Natural Disasters and Intimate Partner Violence: Evidence from Peru

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Abstract

This paper investigates if women experience higher levels of intimate partner violence (IPV) in the aftermath of earthquakes in Peru. We focus specifically on individual, societal, and institutional factors explaining men's violent behavior and women's vulnerability to violence. Combining household-level data on IPV and spatial data on all earthquakes that happened in the country between 2000 and 2009, we show that exposure to very strong earthquakes increases the incidence of IPV by more than ten percentage points. Additional results suggest that the increase in IPV following earthquakes is driven by an increase in male intra-household economic power and a rise in alcohol consumption. In addition, we document substantial heterogeneous effects for urban and rural areas, with the former registering a rise in IPV and the latter experiencing substantial decreases in it. This pattern seems to be partially explained by differences in intra-household dynamics, with couples being more likely to cooperate in rural but less in urban areas. Finally, we document an important mitigating role of protective institutions in urban areas following earthquakes. More specifically, we find that having a women justice center (WJC) in urban districts completely offsets the earthquake effect.

JEL Codes: J12, Q54, J16, I10.

Keywords: Intimate Partner Violence; Natural Disasters; Earthquakes; Peru

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1 Introduction

Natural disasters and extreme weather events have major socio-economic consequences. For example, they are shown to fuel conflict (Miguel *et al.*, 2004; Harari and Ferrara, 2018), create political instability (Dell, 2012; Jia, 2014; Almer *et al.*, 2017), and induce political change (Brückner and Ciccone, 2011).[1] Extreme rainfall is also shown to increase the number of cases of murder of elderly women (Miguel, 2005) and the incidence of dowry deaths (Sekhri and Storeygard, 2014) in agriculture-dependent societies. So far, most of the existing literature investigates these questions in rural contexts, based on the hypothesis that weather shocks have negative economic consequences through a reduction in agricultural income and harvest. Yet, the consequences of large-scale disasters in urban contexts—and through channels other than income losses—have been largely overlooked.

This paper fills this research gap by investigating if women experience higher levels of intimate partner violence (IPV) in the aftermath of earthquakes in Peru. We focus specifically on individual, societal and institutional factors explaining men's violent behavior and women's vulnerability to violence following large-scale natural shocks. More specifically, we document the role of alcohol consumption, intra-household power dynamics, urbanization levels, and protective institutions as mediators of the earthquake effects.

Peru is a particularly interesting context for investigating this research question for a couple of reasons. First, due to its geographic location—at the border of two tectonic plates—the country is prone to large-scale disasters, such as earthquakes and volcanic eruptions. Therefore, understanding the socio-economic consequences of these natural shocks is of first order concern. Second, violence against women is a major public health issue in Peru. Even compared to other Latin American countries, where gender inequality and norms of masculinity are deeply rooted, women's vulnerability to violence is a particularly salient issue in the country. In this context, the Peruvian government has implemented policies aiming at reducing violence against women, the most prominent of them being the creation of "Women Justice Centers".[2] For our purposes, the existence of

[1] For an overview of the literature, see Dell *et al.* (2014).

[2] As it will be discussed in further detail in Section 2, Women Justice Centers are specialized institutions

such centers is important, as it allows us to investigate the role of institutional delivery as a protective force in the context of large-scale disasters. Finally, Peru is a middle-income country with roughly three quarters of its population living in urban and one quarter in rural areas.[3] As social and economic dynamics likely differ in these locations, investigating this research question in this context helps us to uncover important heterogeneities.

Violence against women is pervasive throughout the world. The World Health Organization (WHO) estimates that 35 percent of women experience some form of violence in their lifetime, with the majority of cases corresponding to IPV (WHO, 2013). Women who suffer violence are more likely to develop physical and emotional health problems (Campbell *et al.*, 2002; Plichta, 2004). Sexual violence, in particular, has been shown to decrease educational attainment (Rees and Sabia, 2013) and female labor force participation (Sabia *et al.*, 2013; Chakraborty *et al.*, 2018). For children, exposure to violence results in higher levels of distress (Levendosky *et al.*, 2013) and lower investments in human capital (Sviatschi and Trako, 2021). Therefore, understanding the consequences of natural disasters for violence against women can have important implications for governments and international organizations in post-disaster settings.

We hypothesize that the incidence of violence against women changes in the aftermath of disasters for four main reasons. First, as documented in the existing literature, natural disasters and weather shocks are expected to affect economic conditions, particularly through income and wealth (Bui *et al.*, 2014). Since women's (and men's) economic status are key determinants of intra-household violence, we expect large-scale disasters to affect IPV through an income channel.[4] While some papers show that weather shocks during the growing season are harmful for agriculture-dependent societies (Harari and Ferrara, 2018), others document positive economic effects of large-scale disasters in the

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which provide legal and psychological support to victims of domestic violence.

[3] According to estimates from the World Development Indicators (WDI), the share of urban population in Peru ranged between 73 and 76 percent in 2000-2009.

[4] Intra-household bargaining models and male-backlash models have focused on the role of household resources and intra-household bargaining power in predicting violence against women. While bargaining models predict that violence decreases when women control more resources (Aizer, 2010; Anderberg *et al.*, 2016), backlash models suggest the opposite, with males becoming more violent as a way of compensating for the loss in relative status (Macmillan and Gartner, 1999).

longer run (Gignoux and Menéndez, 2016; Heger and Neumayer, 2019). Therefore, the net effect of earthquakes through economic conditions remains ambiguous. Second, exposure to large-scale disasters can have profound psychological consequences which, together with behavioral changes, could lead to violent behavior, both directly and indirectly (e.g., through a loss in household wealth). These psychological and behavioral changes include, for example, higher mental distress, frustration, and alcohol consumption—well-known determinants of violence against women (Card and Dahl, 2011; Luca *et al.*, 2015). Third, natural disasters might affect institutional capacity and delivery, potentially increasing (or decreasing) women's vulnerability to violence. On the one hand, post-disaster emergency aid and relief assistance could increase women's protection, while a disruption of the existing infrastructure or a reduction in law enforcement are expected to have the opposite effect. Finally, experiencing a large-scale disaster could lead to higher levels of social cohesion (Calo-Blanco *et al.*, 2017), solidarity (Blumenstock *et al.*, 2016), and strengthening of community ties (Hombrados, 2020), potentially leading to a reduction in intra-household violence.

In this paper, we combine geo-referenced data on IPV from the Peruvian Demographic and Health Surveys (DHS) with ShakeMaps of all significant earthquakes that happened in the country between 2000 and 2009. ShakeMaps consist of intensity polygons illustrating the ground motion and shaking intensity of earthquakes, as modeled by the United States Geological Surveys (USGS). During our study period, Peru was hit by two very strong earthquakes (in 2001 and in 2007) and two strong ones (in 2005 and 2009), which affected different regions of the country.[5] We exploit the spatial and temporal distribution of earthquakes and the location of households to investigate if IPV is more pronounced in areas that are severely affected by the shock. The identification of causal impacts relies on the quasi-exogenous nature of earthquakes. To reduce concerns on reporting bias of survey-based IPV in the DHS data, we additionally use administrative information on the number of domestic violence cases at the state level for robustness.

[5] As explained in further detail in section 3, very strong earthquakes are the ones above or equal to 7.0 in the Modified Mercalli intensity (MMI) scale, while strong earthquakes are the ones equal to or above 6.0.

The empirical results show several relevant findings. First, we find robust evidence that exposure to very strong earthquakes six or twelve months prior to the survey interview date increases the probability that women report experiencing violence by more than ten percentage points on average.[6] The effect is very large in magnitude, corresponding to about 30 percent of the baseline incidence of violence in our sample. Similar evidence is also found at the aggregate level, with an increase of about 49-64 percentage points in the change of cases of violence against women in the calendar year after the earthquake. The baseline results are robust to a series of checks, including alternative definitions of earthquake exposure and different model specifications. Second, we explore potential channels explaining the effects of natural disasters on IPV. Based on the existing theoretical and empirical literature, we focus on aspects capturing the behavior of the respondent's partner, the dynamics of decision-making within the household, and measures of economic conditions following earthquakes. Altogether, we show that our results are partially explained by rising intra-household male economic dominance, as well as higher alcohol consumption by the male partner, while objective measures of economic conditions do not play a role on average. Finally, we document substantial heterogeneous effects in urban and rural areas, with the former registering a rise in IPV and the latter experiencing substantial decreases in IPV following the earthquakes. These patterns appear to be explained by differences in intra-household dynamics, with couples being more likely to cooperate in rural, but less in urban areas. In addition, we estimate a reduction in alcohol consumption and an increase in female work in rural households following the earthquake, which is not true for urban households. Third, we document a substantial mitigating role of protective institutions in curbing violence against women in urban districts following earthquakes. Specifically, we find that having a protective institution completely offsets the earthquake effects, with the increase in violence occurring entirely in urban households living in districts without protective institutions.[7] While the existing literature shows

[6]Following Gignoux and Menéndez (2016), we focus on earthquakes greater or equal to 7.0 in the MMI scale, referred to as very strong, due to their large potential of destruction.

