Mental	0.0073	0.0853	0	1	Suicide	0.0153	0.1228	0	1	Life satisfaction	0.7376	0.4400	0	1	Economic situation	0.5889	0.4921	0	1
Poisoning	0.0011	0.0335	0	1	Undetermined intent	0.0092	0.0955	0	1	Interpersonal trust	0.1954	0.3966	0	1	Interpersonal trust	0.5724	0.4948	0	1
Intoxication	0.0045	0.0669	0	1	Mental	0.0028	0.0527	0	1	Trust in church	0.7476	0.4344	0	1	Community participation	0.3724	0.4835	0	1
Injuries	0.0768	0.2662	0	1	Natural disaster	0.0022	0.0470	0	1	Very religious	0.1272	0.3332	0	1	Very religious	0.6601	0.4736	0	1
Observations		8,098,484			Observations		403,051			Observations		4,002			Observations		4,254		

Summary statistics for hospital discharges, deaths, and survey data are reported at the individual and daily level. Earthquake intensity time-window means indicate the mean maximal earthquake intensity in the specified number of days prior to the date of hospital admission, death, or survey data collection, respectively.

Table 2: 2012-2018 hospital discharges

Variables	Mental and behavioural disorders (1)	Poisoning by drug, medication, and biological substance (2)	Intoxication by non-medicinal substance (3)	Injuries (4)
Panel A: Non-null intensity				
7-day MSK intensity	-0.0026	-0.0028	-0.0025	0.1369**
	(0.0080)	(0.0017)	(0.0054)	(0.0493)
8-14-day MSK intensity	-0.0028	0.0004	-0.0063	-0.0100
	(0.0095)	(0.0019)	(0.0045)	(0.0153)
15-21-day MSK intensity	-0.0027	0.0029	-0.0024	-0.0204
	(0.0061)	(0.0031)	(0.0053)	(0.0186)
22-28-day MSK intensity	0.0052	-0.0014	0.0022	-0.0388
	(0.0063)	(0.0022)	(0.0043)	(0.0238)
R-squared	0.0052	0.0006	0.0081	0.0469
Panel B: Intensity IV plus				
7-day MSK intensity	0.0024	-0.0022	-0.0026	0.2893**
	(0.0103)	(0.0027)	(0.0073)	(0.1070)
8-14-day MSK intensity	0.0014	-0.0011	-0.0088	-0.0012
	(0.0125)	(0.0033)	(0.0067)	(0.0260)
15-21-day MSK intensity	0.0067	0.0063	0.0028	0.0017
	(0.0088)	(0.0038)	(0.0066)	(0.0256)
22-28-day MSK intensity	0.0089	-0.0002	0.0079	-0.0548*
	(0.0129)	(0.0034)	(0.0064)	(0.0234)
R-squared	0.0052	0.0006	0.0081	0.0469
Panel C: Intensity VI plus				
7-day MSK intensity	0.0153	-0.0082**	0.0005	1.0613**
	(0.0151)	(0.0012)	(0.0233)	(0.3936)
8-14-day MSK intensity	-0.0144	0.0069	-0.0036	0.0411
	(0.0215)	(0.0077)	(0.0161)	(0.0654)
15-21-day MSK intensity	0.0112	0.0040	-0.0152	-0.0402
	(0.0163)	(0.0055)	(0.0141)	(0.0473)
22-28-day MSK intensity	0.0409	-0.0047	0.0313	-0.0334
	(0.0215)	(0.0034)	(0.0204)	(0.0602)
R-squared	0.0052	0.0006	0.0081	0.0470
Panel D: Intensity VIII plus				
7-day MSK intensity	-0.0101	-0.0067**	0.0253	1.1153
	(0.0163)	(0.0011)	(0.0439)	(0.9432)
8-14-day MSK intensity	-0.0477**	0.0171	-0.0490**	0.0470
	(0.0140)	(0.0160)	(0.0100)	(0.1445)
15-21-day MSK intensity	-0.0058	-0.0064**	0.0106	-0.0767
	(0.0175)	(0.0008)	(0.0329)	(0.0622)
22-28-day MSK intensity	0.0838	-0.0064**	0.0557	0.0428
	(0.0622)	(0.0008)	(0.0507)	(0.0947)
R-squared	0.0052	0.0006	0.0081	0.0469
Observations	8,098,484	8,098,484	8,098,484	8,098,484

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** p<0.01, * p<0.05.

