Marriage Market Responses in the Wake of a Natural Disaster in India

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Abstract

With increasing occurrences of natural disasters globally, there is a need to study their demographic effects both in the short- and long-run. In the backdrop of the 2001 Gujarat earthquake that resulted in over 20,000 casualties and large-scale loss of property, this paper analyzes marriage market responses in the event of a natural disaster. Using the 2004-05 round of the Indian Human Development Survey and employing a difference-in-difference strategy, we find a statistically significant reduction in women's marriage age, a lower probability of marital matches within the same villages, a decrease in spousal educational difference, and an increased likelihood of women marrying into poorer households. We also account for heterogeneity in earthquake intensity and examine whether the above results are driven by the districts that were most affected by the earthquake. Additionally, we provide some evidence on changes in dowry payments as a potential mechanism underlying our results.

JEL Codes: J12; J16; O53

Keywords: Marriage; India; Gujarat earthquake

1. Introduction

Natural disasters are severe and unexpected adverse events that often result in significant loss of life and property. The average economic loss from natural disasters is estimated to be between US $250 billion and US $300 billion annually (United Nations, 2015). Individuals in low- and middle-income countries are especially susceptible to such negative shocks (United Nations, 2015). Even within nations, the impact of these disasters may vary by age, sex, and socioeconomic status, reflecting the differences in vulnerability across these dimensions (Frankenberg et al., 2014). In addition to their immediate effects on the general economy due to mortality and loss of property and infrastructure, disasters also have consequences for health, migration, family formation, and fertility at the population level (Frankenberg et al., 2014).

A burgeoning strand of literature has examined the short-run and long-run effects of natural disasters on various socioeconomic and demographic outcomes. The impacts on fertility, sex-ratio, birth-spacing (Saadat, 2008; Finlay, 2009; Zhao and Reimondos, 2012; Hamamatsu et al., 2014; Nobles et al., 2015; Caruso and Miller, 2015; Nandi et al., 2018), birth weight (Torche, 2011), schooling (Caruso and Miller, 2015), and health indicators (Mazumdar et al., 2014; Thamarapani, 2016) have received a great deal of attention. In contrast, relatively few papers have focused on marriage outcomes. Studies have shown that disasters reduce marital attractiveness (Brandt et al., 2009), lower the quality of marital matches (Almond et al., 2007; Caruso and Miller, 2015), change marriage and divorce rates (Cohan and Cole, 2002; Hamamatsu et al., 2014), increase the likelihood of consanguineous marriages (Mobarak et al., 2013), and decrease the age at first birth of a child (Caruso and Miller, 2015). Age at marriage is also affected by armed conflicts (Shemyakina, 2009) as well as weather shocks (Corno et al., 2017).

Our paper contributes to the literature by providing a comprehensive look at marriage outcomes following the 2001 Gujarat earthquake in India.[1] Specifically, we examine its impact on a woman's age at marriage, autonomy in her choice of spouse, the quality of the match (measured by education and economic status), and the location of her marital household. India provides a unique setting to examine the formation of marriages due to several entrenched features in the marriage market (refer to Anukriti and Dasgupta, 2018). First, an exceedingly high proportion of marriages continue to be family-arranged in India. Women have a tendency to marry more educated men (*educational hypergamy*) although this trend is on the decline. Irrespective of marriages being self-arranged or family-arranged, positive matching with respect to caste prevails (*caste homogamy*). In addition, consanguineous marriages or marriages between close blood relatives is also very common. Finally, marriages in India continue to be characterized by increased dowry payments (Anderson, 2003). A negative financial shock brought on by a disaster can usher in changes to the above-mentioned patterns. For example, it can augment the cost of marrying a daughter due to increased dowry payments or not finding quality matches as would have previously been intended.