[7]As discussed in further detail in Section 2, in Peru "Women Justice Centers" (WJC) have been established to provide social, legal, and psychological support for victims of violence. In addition, these institutions have been actively involved in organizing prevention campaigns and increasing awareness

that the roll-out of protective institutions has at best gradual effects in curbing violence against women, our findings indicate that, in the context of disasters, the presence of such institutions plays a crucial role.[8]

This paper is related mainly to three strands of the literature. First, it adds directly to the literature documenting the socio-economic effects of weather shocks and natural disasters. It is widely documented that natural disasters can fuel civil conflict (Miguel *et al.*, 2004; Harari and Ferrara, 2018), hinder long-run economic growth (Lackner, 2018), decrease human-capital accumulation (Caruso, 2017) and damage the economy (Cavallo *et al.*, 2010). Additionally, papers have documented the negative effects of weather shocks for women in agriculture-dependent societies (Miguel, 2005; Sekhri and Storeygard, 2014; Abiona and Koppensteiner, 2016). Our paper relates most closely to the work of Weitzman and Behrman (2016), which uses two waves of household survey data—one before and one after the 2010 earthquake in Haiti—to investigate the effect of earthquake exposure on violence against women. Our paper differs from previous work in several ways. By relying on more than one earthquake and exploiting multiple survey waves, we provide a detailed picture of the dynamics of the earthquake effects over time. Additionally, the institutional context of Peru, with the existing coverage of WJC, allows us to disentangle the role of institutional delivery—in contrast to intra-household and individual characteristics—in determining women's vulnerability to IPV after large-scale natural shocks. Lastly, by focusing on a middle-income country where the population is present in both urban and rural areas, we can investigate how the effects of natural disasters vary depending on urbanization levels. For instance, rural and urban areas differ substantially in terms of economic composition, social networks and institutional provision. Therefore understanding the dynamics of gender-based violence in these areas has implications for the external validity of results. While the previous analyses focus on countries with the majority of the population living in rural areas and highlight the impact of weather shocks and disasters through the loss of income, we provide a detailed picture showing that disasters operate through channels

about violence against women.

[8] Sviatschi and Trako (2021) estimate that the roll-out of WJC in Peru reduces the incidence of violence against women by approximately 10 percent.

that go beyond the income effects.

Second, the paper contributes to the literature studying—both theoretically and empirically—the determinants of violence against women. For instance, IPV has been shown to depend on a number of factors, including female empowerment (Macmillan and Gartner, 1999; Aizer, 2010; Bhattacharyya *et al.*, 2011; Anderberg *et al.*, 2016; Bulte and Lensink, 2019), transfers to women (Haushofer *et al.*, 2019; Roy *et al.*, 2019; Heath *et al.*, 2020; Menon, 2020), social norms (Green *et al.*, 2020), family structure (Khalil and Mookerjee, 2019; Tur-Prats, 2019; Heath *et al.*, 2020), psychological factors (Card and Dahl, 2011), and formal and informal institutions (Stevenson and Wolfers, 2006; Brassiolo, 2016; Amaral *et al.*, 2021; Cunningham and Shah, 2018; Sviatschi and Trako, 2021; Bargain *et al.*, 2019; Miller and Segal, 2019). We highlight the role of these underlying channels also in the context of large-scale disasters as triggers for violence. More specifically, we show that, in addition to economic factors, the availability of protective institutions, intra-household dynamics, and psychological factors play a crucial role for women's vulnerability to IPV.

Lastly, the paper also fits within the emerging body of research investigating how macro shocks affect intra-household violence. For instance, an increasing number of papers document that during the COVID-19 crisis there was a substantial increase in IPV across the globe (Chandan *et al.*, 2020; Agüero, 2021; Brink *et al.*, 2021). Among potential channels explaining this increase, mental distress, the time that couples spend together, and fluctuations in household income are the most prominent ones. Our study complements this strand of literature by showing similar patterns also in the context of large-scale natural disasters, and by disentangling the role of individual, societal, and institutional channels explaining such effects.

The rest of the paper is structured as follows. Section 2 provides background information on gender violence and earthquakes in Peru. Section 3 describes our data sources and Section 4 discusses our identification strategy and empirical model. The empirical results and robustness checks are presented in Section 5. Sections 6 and 7 discuss underlying channels and heterogeneity analyses, respectively. The last section concludes.

2 Peruvian context

Peru is located at the border of the Nazca and the South American tectonic plates, in the so-called *Ring of Fire*, an area particularly prone to volcanic eruptions and major seismic activity. According to the Global Facility for Disaster Reduction and Recovery (GFDRR), Peru has been affected by more than 30 major earthquakes in the last four centuries, four of which occurred in our study period (2000-2009). Despite being frequently affected by natural disasters, the Peruvian government faces challenges when it comes to providing emergency assistance to affected individuals. Coping with shocks is even more challenging for women and minorities, who often lack resources and social networks.[9] Indeed, pre-existing historical inequalities are expected to be amplified in the aftermath of disasters (Mutter, 2015).

In Peru, gender inequalities are reflected in different dimensions. In addition to the well-documented economic disadvantages, women are underrepresented in political spheres and are more often subject to labor market discrimination (Ñopo, 2009).[10] Violence against women, in particular, is a major public health problem in Peru. In our sample, more than one third of the women who have ever cohabited with a male partner report having suffered some form of violence throughout their lifetime. According to Flake (2005), the high incidence of violence relates closely to rigid gender roles and strong norms of masculinity prevailing in the country. While men are traditionally expected to embody masculine stereotypes by being strong and aggressive, women are often expected to fulfill a submissive role (Suárez Farfán *et al.*, 2016). According to data from the Organisation for Economic Co-operation and Development (OECD), one third of women in Peru agree that in some cases violence against women is justifiable.[11]

In contrast to these informal gender norms, the official legislation in Peru criminalizes

[9] According to the World Development Indicators (WDI), in 2008 around 37 percent of the population in Peru was below the poverty line, as measured by the headcount ratio.

[10] According to the World Bank Gender Indicators (WBGI), in 2018 women held 27.7 percent of seats in national parliament and 27.8 percent of the ministerial positions in Peru. In economic terms, in 2019 only 8.6 percent of Peruvian women were employed in industry while the male share corresponded to 21.1 percent.

[11] The precise definition of the indicator is the following: "The percentage of women who agree that a husband/partner is justified in beating his wife/partner under certain circumstances" (OECD, 2020).

violence against women.[12] Since the creation of the Ministry for the Promotion of Women and of Human Development (PROMUDEH), in 1996, the government has implemented several policies to protect women and other vulnerable groups.[13] One of the most important policies to curb gender violence was the creation of Women Justice Centers (WJC) starting in 1999. Those institutions provide legal and psychological support for victims of domestic violence, besides promoting awareness and prevention campaigns. The roll-out of these centers has been shown to contribute to a significant reduction in violence against women (Sviatschi and Trako, 2021). Yet, their role during the emergency state following large-scale disasters has not been investigated so far.

3 Data

In this section, we describe the data sources we use in the analysis: (i) the two datasets used to measure violence against women and (ii) the dataset used to quantify earthquake exposure in Peru from 2000 to 2009.

3.1 Domestic violence

We measure violence against women using two independent data sources. First, individual-level data on IPV come from the domestic violence module contained in the Demographic and Health Surveys (DHS). All women aged 15-49 that have ever been married or cohabiting are eligible for the survey, and one woman per household is randomly selected for the interview. In addition to the questions about violence against women, the survey contains information on individual and household socio-economic characteristics. We make use of four waves of the Peruvian DHS: the standard DHS 2000, the continuous DHS 2004-06, the continuous DHS 2007-08, and the standard DHS 2009. The data consist of repeated

[12] According to the Ministry of Women and Vulnerable Populations (MIMP), two laws address violence against women and intra-family violence, more generally. First, the law 26260/1993 on the protection against intra-family violence and the law 30364/2015 on the prevention and eradication of violence against women and other family members (Suárez Farfán *et al.*, 2016).

[13] The PROMUDEH was subsequently replaced by the Ministry of Women and Social Development (MIMDES), in 2002, and by the MIMP, in 2012.

cross sections, with part of the survey clusters being interviewed in multiple rounds in the continuous DHS. Additionally, we have information on the GPS coordinates of the centroids of the survey clusters, which allows for the construction of our measures of earthquake exposure at a fine-grained level. Our second data source on violence against women is an administrative database provided by the MIMP. The data contain the yearly number of registered cases of violence against women in each Peruvian state between 2002 and 2009.

Using two different sources of information on violence against women reduces concerns on reporting bias, a frequently discussed issue in the gender violence literature. While the estimated numbers in both sources are likely underestimations due to the high emotional costs and barriers associated with reporting, there are reasons to believe that the sources of bias would be different for a survey in comparison to official statistics. Therefore, we would find it reassuring if the two datasets would show similar patterns. Additionally, as long as there is no differential reporting bias depending on exposure to earthquakes, we should be able to estimate the effect of exposure to earthquakes on changes in IPV.[14]

Panel A of Table 1 shows the descriptive statistics for the individual outcome variable and the socio-demographic controls and Panel B shows the summary statistics for the aggregate data. As shown in Panel A, more than a third of the women in our sample report having experienced some form of violence in their life. Women are on average 33 years old and four years younger than their partners. Seven percent of the women in our sample did not attain any formal education, 39 percent completed primary education, 38 percent completed secondary education, and 17 percent completed tertiary education. The respondents' partners attained, on average, higher levels of education. From Panel B, we see substantial variation in the percentage change of cases of domestic and sexual violence across state. For instance, the change in domestic (sexual) violence ranged from -45% (-82%) to 231% (272%).