Table 3: 2012-2018 hospital discharges, damaging earthquakes, length of hospitalisation

Variables	Mental and behavioural disorders (1)	Poisoning by drug, medication, and biological substance (2)	Intoxication by non-medicinal substance (3)	Injuries (4)
7-day MSK intensity	-0.6503**	-0.0204**	-0.0194	8.8766
	(0.1216)	(0.0079)	(0.1528)	(8.7278)
8-14-day MSK intensity	-0.9317**	0.0082	-0.2339**	1.0126
	(0.3170)	(0.0162)	(0.0410)	(1.0861)
15-21-day MSK intensity	-0.8105**	-0.0155**	0.1179	-1.3421**
	(0.2713)	(0.0047)	(0.1936)	(0.3814)
22-28-day MSK intensity	0.3491	-0.0167**	0.0078	1.3408
	(0.6019)	(0.0049)	(0.1739)	(1.8769)
R-squared	0.0011	0.0002	0.0025	0.0134
Observations	8,098,484	8,098,484	8,098,484	8,098,484
Mean DV	0.1333	0.0038	0.0163	0.3873
	(4.7991)	(0.1918)	(0.4597)	(2.8431)

Notes: Dependent variables are discrete variables measuring the length of the stay in hospital after admission for column-specified causes. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to zero for intensities strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** $p<0.01$, * $p<0.05$.

Table 4: 2013-2018 death records, damaging earthquakes

Variables	Suicide (1)	Undetermined intent (2)	Mental and behavioural disorders (3)	Natural disaster accident (4)
7-day MSK intensity	-0.4122**	-0.1997**	-0.0230**	9.0845**
	(0.0554)	(0.0384)	(0.0064)	(1.3869)
8-14-day MSK intensity	-0.1430**	0.0161	-0.0148	-0.2080
	(0.0460)	(0.0156)	(0.0089)	(0.1145)
15-21-day MSK intensity	-0.1974**	0.0139	-0.0192*	-0.0564*
	(0.0184)	(0.0200)	(0.0087)	(0.0262)
22-28-day MSK intensity	-0.2146**	-0.0112	-0.0220**	-0.0854**
	(0.0373)	(0.0444)	(0.0079)	(0.0324)
R-squared	0.0281	0.0132	0.0023	0.2110
Observations	403,051	403,051	403,051	403,051

Notes: Dependent variables are binary variables taking value 1 if death occurred for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to zero for intensities strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** p<0.01, * p<0.05.

Table 5: 2012-2018 hospital discharges, damaging earthquakes, gender

Variables	Mental and behavioural disorders (1)	Poisoning by drug, medication, and biological substance (2)	Intoxication by non-medicinal substance (3)	Injuries (4)
Panel A: Men				
7-day MSK intensity	0.0220	-0.0124**	0.0487	0.8103
	(0.0418)	(0.0025)	(0.1090)	(1.0034)
8-14-day MSK intensity	-0.0899**	0.0689	-0.1021**	0.0588
	(0.0187)	(0.0435)	(0.0244)	(0.3237)
15-21-day MSK intensity	-0.1041**	-0.0138**	-0.0523	-0.0097
	(0.0147)	(0.0019)	(0.0614)	(0.2407)
22-28-day MSK intensity	0.2344	-0.0122**	0.2379	-0.2792
	(0.1919)	(0.0016)	(0.1317)	(0.3726)
R-squared	0.0084	0.0008	0.0137	0.0442
Observations	2,835,755	2,835,755	2,835,755	2,835,755
Panel B: Women				
7-day MSK intensity	-0.0249**	-0.0044**	0.0051	1.2309
	(0.0066)	(0.0016)	(0.0299)	(0.8956)
8-14-day MSK intensity	-0.0285**	-0.0040**	-0.0184*	0.0859
	(0.0087)	(0.0015)	(0.0078)	(0.0703)
15-21-day MSK intensity	0.0269	-0.0041**	0.0373	-0.1170**
	(0.0209)	(0.0009)	(0.0272)	(0.0283)
22-28-day MSK intensity	0.0243	-0.0043**	-0.0222	0.1709
	(0.0267)	(0.0010)	(0.0280)	(0.0899)
R-squared	0.0022	0.0007	0.0047	0.0163
Observations	5,262,729	5,262,729	5,262,729	5,262,729

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to 0 for intensities strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** p<0.01, * p<0.05.