We use the 2004-2005 wave of the Indian Human Development Survey, a nationally representative dataset, to conduct our empirical examination of the marriages formed post-earthquake. We exploit the district-cohort variation in exposure to the earthquake and rely on a difference-in-differences estimation strategy. Women married after the earthquake in the impacted districts from our treatment group. Our results indicate that the earthquake reduced the

[1] The 2001 Gujarat earthquake is considered 'significant' based on the definition of the United States Geological Survey (USGS). The USGS categorizes an earthquake as *significant* based on a combination of factors including magnitude (https://earthquake.usgs.gov/earthquakes/browse/significant.php?year=2001#sigdef).

age of marriage for women, lowered their probability of marrying within the same village, reduced spousal educational difference, and increased the probability of marrying into poorer households and being related to the spouse prior to marriage. We also account for the intensity of the earthquake to explore whether or not the most severely affected districts in Gujarat drive our results. Additionally, we discuss mechanisms underlying our results and provide some evidence on changes in dowry payments as a potential channel.

One conceivable threat to our analysis is the issue of migration. If migration rates due to marriages are significant, we run the risk of incorrectly identifying women in our treatment and control groups. Our results would be susceptible to a downward bias if the women from the affected regions end up in unaffected areas after the earthquake. However, Munshi and Rosenzweig (2009) document that out-of-state migration is often restricted due to social networks and language barriers; these in-network (within villages/districts) marriages also provide families with much needed insurance and risk-sharing. Migration out of one's state of origin is usually around 4% (Roy 2015; Nandi et al., 2018) – similar numbers are reflected in our dataset as well. This mitigates concerns about the possibility of migration affecting our identification strategy and results.

The remainder of the paper is structured as follows. Section 2 provides background information on the 2001 earthquake in Gujarat. Section 3 describes our data, presents descriptive statistics, and details the construction of variables used in this analysis. Section 4 outlines the empirical strategy, and the results are presented in Section 5. Section 6 provides a discussion of possible mechanisms for our results. The last section concludes.

2. The 2001 Gujarat Earthquake

At approximately 8:46 am on January 26 2001, an earthquake of magnitude M_w 7.7 (6.9 on the Richter scale) struck the Kutch region of Gujarat, a state in western India.[2] The epicenter was 20 km northeast of the town of Bhuj that bore the brunt of the devastation. Upwards of 1000 aftershocks of $M_w \geq 3$ plagued the region for about 2 years, with the largest one recorded at M_w 6 just two days after the main event.

21 out of 25 districts in Gujarat were affected with varying degrees of intensity. The *severely affected* districts included Ahmedabad, Jamnagar, Kutch, Patan, Rajkot, and Surendranagar. *Less affected* districts are: Amrelli, Anand, Banaskantha, Bharuch, Bhavnagar, Gandhinagar, Junagadh, Kheda, Mehsana, Navasari, Porbandar, Sabarkantha, Surat, Vadodara, and Valsad. Only four districts in the state were completely unaffected: Dahod, Dangs, Narmada, and Panch Mahals. Figure 1 provides a visual guide to the districts and the intensity of the earthquake in Gujarat.

The earthquake brought large-scale devastation in the region and affected 16 million people. The extent of devastation spread across 7900 villages in 18 towns (Lahiri et al., 2001; Sinha, 2001). The reported loss of lives was approximately 20,000, and around 165,000 people were injured, and more than 200,000 were rendered homeless (Lahiri et al., 2001; Sinha, 2001; Narayan and Sharma, 2004). Approximately 10,000 adults between 15-59 years died, reducing the pool of both productive individuals and potential spousal matches. Female casualties totaled around 9,100 (Lahiri et al., 2001).[3] The quake destroyed close to 300,000 buildings, damaged

[2] M_w denotes the moment of magnitude scale used to measure the size of an earthquake. It replaced the oft-used Richter scale.

[3] Due to a lack of official data on the gender and age composition of the casualties, Lahiri et al. (2001) use population information from the 1991 Census to calculate these numbers.

another 700,000 and caused damages to 14 earth dams in the region (Madabhushi and Haigh, 2005). The estimated economic loss was in the vicinity of US $2 billion (Sinha, 2001).