[14] We acknowledge that official reporting of cases of violence against women might be disrupted following natural disasters. Nevertheless, we expect this to be less of a concern in the case of DHS, whose data collection is planned in advance.

3.2 Earthquakes

Information on all significant earthquakes that happened in Peru between 2000 and 2009 comes from the USGS. The data consist of ShakeMaps, which portray the distribution and the spread of earthquakes by mapping out its ground motion and shaking intensity.[15] Two very strong earthquakes happened during our sample period (in 2001 and 2007, respectively), as shown in Figure 1.[16] The different polygons show the different earthquake intensities. The map also shows the centroids of the DHS clusters (in dark blue the clusters from the DHS 2000 and in forest green the clusters from the DHS 2009). We construct our exposure measure by intersecting the earthquake intensity polygons and the geographic coordinates of the DHS clusters. Therefore, we have a measure of exposure which is based on inference, rather than actual reporting of earthquake experience.[17] There is arguably a great amount of unpredictability in the locations where the earthquakes hit, which reduces concerns that earthquake exposure is spatially correlated over time (Lackner, 2018). Table A1 provides an overview of the the earthquakes that happened in Peru during the study period—including both the very strong ones which we use in the main analysis and the strong ones that we use for robustness—with the most relevant information on the date, the intensity, the affected states and the estimated damage.

In our analysis, we exploit the temporal and spatial distribution of the earthquakes, as well as their severity, to construct our exposure measure. The next section discusses our identification strategy.

4 Empirical strategy

For our individual-level analysis, we have a pooled sample of 43,110 women interviewed over the period 2000 and 2009. The sample is restricted to women aged 15 to 49 that have

[15]Figure A5 in the Appendix shows examples of ShakeMaps of the two very strong earthquakes (equal to or above 7.0) that happened in Peru over our study period obtained from the USGS. We also show the ShakeMaps of the two strong earthquakes (equal to or above 6.0) which we use for robustness checks.

[16]Following the USGS, we define earthquakes as *very strong* if the shaking intensity is equal to or above 7.0 in the MMI scale. Figure A6 shows the correspondence between the intensity categories and respective perceived shaking and potential damage, as defined by the USGS.

[17]In the DHS data, there is no information on household's experience of natural disasters.

ever been married to or cohabiting with a male partner. Moreover, we restrict the sample to respondents that have been living in the same location for at least three years to ensure that our lagged exposure variables are specified correctly. In our individual specification, we estimate the following model:

$$IPV_{wcdst} = \alpha + \beta Earthquake_{c;(t-i,t)} + \lambda \mathbf{X}_w + \delta_t + \gamma_d + \eta_s \times t + \epsilon_{wcdst} \quad (1)$$

where IPV_{wcdst} is a binary outcome variable, capturing if respondent w, living in DHS cluster c, district d, state s, interviewed in year t, reports having ever experienced IPV.[18] On the right-hand side, α is a constant. $Earthquake_{c;(t-i,t)}$ is a dummy, indicating whether the respondent residing in cluster c experienced an earthquake equal to or above 7.0 in the MMI scale in the past i months before the interview. According to the MMI scale, earthquakes equal to or above 7.0 have very strong shaking intensity and high potential of destruction (Gignoux and Menéndez, 2016). We control for a vector of individual and household characteristics, $\mathbf{X}_w$, including a respondent's age, squared age, age difference with the partner, as well as respondent's and partner's educational levels. We control only for socio-demographic characteristics of the respondents and their partners as these variables are less likely to be bad controls, *i.e.* to be affected by the earthquakes. We additionally control for year fixed effects, δ_t, to account for changes in IPV that are common to all women in the country. District fixed effects, γ_d, account for constant factors that determine violence against women within districts. These include, for example, persistent gender values and norms that stay constant throughout the sample period. By including district fixed effects we are essentially exploiting variation within districts. To account for region-specific trends in IPV, we also include state time trends, $\eta_s \times t$. We estimate the coefficients using a linear probability model (LPM) for ease of interpretation and to accommodate the different fixed effects. Standard errors are clustered at the district level.[19]

[18] The DHS defines that a respondent suffers IPV if she reports that the husband has pushed her, shook her, thrown something at her, slapped her, punched her, kicked her or dragged her.

[19] Our measure of exposure to the earthquakes is at the DHS cluster level. However, while the clusters in the DHS waves of 2000 to 2008 remained the same, the clusters of the 2009 wave were displaced. Thus,

Identification strategy In our main specification, we exploit the temporal and spatial variation in exposure to earthquakes to investigate if women experience higher levels of IPV in the aftermath of an earthquake. The earthquake exposure measure is defined at the DHS cluster level and the outcomes are measured at the individual level. There are a total of 3,936 unique cluster-years, with an average of 10.95 respondents in each cluster-year. To obtain causal estimates, our main assumptions are that the spatial distribution and the timing of earthquakes are exogenous, which seem plausible given the nature of the shock. Our estimation strategy is closely related to that of Caruso (2017), which investigates the long-run inter-generational impacts of natural disasters in Latin America.

There are several potential threats to our identification strategy, which we try to circumvent in a number of ways. First, exposure to natural disasters might induce (in- and out-) migration, which could result in a selected sample of respondents. Depending on the assumptions about the correlation between migration probability and violent behavior, the bias could go both ways. For example, assuming that more vulnerable individuals—with potentially higher likelihood of perpetrating violence against women—are the ones who migrate due to a lack of coping possibilities after the earthquake, our estimated coefficients would be downward-biased. Nevertheless, if we assume that migration is costly and those individuals who have more access to resources—and are potentially less violent—are the ones migrating, we would have an upward-bias. While we can partially address in-migration by restricting our sample to individuals that have been living in the same location for a minimum of three years, we cannot account for out-migration in our individual analysis, due to lack of data. However, our aggregate-level analysis using administrative data allows us to deal with within-state migration, because the outcome variable is aggregated at the state level.

Second, quantitative studies on violence against women are typically plagued by reporting bias. Since intra-household violence is a sensitive topic, respondents often do

we cluster the standard errors at the most disaggregated level that remains constant during the sample period (district level). In total, there are 1,403 unique DHS clusters in the waves 2000-2008, and 1,131 unique clusters in the wave 2009. There is a total of 628 unique districts in the full sample from 2000 to 2009. Thus, we also allow standard errors to be correlated within districts.

not feel comfortable to truthfully report their experiences. Our results would be biased if exposure to the shock differentially affects reporting behavior. While this concern is particularly relevant for the aggregate-level analysis—in case reporting is disrupted following the earthquake—we expect this to be less of a concern in the self-reported data. Altogether, using both data sources reduces concerns on the potential differential reporting bias.

Third, the occurrence of large-scale natural disasters is expected to cause many casualties. In that regard, exposure to the earthquake makes it impossible to observe individuals following the disaster. While in the case of the 2001 earthquake the estimated number of deaths was relatively low (81), it was much higher for the 2007 earthquake, when it was estimated that more than 500 people died, according to the USGS. Nevertheless, compared to the overall population size,[20] these casualties are most likely not large enough to bias the results through selective mortality, i.e., more (or less) vulnerable women dying after the earthquake.

Finally, in our setting we have a staggered treatment, i.e., more than one earthquake occurring at different points in time. Therefore, our estimate is essentially a weighted average of all two-by-two comparisons between the "pure" control group, the early-treatment group (affected by the 2001 earthquake), and the late-treatment group (affected by the 2007 earthquake) (Cunningham, 2021; Goodman-Bacon, 2021). Assuming homogeneous treatment effects, we estimate unbiased coefficients. However, to reduce concerns on the estimation method, we implement alternative specifications with other treatment definitions and different time windows, as discussed in detail in the robustness section.

5 Results

This section starts with the results of the individual-level model, specified in equation (1). Then, it proceeds to discuss a series of robustness checks and the results of the aggregate-level analysis.

[20] According to World Bank (2020), Peru's total population reached 28.6 million in 2008.

5.1 Main results

Table 2 shows the main coefficients of interest of our individual-level specification on the relationship between exposure to earthquakes and IPV. The full table showing all control variables is displayed in the Appendix (Table A3). The main outcome of interest is a binary variable capturing if the respondent has ever experienced IPV. In columns (1) and (2), exposure to earthquakes is also binary and defined as one if respondents live in a DHS cluster that was hit by an earthquake equal to or above 7.0 in the MMI scale in the past six months. In columns (3) and (4) we measure the earthquake exposure in the past 12 months.

Columns (1) and (2) show a positive and highly significant contemporaneous effect of exposure to earthquakes on IPV. More specifically, respondents that experienced a very strong earthquake six months prior to the interview are between 12 and 12.8 percentage points more likely to report suffering IPV. Compared to the baseline, this effect is economically meaningful, corresponding to approximately 30 percent of the average incidence of violence in our sample. When we change the earthquake exposure definition to 12 months prior to the interview date, we still find positive and statistically significant coefficients, although slightly smaller in magnitude (columns (3) and (4)). Altogether, the results indicate that there is a substantial increase in the incidence of violence against women directly in the aftermath of large scale disasters.