Table 6: 2012-2018 hospital discharges, damaging earthquakes, age

Variables	Mental and behavioural disorders (1)	Poisoning by drug, medication, and biological substance (2)	Intoxication by non-medicinal substance (3)	Injuries (4)
Panel A: 0-17 years old				
7-day MSK intensity	-0.0139	-0.0016	0.0123	1.1673
	(0.0073)	(0.0029)	(0.0909)	(0.7163)
8-14-day MSK intensity	-0.0191*	0.0882	-0.1294*	-0.0618
	(0.0090)	(0.0658)	(0.0513)	(0.1026)
15-21-day MSK intensity	0.0575	-0.0056*	0.1312	-0.2761**
	(0.0796)	(0.0024)	(0.1868)	(0.0969)
22-28-day MSK intensity	0.0483	-0.0044	0.0042	0.0553
	(0.0419)	(0.0026)	(0.1002)	(0.1270)
R-squared	0.0078	0.0015	0.0080	0.0621
Observations	1,943,925	1,943,925	1,943,925	1,943,925
Panel B: 18-40 years old				
7-day MSK intensity	0.0247	-0.0083**	-0.0080	0.7358
	(0.0276)	(0.0013)	(0.0330)	(0.7284)
8-14-day MSK intensity	-0.0421*	-0.0070**	-0.0336**	-0.0105
	(0.0189)	(0.0012)	(0.0078)	(0.1387)
15-21-day MSK intensity	-0.0528**	-0.0069**	-0.0024	0.0352
	(0.0133)	(0.0010)	(0.0420)	(0.0856)
22-28-day MSK intensity	0.1012	-0.0074**	0.0406	-0.0279
	(0.0674)	(0.0010)	(0.0286)	(0.1866)
R-squared	0.0107	0.0011	0.0112	0.1658
Observations	3,557,010	3,557,010	3,557,010	3,557,010
Panel C: 41-60 years old				
7-day MSK intensity	0.0247	-0.0099**	0.0169	2.3634
	(0.0276)	(0.0022)	(0.1234)	(1.6649)
8-14-day MSK intensity	-0.0421*	-0.0090**	0.0981	0.0911
	(0.0189)	(0.0019)	(0.1380)	(0.4413)
15-21-day MSK intensity	-0.0528**	-0.0086**	-0.1006*	-0.1421
	(0.0133)	(0.0018)	(0.0464)	(0.2568)
22-28-day MSK intensity	0.1012	-0.0074**	0.3207*	-0.2735
	(0.0674)	(0.0022)	(0.1246)	(0.2121)
R-squared	0.0107	0.0004	0.0121	0.0325
Observations	3,557,010	1,272,726	1,272,726	1,272,726
Panel D: 61 years old and more				
7-day MSK intensity	-0.0489**	-0.0035	0.2002	0.9987
	(0.0105)	(0.0022)	(0.2876)	(1.1967)
8-14-day MSK intensity	-0.0603**	-0.0025	-0.0581*	1.0989**
	(0.0103)	(0.0018)	(0.0265)	(0.2338)
15-21-day MSK intensity	-0.0533**	-0.0048*	-0.0746*	-0.1577
	(0.0104)	(0.0021)	(0.0360)	(0.2289)
22-28-day MSK intensity	0.1184	-0.0048	-0.0749*	0.7341*
	(0.0843)	(0.0026)	(0.0376)	(0.3451)
R-squared	0.0019	0.0004	0.0064	0.0068
Observations	1,324,820	1,324,820	1,324,820	1,324,820

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to 0 for intensities strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** $p<0.01$, * $p<0.05$.