To our knowledge, only three studies have examined the socioeconomic consequences of the Gujarat earthquake. Lahiri et al. (2001) provides an overview of the larger economic impact of the disaster. Two other papers, Finlay (2009) and Nandi et al. (2018) evaluate the earthquake's impact on fertility, sex ratio, and birth spacing. While Finlay (2009) does not find any significant changes in a woman's fertility, Nandi et al. (2018) find an increase in the rates of childbirth and a decrease in birth-spacing among women. Our paper adds to the understanding of the demographic consequences of this earthquake by examining its impact on marriage outcomes, helping us quantify the negative effects of a disaster on a vulnerable sub-population.

3. Data and Descriptive Statistics

Data for our analysis come from the 2004-05 round of the India Human Development Survey (IHDS), a nationally representative sample consisting of 41,554 households from 25 states and union territories of India that covers 1504 villages and 970 urban neighborhoods from 383 districts. The survey collects a rich array of information on household characteristics such as religion, caste, household income, and detailed individual characteristics including age, gender, and completed years of schooling. Pertinent to our study, the IHDS interviews an *eligible woman* in each household, eligible women are married women between the ages of 15-49. These women were asked questions about their marital history and involvement in mate selection, IHDS being the only nationally representative survey to collect information on women's involvement in marriage-related decision making.

We limit our sample to four states: Gujarat and the bordering states of Maharashtra, Madhya Pradesh and Rajasthan. Based on information from Lahiri et al. (2001), 21 out of 25 districts in Gujarat were affected by the quake. These districts form our treatment group. The remaining four districts in Gujarat together with the districts in the three neighboring states were unaffected by the earthquake and form our control group (see Figure 1). Similar to Nandi et al. (2018), our comparison group comprises of the three neighboring states with relatively smaller socioeconomic and cultural differences. Next, the survey documents a woman's year of marriage, allowing us to categorize women into two cohorts: those who were married after the 2001 Gujarat earthquake and hence whose marriage formations could potentially have been negatively affected, and those whose marriages were already formed before the disaster. Therefore, we additionally restrict our sample to marriages that took place between 1996 and 2005 or approximately five years prior to and after the earthquake. We also drop women who have been married more than once since these marriages are likely to be quite different than first marriages.

Descriptive statistics for the treatment and control groups in our analysis are presented in Table 1. Age of an individual is measured in years. Educational attainment is measured as completed years of education. The raw data indicates that women and their spouses in the treatment districts are, on average, older and more educated than those in the control group. Religion is divided into three groups: Hindu, Muslim and Other. The majority of sample in both the treatment and control groups belong to the Hindu community. Caste is divided into four categories: general, scheduled caste (SC), scheduled tribe (ST) and other backward class (OBC). The latter three are the historically disadvantaged caste groups in India since they fall at the bottom of the caste hierarchy. The statistics on log of household income and monthly consumption per capita indicate that women in the treatment group are relatively wealthier compared to their counterparts in the control group. Urban is an indicator for the location of households: the sample statistics reveal that 51% of women in the treatment group reside in urban areas versus 33% in the control group.