To investigate further how these effects change over time, we implement two alternative specifications. First, we construct separate earthquake exposure measures with varying exposure lengths—from 6 up to 48 months prior to the interview date. Additionally, we construct exposure leads to estimate if future earthquakes affect present IPV. Empirically, we estimate equation (1) separately for each exposure variable and plot the β coefficients (Figure 2a). Second, we construct separate leads and lags of the exposure variables and conduct an event-study analysis (Figure 3). In this specification, the omitted reference group are those exposed to earthquakes 13 months or before the interview date.[21] Altogether, the dynamic specifications (Figures 2a and 3) show that the increase in violence

[21] Due to the low number of affected observations, we construct leads and lags of at least 12 months.

following earthquakes is not persistent, but concentrated up to 12 months after the onset of the disaster. Additionally, the falsification exercise confirms that locations that are affected by the earthquakes do not experience higher levels of violence before the disaster.

Since our outcome variable captures if respondents *ever* experienced violence, we interpret the coefficients as changes at the extensive margin rather than at the intensive margin. This means that while we can not assess if there is an intensification of violence following disasters, we document increases in the probability that women *become* victims of violence in the aftermath of earthquakes. Assuming that violence is a persistent phenomenon, our coefficients can be understood as lower-bound estimates.

5.2 Robustness checks

This section provides additional evidence showing that our results are not driven by a particular definition of earthquake exposure. Additionally, we show that aggregate-level results are consistent with our individual-level analysis.

Buffers around clusters To ensure respondent's confidentiality, the DHS randomly displaces the GPS coordinates of part of the survey clusters. The displacement ranges from zero up to two kilometers for urban clusters, from zero up to five kilometers for 99 percent of rural clusters, and ten kilometers for one percent of rural clusters in the sample. Our original earthquake exposure measure only takes into account if the DHS cluster's centroid intersects with earthquake polygons. Therefore, to reduce concerns that our results are affected by this particular definition, we construct an alternative exposure measure by intersecting the earthquake polygons with buffers around the centroids of the DHS clusters. Following the DHS displacement rule, we construct two-kilometer buffers around urban and five-kilometer buffers around rural clusters. The results using this alternative exposure measure are presented in Figure 2b.

Overall, the results remain in line with our baseline model, shown in Figure 2a. We find a positive and significant impact of earthquakes on IPV when respondents experienced an earthquake up to 12 months prior to the interview. Additionally, we do not detect pretrends in the effects, with all coefficients for the lead exposure variables being insignificant.

Difference-in-difference estimations In our baseline regression model, we have a staggered treatment (i.e., two independent earthquakes) occurring at different points in time and affecting different clusters. This implies that we do not have pure control and treatment groups and hence raises the concern that our results could be biased in the presence of heterogeneous treatment effects (Cunningham, 2021; Goodman-Bacon, 2021). We address this concern by implementing alternative difference-in-difference (DID) specifications with varying treatment windows to gain further understanding of the results. Panel A of Table A4 shows the results of a "pooled" DID in which the treatment (*Earthquake*) is equal to one if a cluster was affected by one of the earthquakes (2001 or 2007) and zero otherwise (never treated group). Post is equal to one if interviews were conducted after 2001 (or 2007) and zero otherwise. The interaction coefficient in this specification captures the average effect of being treated by either of the earthquakes over all years. In column (2), the interaction coefficient ($Post \times Earthquake$) is positive and significant, which indicates that our previous estimates are mainly driven by the "short-run" effects of the 2007 earthquake. The null results for the 2001 earthquake indicate that in the medium run the effect of earthquakes on IPV fades away. In this specification, we can only capture medium to long run effects, since the first DHS wave after the 2001 earthquake was conducted in 2004 (three years after the shock).

Alternative intensity threshold In our baseline specification, we consider women as exposed to an earthquake if they reside in a cluster that was hit by a very strong earthquake (equal to or above 7.0 in the MMI scale). Now, we lower the exposure threshold to 6.0 in the MMI scale to check if exposure to less intense earthquakes also increases the incidence of violence against women. By doing this, two additional earthquakes are included in the analysis (one in 2005 and another in 2009), as shown in Figure A3. The results are shown in Figure A1 in the Appendix. Overall, we find less precise and positive coefficients up to 18 months after the earthquake, indicating that the increase in violence is driven particularly by the very strong earthquakes. Similarly to the results presented earlier, we find evidence that the earthquake effect fades away in the medium-run.

Alternative IPV measures In the domestic violence module of the DHS, there are four different measures of IPV: less severe violence, mental violence, severe violence, and sexual violence. Due to data availability constraints, in our main specification, we use the less severe violence variable as the main outcome of interest.[22] In this exercise, we use the other three measures of IPV as alternative outcome variables. It is worth noting that, in these specifications, the estimation of the effects is only based on the survey waves collected between 2004 and 2009. The estimation results are plotted in Figure A2 in the Appendix. The figure shows that being exposed to earthquakes results in a long lasting increase in the probability that women experience mental violence, although the coefficients are only marginally significant (Figure A2a). For severe violence (Figure A2b) and sexual violence (Figure A2c), we find null effects. Despite the insignificant coefficients for severe and sexual violence, we can not rule out that there is an intensification of these forms of violence following earthquakes, since our measure only captures changes at the extensive and not at the intensive margin. This also potentially explains why we only detect increases in the incidence of "less severe" forms of violence, but not the severe ones.

Aggregate-level results We now test empirically if aggregate patterns of violence in the aftermath of earthquakes are consistent with the individual-level results. As mentioned before, since reporting bias is a common issue in quantitative studies of violence against women, comparing individual survey information with official numbers can shed light on the strength of the results. For our aggregate-level analysis, we collect data on the number of registered cases of domestic and sexual violence using Peruvian administrative records at the state level. The data is disclosed officially by the Peruvian government on a yearly basis starting from 2002. Based on this information, we construct an unbalanced yearly panel with the number of registered cases of domestic and sexual violence covering all

[22] In the 2000 wave of the Peruvian DHS, only the variable "less severe violence" is available in the dataset. In later waves, all four types of IPV incidence are available.

Peruvian states between 2002 and 2009. Since the aggregate data on domestic violence is disclosed yearly, we can not construct a very disaggregated measure of earthquake exposure time-wise (i.e. at the month level). Instead, we define the temporal dimension of the earthquake exposure as whether the state has been hit by a severe earthquake in the past calendar year or not. The descriptive statistics of the aggregate data are shown in Panel B of Table 1. On average, the number of domestic (sexual) violence cases increases by 15.34% (20.59%) yearly. Additionally, there is substantial variation around these numbers, with some states experiencing stark reductions in violence and others experiencing substantial increases.

We estimate the following two-way fixed-effects model:

$$\%\Delta Y_{sy} = \alpha + \beta_1 Earthquake_{s,y-1} + \delta_y + \gamma_s + \theta Population_{sy} + \epsilon_{sy} \tag{2}$$

Where the main outcome of interest is the percentage change in the number of cases of domestic (or sexual) violence registered in state s and year y. Exposure to earthquake is a dummy variable and captures if a state was hit by an earthquake equal to or above 7.0 in the MMI scale in the previous year.[23] We control for year fixed effects δ_y and state fixed effects γ_s. Since the number of registered cases may depend on the population size, we additionally control for the population of each state.

Consistent with our individual-level results, Table 3 shows a significant increase in the number of cases of domestic violence registered at the WJC one year after the earthquake, while we find null effects for sexual violence once we control for the size of the population. One should note, however, that a direct comparison between the magnitude of the coefficients is not possible because in this specification we capture changes at the intensive margin. Nevertheless, even with a very small sample size, the results are in line with the patterns described at the individual level.

[23]Figure A4 in the Appendix illustrates which states have been affected by the earthquakes.

6 Underlying Channels

In this section, we document potential channels explaining the effects of natural disasters on IPV. Based on the existing literature, we focus on well-known determinants of violence against women and investigate if they are triggered following large-scale earthquakes. We focus on aspects capturing the behavior of the respondent's partner, the dynamics of decision-making within the household, and measures of economic conditions. More specifically, we look at the role of alcohol consumption by the respondent's partner, co-residence with the partner, male economic dominance, intra-household cooperation, household wealth, and female employment. Empirically, we estimate a regression model similar to equation (1), in which the outcome variable is replaced by the respective channel variable.

Alcohol consumption Existing evidence shows that exposure to earthquakes is frequently associated with post-traumatic stress disorder (PTSD).[24] This could lead to behavioral changes such as substance abuse and dependence (Stewart *et al.*, 1998; Brady *et al.*, 2004). Since mental distress and substance abuse are shown to affect inter-personal violence (WHO, 2019), we expect that these could be potential channels explaining the rise of IPV following earthquakes. In this section, we use two DHS questions containing information on the alcohol consumption of the respondent's partner to investigate whether this is an underlying mechanism explaining our previous results.

The results are presented in columns (1) and (2) of Panel A of Table 6. In column (1), the outcome variable captures changes in alcohol consumption at the extensive margin (a dummy indicating whether the partner drinks alcohol or not), while column (2) captures changes at the intensive margin (whether the partner gets drunk frequently or not). The results show that earthquake exposure increases the probability that the respondent's partner drinks by 15.1 percentage points, although there is no corresponding effect for the frequency of getting drunk. Moreover, the results in Panel B indicate that alcohol intake is an important trigger of violence against women, as seen by the positive and statistically

[24]For a comprehensive meta analysis of existing evidence, see Tang *et al.* (2017).

significant coefficient in column (1).