Table 7: 2012-2018 hospital discharges, damaging earthquakes, mental and behavioural disorder subcategories

Variables	Organic disorders (1)	Psychoactive substance use (2)	Schizophrenia, schizotypal, delusional disorders (3)	Mood disorders (4)	Neurotic, stress-related, somatoform disorders (5)	Physiological disturbances and physical factors (6)	Disorders of adult personality and behaviour (7)	Mental retardation (8)	Psychological development (9)	Disorders with onset in childhood and adolescence (10)
7-day MSK intensity	-0.0045**	-0.0104**	0.0041	-0.0100**	0.0125	-0.0007*	-0.0005	0.0000	-0.0000	-0.0004
	(0.0008)	(0.0015)	(0.0092)	(0.0025)	(0.0189)	(0.0003)	(0.0004)	(0.0002)	(0.0002)	(0.0003)
8-14-day MSK intensity	-0.0043**	-0.0085**	-0.0140**	-0.0117**	-0.0074**	-0.0008**	-0.0005	-0.0000	0.0000	-0.0004
	(0.0014)	(0.0032)	(0.0051)	(0.0030)	(0.0018)	(0.0003)	(0.0004)	(0.0002)	(0.0002)	(0.0003)
15-21-day MSK intensity	-0.0034*	-0.0094**	0.0088	-0.0133**	0.0126	-0.0006*	-0.0006	-0.0002	0.0003	-0.0001
	(0.0014)	(0.0021)	(0.0229)	(0.0029)	(0.0129)	(0.0002)	(0.0004)	(0.0002)	(0.0002)	(0.0003)
22-28-day MSK intensity	0.0341	-0.0098**	0.0053	0.0057	0.0301	0.0193	-0.0007	-0.0003	0.0003	-0.0002
	(0.0252)	(0.0023)	(0.0081)	(0.0100)	(0.0249)	(0.0200)	(0.0005)	(0.0002)	(0.0002)	(0.0003)
R-squared	0.0008	0.0056	0.0014	0.0014	0.0005	0.0003	0.0001	0.0001	0.0002	0.0001
Observations	8,098,484	8,098,484	8,098,484	8,098,484	8,098,484	8,098,484	8,098,484	8,098,484	8,098,484	8,098,484

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to 0 for intensities strictly lower than VIII, and rescaled (divided by 100) for readablity purposes. Specifications control for gender, age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** p<0.01, * p<0.05.

Table 8: Survey data

Variables	(1)	(2)	(3)	(4)
Panel A: 2013-2018 Latinobarómetro				
	Life satisfaction	Interpersonal trust	Trust in church	Very religious
7-day MSK intensity	0.0232	-0.0293	0.0344**	0.0024
	(0.0120)	(0.0155)	(0.0115)	(0.0149)
8-14-day MSK intensity	0.0276	-0.0039	0.0305*	0.0112
	(0.0159)	(0.0227)	(0.0143)	(0.0161)
15-21-day MSK intensity	0.0053	0.0162	0.0471**	-0.0037
	(0.0147)	(0.0240)	(0.0132)	(0.0111)
22-28-day MSK intensity	-0.0038	0.0138	0.0641**	0.0253
	(0.0177)	(0.0260)	(0.0167)	(0.0173)
R-squared	0.0781	0.0800	0.0708	0.0710
Observations	4,002	4,002	4,002	4,002
Panel B: 2014-2019 AmericasBarometer				
	Economic situation	Interpersonal trust	Community participation	Very religious
7-day MSK intensity	-0.0355**	-0.0180	-0.0007	0.0279*
	(0.0122)	(0.0136)	(0.0117)	(0.0118)
8-14-day MSK intensity	-0.0059	-0.0258	-0.0280	0.0091
	(0.0093)	(0.0199)	(0.0170)	(0.0157)
15-21-day MSK intensity	0.1700*	0.1285	0.1613	-0.0477
	(0.0690)	(0.0679)	(0.0919)	(0.0511)
22-28-day MSK intensity	0.0811	0.0394	0.1474*	-0.0331
	(0.0892)	(0.0222)	(0.0621)	(0.0429)
R-squared	0.1367	0.0803	0.0845	0.0971
Observations	4,254	4,254	4,254	4,254

Notes: In Panel A, dependent variables are binary variables taking value 1 if a respondent is satisfied with her life in column (1), trusts people in column (2), trusts the Church in column (3), and views herself as very religiously observant in columns (4); 0, otherwise. Specifications control for gender, age categories, ethnicity, nationality, work status, marital status, and education categories. In Panel B, dependent variables are binary variables taking value 1 if a respondent perceives her economic situation similar or better than 12 months ago in column (1), trusts people in column (2), participates in solving community problems at least once a year in column (3), and considers religion as very important in column (4); 0, otherwise. Specifications control for gender, age, ethnicity, work status, marital status, and education. In Panels A and B, MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows. Specifications include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** $p<0.01$, * $p<0.05$.