We draw our outcome variables from the section in the survey dedicated to the demographic and household characteristics of the eligible women. In Table 2, we present descriptive statistics for these variables, and again the sample is divided by treatment status. Specifically, our analysis examines 13 dependent variables: a woman and her spouse's age at the time of marriage, spousal age difference, an indicator for whether her marital and natal households are in the same village, an indicator for whether she belongs to the same caste as that of her husband, difference in spousal education levels, an indicator for whether her spouse is more educated than her, an indicator for whether the economic status of her marital household is worse off compared to her natal family, three indicators for type of marriage, and indicators for whether a woman knew her husband before the wedding day or was related by blood to him (for example, uncle or cousin) prior to marriage. Following Allendorf and Pandian (2016), marriages are categorized into three types and are derived from two survey questions that women were asked to elicit information on the mate selection process. The first question asked was "Who chose your husband?" Women responded that the choice was either made by herself, together with her parents, only by her parents or only by "others" (extended family members or individuals outside the family). Only when women responded that parents or others chose their spouses alone was the question "Did you have any say in choosing him?" asked to which they could respond "Yes" or "No". If a woman reported that she chose her own husband, then the marriage is labeled as "self-arranged marriage". If she responded that she chose her husband together with her parents or if parents or others chose a woman's spouse and she had a say in choosing him, then the marriage is labeled as "parent-arranged with consent of woman". If a woman's parents chose her spouse and she had no say in the choice, the marriage is labeled as "parent-arranged without consent of woman". These three categories thus represent marriage types ranging from one in which women made the decisions to one in which they had no say at all in the choice of their spouse and their parents or others made the decisions. Overall, these outcome variables help us analyze marital matching patterns as well as the quality of the matches.

4. Empirical Strategy

The main objective of this study is to analyze the effects of a natural disaster, such as an earthquake, on the marriage market. There are two sources of variation on how the 2001 Gujarat earthquake could affect women's marriage outcomes. First, there is a time component: the cohort of women who were married after the earthquake versus those already married before an unexpected negative shock. The next source of variation is geographical: earthquake affected districts in Gujarat constitute the treatment group while the remaining districts of Gujarat and all districts in the three neighboring states of Rajasthan, Madhya Pradesh, and Maharashtra that were not affected by the earthquake form the control group. Our basic empirical strategy can be summarized by the following equation:

$$y_{idt} = \alpha_0 + \alpha_1\left(Affected_d \times Post_t\right) + \alpha_2(Affected_d) + \alpha_3(Post_t) + \boldsymbol{X}\pi + \theta_s + \lambda_t + \gamma(State_s \times Year_t) + \epsilon_{idt} \quad \textbf{(1)}$$

where y_{idt} is the marriage outcome of woman *i* in district *d* in year *t*. $Affected_d$ is an indicator variable for whether a district was impacted by the earthquake or not. $Post_t$ is a dummy variable equals one for marriages that took place between 2001 and 2005, and is equal to zero for marriages between 1996-2000.[4] The difference-in-difference coefficient is α_1, which gives the differential impact of the earthquake in the treatment districts compared to the control districts. The vector of household characteristics is given by $\boldsymbol{X}$ and includes caste and religion indicators, dummy for urban location of the household, log of the household's total income and log of monthly consumption per capita. Base groups in the regression are general caste, Hindu religion, and rural household location. θ_s and λ_t are state and year of marriage fixed effects respectively and are included to capture any heterogeneity at the state-level and in aggregate time trends. We also include *State* × *Year* fixed effects to soak up any differential time trends across states. ϵ_{idt} is the error term.

The above analysis estimates the net effect of the earthquake on marriage outcomes. However, the negative shock of a natural disaster can affect families differentially based on the intensity of the earthquake in their area of residence. For example, households in districts with extreme devastation may suffer more economic losses and household member deaths thereby finding it harder to recover than those residing in areas of less destruction and damage. Accounting for the information on earthquake intensity presented in Lahiri et al. (2001) and shown in Figure 1, we modify Equation (1) to incorporate this heterogeneity in impact. The revised regression equation we estimate is as below:

[4] We include marriages from 2001 as well since the earthquake took place in the beginning of the year on January 26, 2001.