Co-residence In our sample, about five percent of the women report that they do not reside with their partner. In the absence of co-residence, the likelihood of women suffering from IPV is lower. We hypothesize that after a large-scale natural disaster, partners might be more likely to return home and engage in the re-construction of their homes, which could affect vulnerability to violence due to a purely mechanic channel. To check if this partially explains our results, we estimate whether the male partner is more likely to be in the household after a large-scale earthquake. The result is presented in column (3), Table 6. We estimate that being exposed to a very strong earthquake in the past 12 months indeed increases the likelihood of the partner living in the household. Nevertheless, as shown in column (3) of Panel B, we do not detect a direct effect of male cohabitation on the incidence of IPV, which reduces the concerns that the increase in violence is explained by a purely mechanical channel.

Intra-household economic dominance In addition to objective measures of economic status, intra-household dynamics on economic decisions might also affect women's vulnerability to IPV (Naved *et al.*, 2018). In this section, we look at the relative power balance between spouses with respect to economic decisions to investigate if this is a channel explaining the rise in IPV following earthquakes. We focus on two DHS questions: (i) who has the final saying on large household purchases, and (ii) who has the final saying on what to do with the money the husband earns. We construct two binary variables measuring intra-household economic power: 1) *Male Dominance* equals to one if the male partner is solely responsible for either of the economic decisions; and 2) *Any Joint Decision*, equals to one if the respondent and the partner share either of the two decisions. In our sample, 29 percent of the households report that the male partner is solely responsible for both of the economic decisions, and about 89 percent of the surveyed couples make at least one joint decision. We use these variables as alternative outcomes in our main estimation model specified in equation (1). The results are presented in columns (4) and (5) in Table

6.

Our results show that when households experience very strong earthquakes, there is a rise of about 9.5 percentage points in the probability of male dominance in economic decisions and a decrease of about 4.0 percentage points in the probability that the spouses make joint decisions. In addition, from the results in Panel B, we see that male dominance is positively associated with women's vulnerability to IPV while cooperation has the opposite effect. All in all, these results indicate that the increase in IPV following earthquakes can be partially explained by a shift in the power dynamics within the household.

Economic conditions As a last step, we check if earthquakes affect women's vulnerability to violence through objective economic conditions. Previous work on the impact of weather shocks and natural disasters highlight income losses as an important channel (Miguel, 2005; Sekhri and Storeygard, 2014; Abiona and Koppensteiner, 2016) explaining women's vulnerability to violence. More broadly, a large literature shows that economic conditions—particularly employment and wages—are important predictors of violence (Aizer, 2010; Hidrobo and Fernald, 2013; Anderberg *et al.*, 2016; Haushofer *et al.*, 2019). First, we investigate if there are wealth losses following the shock (column (6)) and then we focus specifically on women's employment status (column (7)).[25] Differently from the results presented in the literature on weather shocks and violence against women in agriculture-dependent societies, we do not find evidence that large-scale disasters operate through economic channels. For instance, despite being negative, both earthquake coefficients are statistically insignificant (Panel A, columns (6) and (7)). When we look at the direct impact of wealth and female employment status on IPV, we find a positive and statistically significant coefficient, consistent with the predictions of male-backlash models. Nevertheless, the potential endogeneity of female employment and differential reporting bias could also explain the positive coefficient.

Altogether, the results presented in this section show that alcohol consumption by the male partner and a change in household decision-making process following the earthquakes

[25] The outcome variable in column (6) is the standardized wealth index based on the ownership of multiple items of assets in the DHS dataset.

are potential channels explaining the rise in violence. At the same time, economic conditions seem to play a smaller role in this context.

7 Heterogeneity analysis

To gain further understanding on how the earthquakes operate and affect the incidence of violence against women, we conduct a series of heterogeneity analyses depending on individual, household and district characteristics. We start with two macro-level characteristics, namely rural or urban status and availability of protective institutions. Later on, we turn to socio-demographic characteristics at the individual level, which are arguably exogenous to the shock. In practice, we interact the heterogeneity variables with our earthquake exposure variable and include the interaction term as well as the separate variables into equation (1). The estimation results are shown in Tables 4 and 5.

7.1 Macro-level and institutional characteristics

Rural and urban locations Rural and urban areas are arguably different in terms of economic composition, social networks and institutional provision. For instance, while urban areas are typically characterized by higher population density and larger concentration of buildings, rural areas are much more sparsely populated and mainly dependent on agriculture. Additionally, as shown in Figure A7, rural and urban areas experience largely different patterns of violence against women. We expect, therefore, that natural disasters and extreme weather events might evolve differently in these locations. While the existing literature has convincingly shown that rainfall shocks increase the incidence of violence against women in agriculture-dependent societies, the dynamics of violence against women in urban areas following large-scale disasters is largely understudied. In this section, we investigate if there are heterogeneous earthquake effects in rural and urban locations. Our main hypothesis is that due to the larger concentration of buildings and existing infrastructure, earthquakes might have a larger potential of destruction in urban as opposed to rural areas.

Table 4 shows our heterogeneity results along this dimension. First, we notice that individuals living in rural areas report lower levels of violence at baseline, as seen by the negative and statistically significant coefficient for the rural dummy. On top of that, the interaction coefficient in column (1) indicates that being affected by an earthquake in an urban area increases the probability that women experience violence in the following 12 months by 10.9 percentage points. For rural areas, on the contrary, we find that being exposed to a very strong earthquake decreases the likelihood of women experiencing IPV by 10.0 percentage points.[26] The effects in both urban and rural areas are highly significant, similar in magnitude, but with opposite signs.

The positive effect of earthquakes on IPV in urban areas is consistent with the hypothesis that large-scale disasters might have a higher potential of disruption of the social order and destruction of infrastructure in more densely populated areas. As for the negative effects in rural areas, we hypothesize that, besides the different patterns of occupation of the territory, differences in access to social networks could play a mitigating role. For instance, existing papers have shown that experiencing a common shock might lead to higher social cohesion (Calo-Blanco *et al.*, 2017; Thomas *et al.*, 2022). Additionally, in the aftermath of disasters, it is possible that individuals in rural areas rely more on other community members (Blumenstock *et al.*, 2016).

To gain further understanding on the channels behind the opposing earthquake effects found in urban and rural areas, we investigate how behavioral, economic, and social outcomes evolve in the aftermath of earthquakes. In practice, we conduct a channel analysis similar to the one presented in the previous section separately for respondents living in urban and rural locations. Results are presented in Table 7. Interestingly, we document that exposure to earthquakes has diverging consequences for rural and urban areas. While in the former we see a stark decrease in risk factors for violence, such as a reduction in alcohol consumption, a decrease in male economic dominance, an increase in cooperation, and an increase in female work, we have opposite effects for the latter.[27]

[26]The net effect of earthquakes on IPV in rural areas is estimated by the linear combination of the earthquake dummy and the interaction term.

[27]The estimated positive employment effect found in rural areas is consistent with the positive income

For instance, we estimate that in urban areas there is an increase in the probability that the partner drinks, an increase in male dominance, and a decrease in the probability that individuals make decisions jointly. This is consistent with the earthquake increasing violence in urban and decreasing violence in rural areas due to a change in intra-household dynamics.

In what follows, we look at one dimension that also differs for rural and urban areas, namely the availability of protective institutions, to investigate if they also play a role in the aftermath of disasters.

External protective institutions Existing evidence documents the role of protective institutions in reducing violence against women, both in Peru (Sviatschi and Trako, 2021) and in other developing countries (Amaral *et al.*, 2021; Miller and Segal, 2019). In this section, we investigate if the availability of protective institutions affects women's vulnerability to violence at the time of the earthquake. On the one hand, having protective institutions might be crucial to protect women both at the onset and in the aftermath of disasters. However, if access is temporarily or permanently restricted due to the disaster, violence might actually increase. We construct a measure of access to WJC at the district level and interact it with our measure of exposure to earthquakes. In our sample, 12.8 percent of the individuals live in districts with protective institutions. If we break down this number by rural and urban areas, we see that the majority of WJC is concentrated in urban areas. For instance, approximately 2.4 percent of the individuals living in rural areas have access to a WJC, while for individuals in urban areas the share is much larger—around 21 percent. As we documented previously that the increase in violence following earthquakes is born entirely by women living in urban areas, it is worth investigating if institutional capacity, mostly present in those areas, has a mitigating role.

Results are presented in columns (2) to (4) of Table 4. In column (2) we find that having a protective institution completely offsets the earthquake effect.[28] In terms of magnitude,

effects documented by Gignoux and Menéndez (2016) in rural areas of Indonesia following earthquakes.

[28] We acknowledge that our results should be interpreted with caution, due to the potential endogeneity of WJC location.

we find that there is an increase of about 16.8 percentage points in the probability that women experience IPV 12 months after the earthquake for respondents living in locations without WJC, while there is a slight decrease in violence (of about 2.0 percentage points) for those respondents with access to WJC. In a second step, we split the sample into rural and urban areas and repeat the heterogeneity analysis (columns (3)-(4)). We find evidence that the heterogeneity is entirely driven by urban areas.[29] Altogether, we find that women living in urban districts where a WJC is available do not experience higher levels of IPV following earthquakes. On the contrary, women living in urban districts without a WJC experience a substantial increase in IPV after being exposed to a large-scale earthquake.

7.2 Individual socio-demographic characteristics

Female employment status Female economic status is considered an important determinant of violence against women. While bargaining models predict that increasing women's economic status leads to a decrease in violence through a change in women's outside options (Aizer, 2010; Anderberg *et al.*, 2016), backlash models predict the opposite, with males becoming more violent as a way of compensating for the loss in relative status (Macmillan and Gartner, 1999). In this subsection, we investigate the role of economic status as a source of heterogeneity linking earthquakes and IPV.