Appendices

Table A1: Prevalence of health problems and use of health facilities, 2012 and 2018 *Encuesta Nacional de Salud y Nutrición* (Ensanut)

Variables	Health issues(s) in the last 30 days (1)	What did you do to solve your health issue? Outpatient visit (2)	Home visit (3)	Self-medication (4)	Inpatient visit (5)	Nothing (6)
Panel A: 2012						
All health issues	0.4283	0.5057	0.0108	0.3376	0.0022	0.1437
	(0.0048)	(0.0054)	(0.0012)	(0.0051)	(0.0004)	(0.0036)
Population size	15,500,949	6,638,467	6,638,467	6,638,467	6,638,467	6,638,467
Panel B: 2018						
All health issues	0.2283	0.6516	0.0156	0.2430	0.0046	0.0852
	(0.0033)	(0.0061)	(0.0015)	(0.0058)	(0.0007)	(0.0039)
Population size	17,145,794	3,916,503	3,916,503	3,916,503	3,916,503	3,916,503

Notes: Statistics are average shares of the Ecuadorian population who reported having health issues in the 30 days preceding the date of interview in column (1), and solutions they sought to address their health problems in columns (2) to (6), for the year 2012 in Panel A, and 2018 in Panel B. Standard errors are provided in parentheses. Sample weights were used to ensure statistics to be nationally representative.

Table A2: Non-null MSK intensities

Variables	Mean (1)	SD (2)	Min (3)	Max (4)	Obs (5)
Panel A: 2012-2018 hospital discharges					
7-day	1.37253	1.36008	0.00002	10.1750	573,723
8-14-day	1.38751	1.36613	0.00002	10.1750	503,334
15-21-day	1.39747	1.37989	0.00002	10.1750	507,998
22-28-day	1.39946	1.37829	0.00002	10.1750	503,680
Panel B: 2013-2018 death records					
7-day	1.49275	1.60086	0.00002	9.24160	31,759
8-14-day	1.36189	1.36661	0.00002	10.17504	27,585
15-21-day	1.38533	1.39344	0.00130	10.17504	27,289
22-28-day	1.39237	1.39434	0.00033	10.17504	27,088
Panel C: 2013-2018 Latinobarómetro					
7-day	1.41688	1.24664	0.13793	4.10453	512
8-14-day	1.96816	0.90346	0.15636	4.10453	320
15-21-day	1.98392	1.38744	0.13793	5.92620	566
22-28-day	1.09749	1.29164	0.03955	5.92620	349
Panel D: 2014-2019 AmericasBarometer					
7-day	2.69768	1.11041	0.00796	4.20645	599
8-14-day	1.82779	1.30609	0.02599	5.84696	411
15-21-day	0.79497	1.03829	0.05097	3.10409	15
22-28-day	1.28875	0.01137	1.28036	1.31104	53

Summary statistics for non-null earthquake intensities at the individual and daily level. The earthquake intensity time-window means indicate the mean maximal earthquake intensity in the specified number of days prior the date of hospital admission, death, or survey data collection, respectively.

Table A3: 2012-2018 hospital discharges, damaging earthquakes, placebo

Variables	Neoplasms (1)	Endocrine and metabolic (2)	Genito-urinary track (3)	Skin and subcutaneous tissue (4)
7-day MSK intensity	-0.1783	-0.0302	-0.1079	0.0572
	(0.1305)	(0.0601)	(0.1161)	(0.0490)
8-14-day MSK intensity	0.0828	-0.0957	-0.0395	0.0476
	(0.0771)	(0.0735)	(0.0662)	(0.0509)
15-21-day MSK intensity	0.0187	-0.0146	-0.0512	-0.0514
	(0.0682)	(0.0583)	(0.1023)	(0.0312)
22-28-day MSK intensity	0.0279	-0.0011	-0.1248	0.0107
	(0.0910)	(0.0557)	(0.2375)	(0.0536)
R-squared	0.0411	0.0176	0.0165	0.0056
Observations	8,098,484	8,098,484	8,098,484	8,098,484
Mean DV	0.0578	0.0256	0.0779	0.0147
	(0.2333)	(0.1580)	(0.2680)	(0.1203)

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to 0 if strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** $p<0.01$, * $p<0.05$.