$$y_{idt} = \beta_0 + \beta_1(MostAffected_d \times Post_t) + \beta_2(LessAffected_d \times Post_t) + \beta_3(MostAffected_d) + \beta_4(LessAffected_d) + \beta_5(Post_t) + \boldsymbol{X}\pi' + \theta_s + \lambda_t + \gamma(State_s \times Year_t) + \epsilon'_{idt} \quad \textbf{(2)}$$

where $MostAffected_d$ equals one for the 6 districts in Gujarat that were severely affected. Similarly, $LessAffected_d$ is an indicator for the districts that were classified as moderately impacted by the earthquake. The comparison group is the control group comprising of the unaffected districts in Gujarat and the three neighboring states. Thus, β_1 gives the difference-in-difference impact of the earthquake in severely affected districts while β_2 gives the differential impact on less severely affected districts. As before, $\boldsymbol{X}$ represents a vector of household controls, and we include state, year of marriage, and state × year fixed effects. In all our regressions, we apply the survey sampling weights and use robust standard errors that are clustered at the district level.

Before continuing on to our results, it is important to consider a few limitations of this study. First, given that a catastrophic and unpredictable event like that of an earthquake is a negative shock to households, a more precise way to identify the affected cohort of women would be through their marriage date. Although IHDS records the date of marriage, the variable suffers from numerous missing observations. Hence, we rely on the information on woman's year of marriage. Second, the dataset collected information from only 383 out of 602 districts in India. For example, it omits eight districts in Gujarat: five less severely affected and three unaffected districts. Thus, our analysis is restricted to those districts for which data are available. Third, IHDS only interviews only one eligible woman per household and so we are unable to extend our study to other women in these families whose marriage outcomes might also have been impacted by the earthquake. Fourth, in an analysis of marriage market outcomes, it is imperative to control for women's natal family characteristics such as the educational level of their parents. However, this information is not available from our survey dataset. Finally, unlike other large Indian surveys such as the District Level Household Survey or the National Family and Health Survey, the IHDS has a relatively smaller sample size, limiting our ability to conduct regressions on subsamples to examine heterogeneous treatment effects.

5. Results

5.1 Effects on Marriage Outcomes

The results from estimating Equation (1) are presented in Tables 3A and 3B. The first row gives the difference-in-difference impact of the earthquake on the affected districts compared to the unaffected districts. Turning to Table 3A, we find significant effects of the earthquake on the probability of the spouse being from the same village, difference in spousal education, and probability of the woman's marital family being economically worse off compared to her natal family. Controlling for household characteristics, we find a 6.5 percentage point reduction in the probability of the spouse being from the same village as the woman across the two time periods (2001-2005 versus 1996-2000) in the earthquake-affected districts compared to the unaffected districts. Similarly, spousal educational difference is found to reduce by an average of 1.56 years. There is a 13 percentage point increase in the likelihood of women marrying spouses whose families are poorer than their natal families. The effects on age at marriage, spousal age difference, and probability of marrying within the same caste are statistically indistinguishable from zero. Turning to Table 3B, we find a 26 percentage point reduction in the probability of self-arranged marriages coupled with an almost equivalent increase in the probability of parent-arranged marriages with the consent of women. No statistically significant results are obtained for the probability of arranged-marriages without the consent of woman, and probability of knowing spouse or being related to spouse prior to marriage.

5.2 Results by intensity of earthquake

The above-mentioned results may mask the nuanced effects of the disaster since the estimation equation does not take into account the intensity of the earthquake. Therefore, we turn to our next set of results from estimating Equation (2) that incorporates heterogeneity in the magnitude of the earthquake. The first two rows in Tables 4A and 4B give the difference-in-difference impact of the earthquake on the *most-affected* and *less-affected* districts respectively. In Table 4A, we find that the marriage age for women decreases by an average of 1.4 years in most-affected districts. This, in turn, also increases the spousal age difference. Reduction in the probability of spouse being from the same village as the woman occurs in most-affected and less-affected districts. Likewise, the results on lowering of spousal educational difference and increase in the probability of women marrying men from poorer households hold regardless of the severity of the earthquake. From Table 4B, we find no differences in the results on self-arranged marriages and parent-arranged marriages with woman's consent once we differentiate the districts based on intensity of the earthquake. The last column also uncovers an increase in the probability of women being related to their spouses in less-affected districts compared to unaffected districts. However, although the coefficient on *Post×MostAffected* is positive (0.081), it is not statistically significant.