We interact women's employment status at the time of the interview with exposure to earthquakes. The results are presented in column (1), Table 5. Although we do not detect any significant heterogeneous impact of earthquakes on exposure to IPV, we find that, at baseline, women who are employed are 5.2 percentage points more likely to report having ever experienced IPV, as compared to unemployed women. One should note, however, that the differences in the incidence of IPV could be related to differential reporting behavior depending on economic status.

[29]We can not estimate the interaction coefficient in rural areas due to the lack of statistical power. As mentioned before, the majority of WJC are concentrated in urban districts.

Female and male educational attainment Educational attainment is also an important trigger for IPV (Hidrobo and Fernald, 2013). Similarly to female employment status, educational attainment is related to women's bargaining power, which can lead both to higher or lower levels of IPV.[30] On the one hand, highly educated women might have more income and resources, which enhances their capacity to cope with the shock and potentially decreases their vulnerability to IPV. On the other hand, relatively higher levels of empowerment and control could lead to higher violence due to a male-backlash channel.

To check for the potential heterogeneity of earthquakes depending on educational attainment, we interact the earthquake exposure measure with categorical indicators of educational attainment (no education, primary education, secondary education and tertiary education) both for the respondent as well as for her partner.[31] The results are presented in columns (2)-(3) of Table 5.

Compared to women with tertiary education, respondents with no formal schooling are 51.4 percentage points more likely to experience IPV when exposed to a very strong earthquake in the past 12 months. Similarly, compared to women whose partners have tertiary education, the effect of earthquakes on IPV for those having partners with no formal schooling is 52.8 percentage points higher.

Both sets of results indicate that vulnerability to IPV is substantially higher for women with lower levels of education and also those with lower-educated partners. This suggests that post-disaster relief programs targeted at women with lower levels of education could be potentially more effective.

Female age Another socio-demographic characteristic related to female empowerment is women's age (Sell and Minot, 2018). For instance, older women might have more resources and better coping strategies compared to younger women and therefore experience different levels of vulnerability to violence following disasters. Table 5 shows the heterogeneity

[30] Theoretically, as discussed in the introduction, bargaining models predict that higher female empowerment leads to lower levels of violence, while backlash models predict the opposite.

[31] In addition to interacting the categorical indicators of educational attainment with the earthquake exposure measure, we also interact it with continuous measures of education and the difference in education attainment between spouses. Results are presented in Table A6 in the Appendix.

analysis depending on the respondent's age group at the time of the shock.[32] Compared to women aged 37 to 49, we find no evidence that younger women experience different levels of violence in the aftermath of earthquakes. All interaction coefficients are statistically insignificant, indicating that age does not play a differential role in this context.

In sum, this section documents important heterogeneities depending on macro-level institutional dimensions and micro-level socio-demographic characteristics. First, we find evidence that the increase in the incidence of violence following disasters is entirely born by women living in urban areas. Additionally, we find an important mitigating role of protective institutions in this context, with women justice centers completely offsetting the earthquake effect. Finally, in terms of characteristics of the respondents and their spouses, we show that individuals with lower levels of education are the ones experiencing the increases in violence, while age and women's employment status at the time of the shock do not seem to play a role in this context.

8 Conclusions

While the socio-economic consequences of natural disasters and extreme weather events are well documented in the literature, the dynamics of intra-household violence in the aftermath of disasters has not been investigated extensively. This paper provides new empirical evidence on the effects of earthquakes on IPV in Peru, a country with high levels of gender violence. Exploiting the temporal and spatial distribution of earthquakes, our results show that earthquake exposure significantly increases the likelihood that women suffer violence. For instance, being affected by a very strong earthquake in the past six months increases the probability that women report having experienced violence by about 12 percentage points. The effect persists up to 12 months after the shock, indicating that vulnerability to violence relates not only to the emergency state immediately after the earthquake, but is also extended to the reconstruction period.

In terms of underlying channels and heterogeneities, we shed light on the role of

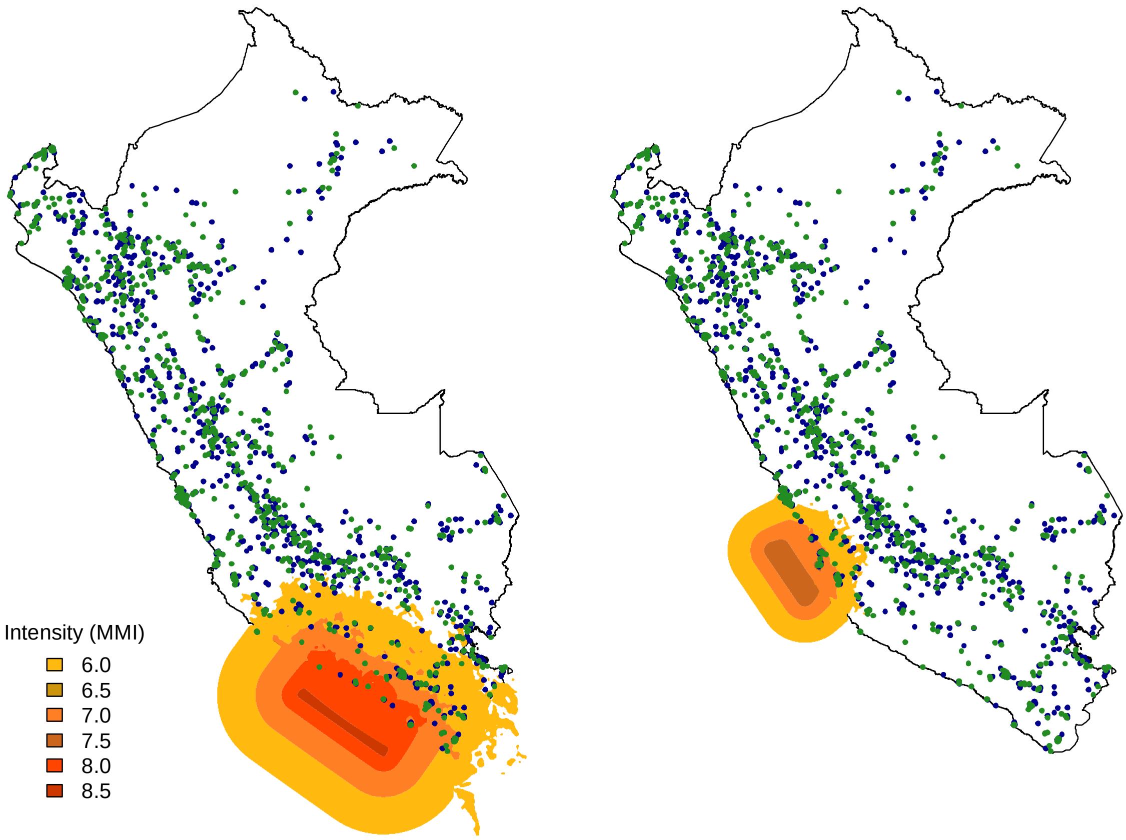
[32] Alternatively, we also interact the earthquake exposure measure with continuous age variables and age difference with the partner. Results are presented in Table A6 in the Appendix.

individual, societal and institutional characteristics affecting the incidence of IPV following earthquakes. For instance, channel analyses suggest that an increase in male intra-household economic dominance and a rise in male alcohol consumption are plausible underlying mechanisms explaining the rise in IPV following the earthquakes. Additionally, our results show that there is substantial heterogeneity in earthquake effects for urban and rural areas, which seem to be related to different household dynamics following the shock. While in rural areas we document an increase in cooperation between spouses, a reduction in alcohol consumption, and an increase in female work (all consistent with lower levels of violence), the same is not true for urban areas, which register stark increases in IPV. Finally, we show the important role of institutional delivery in protecting women in urban areas from experiencing violence in the aftermath of earthquakes. More specifically, we document that the increase in IPV estimated in urban areas is entirely born by women without access to protective institutions. Altogether, we provide a detailed picture on factors that hinder or trigger violence following large-scale shocks, potentially contributing to the elaboration of more effective protective policies.

The nature of earthquakes is similar in many respects to other unexpected and highly destructive shocks, including other large-scale natural disasters (typhoons, tsunamis, etc.) as well as global or local epidemics. Therefore, the documented increase in women's vulnerability to IPV in the aftermath of natural disasters provides highly relevant policy implications that could be potentially extended to other settings. The vast majority of post-disaster relief programs focuses on the reconstruction of infrastructure and economic transfers. This paper draws attention to an important but often neglected perspective, which also needs to be considered in post-disaster settings.