Table A4: 2012-2018 hospital discharges, damaging earthquakes, excluding shorter hospitalisations

Variables	Mental and behavioural disorders (1)	Poisoning by drug, medication, and biological substance (2)	Intoxication by non-medicinal substance (3)	Injuries (4)
7-day MSK intensity	-0.0010	-0.0065**	0.0120	1.4953
	(0.0213)	(0.0017)	(0.0578)	(1.1378)
8-14-day MSK intensity	-0.0672**	-0.0053**	-0.0419**	0.1319
	(0.0185)	(0.0016)	(0.0143)	(0.1557)
15-21-day MSK intensity	-0.0243**	-0.0064**	0.0340	-0.0829
	(0.0076)	(0.0010)	(0.0469)	(0.0667)
22-28-day MSK intensity	0.1545	-0.0060**	0.0780	0.0781
	(0.0970)	(0.0010)	(0.0663)	(0.1166)
R-squared	0.0067	0.0005	0.0091	0.0452
Observations	5,486,365	5,486,365	5,486,365	5,486,365

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to 0 if strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** $p<0.01$, * $p<0.05$.

Table A5: 2012-2018 hospital discharges, damaging earthquakes, two-year window

Variables	Mental and behavioural disorders (1)	Poisoning by drug, medication, and biological substance (2)	Intoxication by non-medicinal substance (3)	Injuries (4)
7 days	-0.0108	-0.0061**	0.0170	1.1162
	(0.0161)	(0.0013)	(0.0415)	(0.9444)
8 to 14 days	-0.0493**	0.0176	-0.0568**	0.0424
	(0.0150)	(0.0165)	(0.0125)	(0.1456)
15 to 21 days	-0.0071	-0.0058**	0.0027	-0.0795
	(0.0177)	(0.0010)	(0.0297)	(0.0583)
22 to 28 days	0.0822	-0.0058**	0.0483	0.0378
	(0.0618)	(0.0010)	(0.0537)	(0.0978)
29 to 56 days	-0.0218**	-0.0006	0.0129	-0.1328**
	(0.0054)	(0.0039)	(0.0221)	(0.0341)
57 to 84 days	-0.0028	-0.0006	-0.0069	-0.0169
	(0.0140)	(0.0040)	(0.0288)	(0.0614)
85 to 168 days	-0.0131	0.0025	-0.0069	-0.0029
	(0.0147)	(0.0036)	(0.0108)	(0.0412)
169 to 224 days	-0.0204**	0.0067	-0.0223	0.0214
	(0.0056)	(0.0043)	(0.0315)	(0.0318)
225 to 364 days	-0.0160*	-0.0021	-0.0282	-0.0036
	(0.0073)	(0.0023)	(0.0239)	(0.0362)
365 day to 1 year, 3 months	-0.0198**	-0.0010	-0.0198	-0.0611*
	(0.0042)	(0.0040)	(0.0125)	(0.0289)
1 year, 3 months, 1 day to 1 year, 6 months	0.0030	0.0014	-0.0283	-0.0361
	(0.0085)	(0.0031)	(0.0213)	(0.0376)
1 year, 6 months, 1 day to 1 year, 9 months	0.0043	-0.0014	-0.0260	-0.0512**
	(0.0042)	(0.0025)	(0.0249)	(0.0133)
1 year, 9 months, 1 days to 2 years	0.0070	0.0088*	-0.0498*	-0.0415
	(0.0066)	(0.0043)	(0.0201)	(0.0226)
R-squared	0.0052	0.0006	0.0081	0.0469
Observations	8,098,484	8,098,484	8,098,484	8,098,484

Notes: Dependent variables are binary variables taking value 1 if hospitalisation for column-specified causes; 0, otherwise. MSK intensity variables are continuous variables measuring the maximum earthquake intensity felt in canton c in specified time-windows; they are set to 0 if strictly lower than VIII, and rescaled (divided by 100) for readability purposes. Specifications control for gender, age, squared age, distance between an individual's canton of residence and the medical unit where she is hospitalised, and include day-of-week, month, year, and canton fixed effects. Robust standard errors in parentheses, clustered at the canton level.** p<0.01, * p<0.05.