5.3 Robustness Checks

A natural disaster such as an earthquake is, indeed, an exogenous shock. However, it may be the case that certain confounding factors could be present in our treatment districts or our control districts, in which case our estimates will be rendered biased. Again, our results could be dependent on our choice of study period. To assuage such concerns, we conduct a series of robustness checks. First, we estimate regressions based on Equation (1) in which we simulate false locations for the earthquake. In three sets of regressions, we designate districts in the states of Rajasthan, Maharashtra, and Madhya Pradesh respectively as the treatment group. These results, presented in Appendix Table A1, reveal that the coefficients are largely statistically insignificant. Next, we test the sensitivity of our results to the choice of control states and we again estimate modified regressions based on equation (1) in which we drop the states of Rajasthan, Maharashtra, and Madhya Pradesh respectively from the control group. From Appendix Table A2 we find that these results are largely similar to those presented in Tables 3A and 3B. Finally, we also test the robustness of our results by estimating regressions based on equation (1) for additional study periods: from 1998 to 2003 (a shorter time period), and from 1991 to 2005 (a longer time period). These results are given in Appendix Table A3. Although we lose statistical power due to a smaller sample size for the time period between 1998 and 2003, it is reassuring that the results from both sets of regressions are similar to spirit to our main results presented in Tables 3A and 3B.

5.4 Parallel Trends Analysis

As a final point, we want to ensure that our difference-in difference analysis framework is valid. For this, we need to verify that the parallel trend assumption holds, barring which our estimates would be biased. In other words, we must confirm that the trends in the outcome variables for the treatment and control groups are not statistically different in the pre-treatment (in our case, the pre-earthquake) era. We test this necessary condition in the following way. First, we limit the years of marriage between 1990 and 2000. Next, we estimate a time trend variable *t* and interact it with the indicator for affected districts. Then, we estimate a regression similar to equation (1) with the different marriage outcomes as the dependent variables and the indicator for earthquake-affected districts (*Affected*), time trend (*t*), and the interaction term ($t \times Affected$) as our independent variables. The vector of controls denoted by ***X*** as well as state and year of marriage fixed effects are also included in the estimation equation. The coefficients on the interaction term from these regressions are presented in Appendix Table A4. Upon inspection, this coefficient is found to be statistically equal to zero in nearly all the cases where we obtain statistically significant results (difference-in-difference coefficients). The only exception is the coefficient on "parent-arranged marriages with consent of woman". Thus, we can reasonably expect the parallel trend assumption to hold, which testifies to the validity of our empirical strategy.