Figures and Tables

Figure 1: DHS survey clusters and 2001, and 2007 Earthquakes

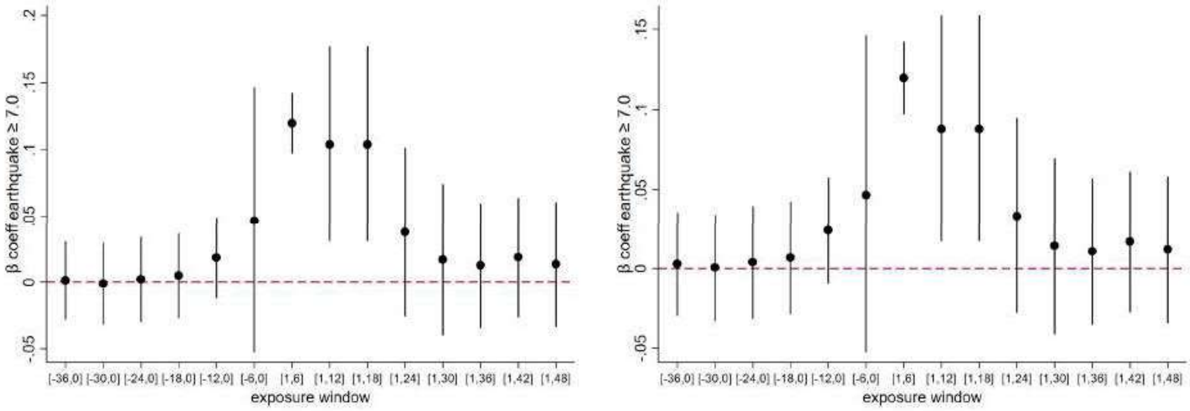


(a) 2001

(b) 2007

Figures (a) and (b) show earthquake polygons equal to or above 6.0 in the MMI scale for the earthquakes that happened in Peru in 2001, and 2007. In addition, DHS clusters of the 2000 wave are shown in dark blue and DHS clusters of the 2009 wave are shown in forest green.

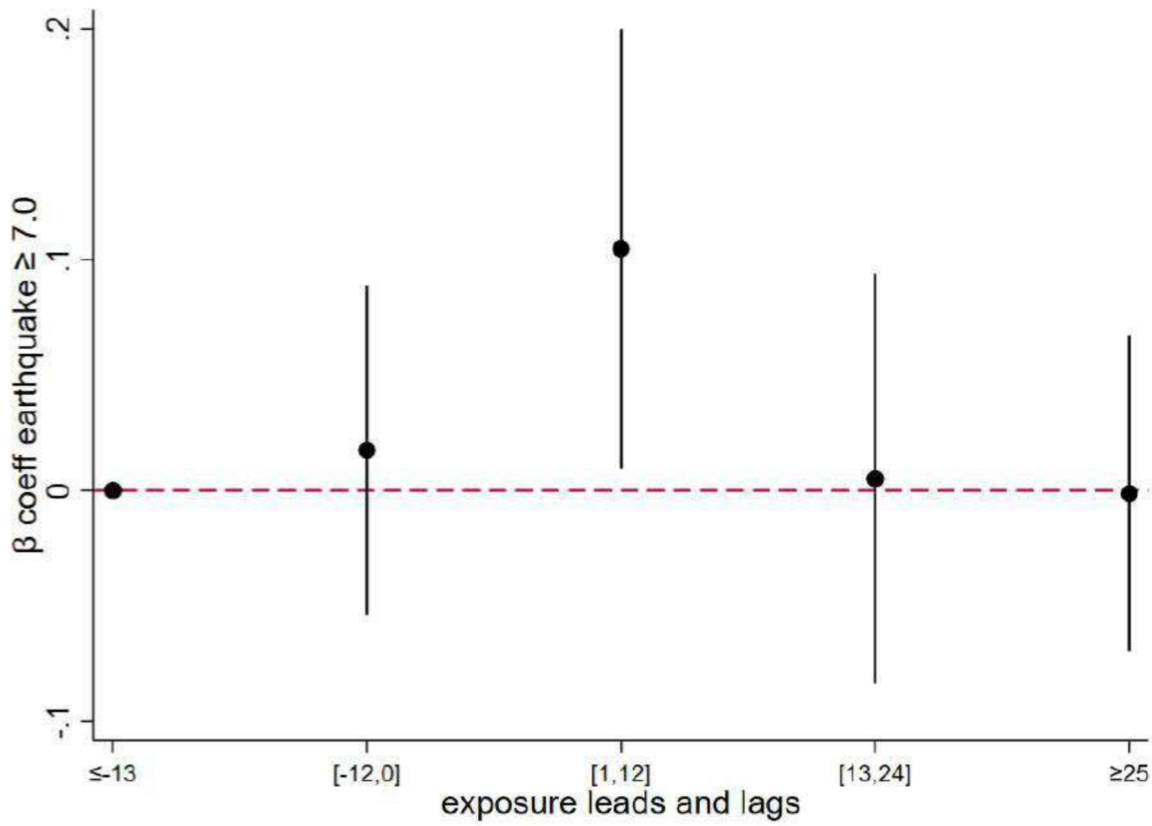
Figure 2: Earthquakes and Intimate Partner Violence



(a) No Buffer (b) With Buffer

Notes: Plot of leads and lags of earthquake coefficients estimated separately for earthquakes equal to or above 7.0 in the MMI scale. 90 percent confidence intervals.

Figure 3: Earthquakes and Intimate Partner Violence: Alternative Definition



Notes: Plot of leads and lags of earthquake coefficients estimated separately for earthquakes equal to or above 7.0 in the MMI scale. 90 percent confidence intervals.

Table 1: Summary Statistics

	mean	sd	min	max
Panel A: Individual-level Information				
IPV - Less Severe Violence (0/1)	0.385	0.487	0	1
IPV - Mental Violence (0/1)	0.307	0.461	0	1
IPV - Severe Violence (0/1)	0.173	0.379	0	1
IPV - Sexual Violence (0/1)	0.084	0.277	0	1
Earthquake $\geq$ 7.0 in the Past 6 Months (0/1)	0.001	0.027	0	1
Earthquake $\geq$ 7.0 in the Past 12 Months (0/1)	0.003	0.055	0	1
Rural (0/1)	0.445	0.497	0	1
Women Justice Center in the District (0/1)	0.128	0.334	0	1
Currently Employed (0/1)	0.650	0.477	0	1
Partner Drinks (0/1)	0.741	0.438	0	1
Partner Frequently Drunk (0/1)	0.762	0.426	0	1
Partner in the Household (0/1)	0.958	0.202	0	1
Partner Economic Dominance (0/1)	0.295	0.456	0	1
Any Joint Decision (0/1)	0.886	0.317	0	1
Household Wealth Index	0.105	0.957	-2.003	2.511
Age	33.374	8.324	15	49
Squared Age	1183.107	561.625	225	2401
Age Difference Between the Respondent and the Partner	4.064	5.802	-32	72
Respondent Has No Education	0.066	0.249	0	1
Respondent Has Primary Education Level	0.389	0.488	0	1
Respondent Has Secondary Education Level	0.376	0.484	0	1
Respondent Has Tertiary Education Level	0.169	0.375	0	1
Partner Has No Education	0.016	0.125	0	1
Partner Has Primary Education Level	0.313	0.464	0	1
Partner Has Secondary Education Level	0.489	0.500	0	1
Partner Has Tertiary Education Level	0.182	0.386	0	1
Observations	43,110			
Panel B: Department-level Information				
$\%\Delta$ Physical Violence Cases	15.338	38.573	-45	231
$\%\Delta$ Sexual Violence Cases	20.579	54.835	-82	272
Earthquake $\geq$ 7.0 in the Past Calendar Year (0/1)	0.015	0.120	0	1
ln Population	13.586	0.841	11.623	15.996
Observations	137			

Table 2: Earthquake and Intimate Partner Violence: Individual-level Results

	(1)	(2)	(3)	(4)
Earthquake $\geq$ 7.0 in the Past 6 Months (0/1)	0.128***	0.120***		
	(0.014)	(0.014)		
Earthquake $\geq$ 7.0 in the Past 12 Months (0/1)			0.079*	0.104**
			(0.043)	(0.044)
Year FE, District FE, Department Trend	✓	✓	✓	✓
Controls		✓		✓
Observations	43,110	43,110	43,110	43,110
R^2	0.056	0.079	0.056	0.079

Notes: The table reports the estimation results of equation (1) using linear probability model. Respondents are females aged 15 to 49 that have ever been married or cohabiting. The sample is restricted to females that have been living in the same location for at least 3 years. The outcome variable is a binary indicator which equals to one if the respondent reports having suffered any type of intimate partner violence and zero otherwise. Columns (1) and (2) report the effect of being exposed to earthquakes equal to or above 7.0 in the MMI scale in the past six months, while columns (3) and (4) show the effects of being exposed to earthquakes in the past 12 months. Control variables include respondents age, age squared, age difference with the partner, educational level and partner's educational level, and the number of children. Standard errors are clustered at the district level in all specifications.
*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Standard errors in parentheses.

Table 3: Earthquake and Intimate Partner Violence: Aggregate-level Results

	Percentage Change (%Δ) in the Violence Cases			
	Domestic Violence		Sexual Violence	
	(1)	(2)	(3)	(4)
Earthquake $\geq$ 7.0 in the Past Year (0/1)	63.626***	60.262***	48.638*	27.825
	(9.673)	(11.704)	(25.059)	(25.986)
ln Population		82.613		511.024**
		(167.714)		(222.339)
Observations	137	137	137	137
R^2	0.048	0.050	0.011	0.050

Notes: The table reports the results of fixed effects (FE) estimates reported with robust standard errors clustered at the department level. The sample is an unbalanced panel of Peruvian states between 2002 and 2008. The outcome variable in columns (1) and (2) is the percentage change in the number of cases of cases of domestic violence registered in the Women Justice Centers. In columns (3) and (4) the outcome variable is the percentage change in the number of cases of cases of sexual violence registered in the Women Justice Centers.
*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.