6. Possible Mechanisms

There are several mechanisms through which an earthquake can affect marriage market outcomes. First, parents might rush to marry off their daughters when faced with a negative economic shock since there would be one less mouth to feed. Also, the greater percentage of deaths and devastation in the affected areas could lead altruistic parents to find spouses for their daughters from another village to shield them against this shock (out-of-network marriages). Another plausible mechanism is through the effects of the earthquake on dowry payments. Since direct information on dowries is not collected by the IHDS, we make use of a proxy variable. The IHDS asks women "Generally in your community for a family like yours, what are the kinds of things that are given as gift at the time of the daughter's marriage?" Of the different options, we focus on the information on "Gold" and "Cash" since these are the two most common elements of dowry payments. We construct indicator variables with a value of one if women responded that gold or cash is sometimes or usually given and a value of zero if it is rarely or never given. Our conjecture is that women's response to this question will be largely driven by their own wedding (and hence dowry) experience. Therefore, we estimate regressions based on equations (1) and (2) but with this indicator variable on gold or cash gifts as our dependent variable. The coefficients on the interaction term are presented in Tables 5A and 5B. Columns (1) and (2) indicate that the earthquake increased the probability of giving gold or cash at the time of daughter's marriage: this is true regardless of the intensity of the earthquake. We then divide our sample into a) women who married into poorer families; and b) women whose marital households have a higher or same economic status as their natal families. Column (3) and (4) present the results for the first subsample: the estimates indicate that dowry payments in the form of gold or cash are discounted when women marry into poorer households. Results from the last two columns show that the probability of giving gold or cash during the time of daughter's marriage increases when women marry into richer households or into households of the same economic status. This suggests that changes in dowry payments could be linked to the quality of matches. Finally, the result on increased likelihood of being related to spouse prior to marriage could also be driven by dowry payments. In fact, previous studies have found a negative association between dowry levels and the probability of consanguineous marriages (Do, Iyer, and Joshi, 2013; Mobarak, Kuhn, and Peters, 2013). Thus, if an exogenous shock that negatively affects earnings and livelihood reduces the amount of dowry parents can afford, marrying off daughters to blood relatives could emerge as an attractive option since lower dowry amounts are required for these matches.

7. Conclusion

Exploiting the 2001 Gujarat earthquake as a quasi-natural experimental setting, this paper investigates the impact on the marriage market following a natural disaster in India. The empirical analysis is carried out using data from a nationally representative survey, and we rely on a double difference estimation strategy. Our results indicate a lower age at marriage for women, lowering of the probability of marrying someone from the same village, a reduced spousal educational gap, and increasing of the probability of women marrying into poorer households and being related to the spouse prior to marriage in earthquake-affected districts compared to unaffected districts. These results stand the test of a series of robustness checks. We also provide some preliminary evidence about changes in dowry payments driving our results. Thus, together with previous literature (Lahiri et al., 2001; Finlay, 2009; Nandi et al., 2018), our findings on the marriage market post-disaster help paint a comprehensive picture of the demographic effects of the Gujarat earthquake. These results are also notable because a woman's marriage prospects have important implications for her subsequent life outcomes and well-being as well as that of her children.

Our paper contributes to a growing, yet small, literature that estimates the demographic effects of natural disasters, especially on the lives of the vulnerable population. Currently, there is a lack of policies that include post-disaster rehabilitation efforts for the vulnerable and historically disadvantaged population. Further rigorous studies on the welfare implications of natural disasters are required to help policymakers formulate comprehensive disaster management policies that can help mitigate the negative shock brought on about by such unpredictable and devastating events.

References

Anderson, Siwan. 2003. "Why Dowry Payments Declined with Modernization in Europe but Are Rising in India," *The Journal of Political Economy*, 111(2): 269-310.

Allendorf, Keera, and Roshan K. Pandian. 2016. "The Decline of Arranged Marriage? Marital Change and Continuity in India," *Population and Development Review*, 42(3): 435-464.

Almond, Douglas, Lena Edlund, Hongbin Li, and Junsen Zhang. 2007. "Long-Term Effects of the 1959-1961 China Famine: Mainland China and Hong Kong," NBER Working Paper 13384.

Anukriti, S, and Shatanjaya Dasgupta. 2018. "Marriage Markets in Developing Countries," in *Oxford Handbook of Women and the Economy*, Susan L. Averett, Laura M. Argys, and Saul D. Hoffman (eds.), Oxford University Press: New York.

Brandt, Loren, Aloysius Siow, and Carl Vogel. 2016. "Large Demographic Shocks and Small Changes in the Marriage Market," *Journal of the European Economic Association*, 14(6): 1437-1468.

Caruso, Germán, and Sebastian Miller. 2015. "Long run effects and intergenerational transmission of natural disasters: A case study on the 1970 Ancash Earthquake," *Journal of Development Economics*, 117: 134-150.