Table 4: Earthquake and Intimate Partner Violence: Heterogeneity by Macro Characteristics

Heterogeneity Var:	Rural	WJC in District		
		All	Urban	Rural
	(1)	(2)	(3)	(4)
Earthquake $\geq$ 7.0 in the Past 12 Months (0/1)	0.109**	0.168***	0.164***	-0.095***
	(0.043)	(0.043)	(0.029)	(0.017)
EQ $\geq$ 7.0 $\times$ Rural	-0.209***			
	(0.043)			
Rural (0/1)	-0.078***			
	(0.011)			
EQ $\geq$ 7.0 $\times$ WJC		-0.188***	-0.180***	omitted
		(0.043)	(0.029)	(.)
WJC in the District (0/1)		0.027*	0.014	-0.010
		(0.015)	(0.016)	(0.053)
Linear Combination of Coefficients:				
EQ + EQ $\times$ Var	-0.100***	-0.020*	-0.016	-0.095***
	(0.012)	(0.011)	(0.016)	(0.017)
Year FE, District FE, Department Trend	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Observations	43,110	43,110	23,936	19,174
R^2	0.081	0.079	0.071	0.114

Notes: The table reports the estimation results of equation (1) using linear probability model. Respondents are females aged 15 to 49 that have ever been married or cohabiting. The sample is restricted to females that have been living in the same location for at least 3 years. The outcome variable is a binary indicator which equals to one if the respondent reports having suffered any type of intimate partner violence and zero otherwise. The two heterogeneity variables are both dummies, indicating whether the respondent resides in rural area or not, whether there was a Women Justice Center in the district.All regressions include a full set of control variables as in column (4) of Table 2. Standard errors are clustered at the district level in all specifications.

*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Standard errors in parentheses.

Table 5: Earthquake and Intimate Partner Violence: Heterogeneity by Individual Characteristics

	Female Work	Female Edu	Male Edu	Female Age
	(1)	(2)	(3)	(4)
EQ $\geq$ 7.0 12M (0/1)	0.117*	0.152*	0.043	0.157***
	(0.071)	(0.083)	(0.060)	(0.051)
EQ $\geq$ 7.0 12M (0/1) $\times$ Working (0/1)	-0.027			
	(0.093)			
Working (0/1)	0.052***			
	(0.005)			
Reference: Tertiary Education				
EQ $\geq$ 7.0 12M (0/1) $\times$ No educ (0/1)		0.514***		
		(0.072)		
EQ $\geq$ 7.0 12M (0/1) $\times$ Prim educ (0/1)		-0.139		
		(0.110)		
EQ $\geq$ 7.0 12M (0/1) $\times$ Sec educ (0/1)		-0.068		
		(0.110)		
No educ (0/1)	0.022	0.012	0.012	0.012
	(0.016)	(0.015)	(0.015)	(0.015)
Prim educ (0/1)	0.049***	0.041***	0.041***	0.041***
	(0.011)	(0.010)	(0.010)	(0.010)
Sec educ (0/1)	0.080***	0.072***	0.071***	0.071***
	(0.009)	(0.008)	(0.008)	(0.008)
Reference: Partner Tertiary Education				
EQ $\geq$ 7.0 12M (0/1) $\times$ Partner no educ (0/1)			0.528***	
			(0.067)	
EQ $\geq$ 7.0 12M (0/1) $\times$ Parter prim educ (0/1)			0.191	
			(0.126)	
EQ $\geq$ 7.0 12M (0/1) $\times$ Partner sec educ (0/1)			0.083	
			(0.060)	
Partner no educ (0/1)	0.062***	0.062***	0.061***	0.062***
	(0.020)	(0.021)	(0.021)	(0.021)
Parter prim educ (0/1)	0.082***	0.084***	0.084***	0.085***
	(0.010)	(0.009)	(0.009)	(0.009)
Partner sec educ (0/1)	0.082***	0.085***	0.084***	0.085***
	(0.008)	(0.007)	(0.007)	(0.007)
Reference: Age 37 to 49				
EQ $\geq$ 7.0 12M (0/1) $\times$ Age 15 to 25 (0/1)				-0.133
				(0.085)
EQ $\geq$ 7.0 12M (0/1) $\times$ Age 26 to 36 (0/1)				-0.071
				(0.059)
Age 15 to 25 (0/1)				-0.013
				(0.017)
Age 26 to 36 (0/1)				0.006
				(0.010)
Year FE, District FE, and Department Trend	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Observations	42,118	43,110	43,110	43,110
R^2	0.082	0.079	0.079	0.079

Notes: The table reports the estimation results of equation (1) using linear probability model. Respondents are females aged 15 to 49 that have ever been married or cohabiting. The sample is restricted to females that have been living in the same location for at least 3 years. The outcome variable is a binary indicator which equals to one if the respondent reports having suffered any type of intimate partner violence and zero otherwise. The heterogeneity variables are dummies, indicating whether the respondent is currently working or not, whether her or her partner's education level belongs to one of the education categories, and the age group of the respondent.All regressions34clude a full set of control variables as in column (4) of Table 2. Standard errors are clustered at the district level in all specifications.

*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Standard errors in parentheses.

Table 6: Earthquake and Intimate Partner Violence: Channels

	Partner Drinks (0/1)	Frequent Drunk (0/1)	Male in the hh (0/1)	Male Dominance (0/1)	Joint Decision (0/1)	hh Wealth (continuous)	Female Work (0/1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Outcome Variable - Channel Variables as Specified							
EQ $\geq$ 7.0 12M (0/1)	0.153***	0.003	0.032**	0.095*	-0.040*	-0.080	-0.028
	(0.052)	(0.036)	(0.015)	(0.054)	(0.024)	(0.136)	(0.048)
Year FE, District FE, and Department Trend	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓
Observations	27,290	35,901	43,106	43,106	37,843	27,290	42,118
R^2	0.080	0.054	0.038	0.133	0.112	0.743	0.174
Panel B: Outcome Variable - IPV (0/1)							
Channel Variable	0.169***	0.354***	0.004	0.044***	-0.098***	0.004	0.052***
	(0.007)	(0.009)	(0.011)	(0.005)	(0.008)	(0.007)	(0.005)
Year FE, District FE, and Department Trend	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓
Observations	27,290	35,901	43,106	43,106	37,843	27,290	42,118
R^2	0.109	0.118	0.079	0.081	0.083	0.087	0.082
Panel C: Outcome Variable - IPV (0/1)							
EQ $\geq$ 7.0 12M (0/1)	0.139***	0.070	0.104**	0.100**	0.109**	0.166***	0.101**
	(0.049)	(0.055)	(0.044)	(0.046)	(0.046)	(0.055)	(0.041)
Channel Variable	0.169***	0.354***	0.004	0.044***	-0.098***	0.005	0.052***
	(0.007)	(0.009)	(0.011)	(0.005)	(0.008)	(0.007)	(0.005)
Year FE, District FE, and Department Trend	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓
Observations	27,290	35,901	43,106	43,106	37,843	27,290	42,118
R^2	0.109	0.118	0.079	0.081	0.083	0.087	0.082

Notes: The table reports the estimation results of equation (1) using linear probability model. Respondents are females aged 15 to 49 that have ever been married or cohabiting. The sample is restricted to females that have been living in the same location for at least 3 years. In panel A, the outcome variables in columns (1)-(7) are all dummies and are specified in each column. In panel B and C, the outcome variable in all columns is a binary indicator which equals to one if the respondent reports having suffered any type of intimate partner violence and zero otherwise. All regressions include a full set of control variables as in column (4) of Table 2. Standard errors are clustered at the district level in all specifications. The variable indicating whether the partner drinks is not available in the DHS collected in 2000.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses.

Table 7: Earthquake and Intimate Partner Violence: Channels by Rural or Urban Status

Outcome Variable:	Partner Drinks (0/1)	Frequent Drunk (0/1)	Male in the hh (0/1)	Male Dominance (0/1)	Joint Decision (0/1)	hh Wealth (continuous)	Female Work (0/1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Rural							
EQ $\geq$ 7.0 12M (0/1)	omitted	-0.119***	0.012*	-0.130***	0.047***	omitted	0.212***
	(.)	(0.014)	(0.007)	(0.022)	(0.016)	(.)	(0.028)
Year FE, District FE, and Department Trend	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓
Observations	12,145	15,788	19,172	19,173	16,790	12,145	18,806
R^2	0.126	0.084	0.079	0.164	0.136	0.645	0.237
Panel B: Urban							
EQ $\geq$ 7.0 12M (0/1)	0.151**	0.032	0.031*	0.129**	-0.044*	-0.190	-0.019
	(0.061)	(0.040)	(0.017)	(0.059)	(0.026)	(0.125)	(0.048)
Year FE, District FE, and Department Trend	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓
Observations	15,145	20,113	23,934	23,933	21,053	15,145	23,312
R^2	0.066	0.039	0.028	0.090	0.106	0.584	0.136

Notes: The table reports the estimation results of equation (1) using linear probability model. Respondents are females aged 15 to 49 that have ever been married or cohabiting. The sample is restricted to females that have been living in the same location for at least 3 years. The outcome variables in columns (1)-(7) are all dummies and are specified in each column. All regressions include a full set of control variables as in column (4) of Table 2. Standard errors are clustered at the district level in all specifications. The variable indicating whether the partner drinks is not available in the DHS collected in 2000.
*** $p < 0.01$, ** $p < 0.05$, $^{*}p < 0.1$. Standard errors in parentheses.

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