Cohan, Catherine L., and Steve W. Cole. 2002. "Life Course Transitions and Natural Disaster: Marriage, Birth, and Divorce Following Hurricane Hugo," *Journal of Family Psychology*, 16(1): 14-25.

Corno, Lucia, Nicole Hildebrandt, and Alessandra Voena. 2017. "Age of Marriage, Weather Shocks, and the Direction of Marriage Payments," NBER Working Paper 23604.

Do, Quy- Toan, Sriya Iyer, and Shareen Joshi. 2013. "The Economics of Consanguineous Marriages," *Review of Economics and Statistics*, 95(3): 904-918.

Finlay, Jocelyn E., 2009. "Fertility Response to Natural Disasters: The Case of Three High Mortality Earthquakes," World Bank Policy Research Working Paper No. 4883.

Frankenberg, Elizabeth, Maria Laurito, and Duncan Thomas. 2014. "The Demography of Disasters," in *International Encyclopedia of the Social and Behavioral Sciences*, (Area 3), North Holland, Amsterdam.

Hamamatsu, Yuri, Yosuke Inoue, Chiho Watanabe, and Masahiro Umezaki. 2014. "Impact of the 2011 earthquake on marriages, births and the secondary sex ratio in Japan," *Journal of Biosocial Science*, 46(6): 830-841.

Lahiri, Ashok K., Tapas K. Sen, R. Kavita Rao, and Pratap Ranjan Jana. 2001. "Economic Consequences of Gujarat Earthquake," *Economic and Political Weekly*, 36(16): 1319-1332.

Madabhushi, S.P.G., and S.K. Haigh (2005). "The Bhuj, India Earthquake of 26th January 2001," A Field Report by EEFIT, Earthquake Engineering Field Investigation Team, London.

Mazumdar, Sumit, Papiya Guha Mazumdar, Barun Kanjilal, and Prashant Kumar Singh. 2014. "Multiple Shocks, Coping and Welfare Consequences: Natural Disasters and Health Shocks in the Indian Sundarbans," *PLoS One*, 9(8): e105427.

Mobarak, Ahmed Mushfiq, Randall Kuhn, and Christina Peters. 2013. "Consanguinity and Other Marriage Market Effects of a Wealth Shock in Bangladesh," *Demography*, 50(5): 1845-1871.

Munshi, Kaivan, and Mark Rosenzweig. 2009. "Why is Mobility in India so Low? Social Insurance, Inequality, and Growth," NBER Working Paper 14850.

Nandi, Arindam, Sumit Mazumdar, and Jere R. Behrman. 2018. "The Effect of Natural Disaster on Fertility, Birth Spacing, and Child Sex Ratio: Evidence from a Major Earthquake in India," *Journal of Population Economics*, 31(1): 267-293.

Narayan, J.P., and M.L. Sharma. 2004. "Effects of Local Geology on Damage severity during Bhuj, India Earthquake," *13th World Conference on Earthquake Engineering*, Vancouver, B.C., Canada, Paper No. 2042.

Nobles, Jenna, Elizabeth Frankenberg, Duncan Thomas. 2015. "The Effects of Mortality on Fertility: Population Dynamics After a Natural Disaster," *Demography*, 52(1): 15-38.

Roy, Sanchari. 2015. "Empowering Women? Inheritance Rights, Female Education and Dowry Payments in India," *Journal of Development Economics*, 114, 233-251.

Saadat, Mostafa. 2008. "Decline in Sex Ratio at Birth after Bam (Kerman Province, Southern Iran) Earthquake," *Journal of Biosocial Science*, 40(6): 935-937.

Shemyakina, Olga. 2009. "The marriage market and Tajik armed conflict," HiCN Working Papers 66.

Sinha, Anil K. 2001. "The Gujarat Earthquake 2001," Asian Disaster Reduction Center.

Torche, Florencia. 2011. "The Effect of Maternal Stress on Birth Outcomes: Exploiting a Natural Experiment," *Demography*, 48(4): 1473-1491.

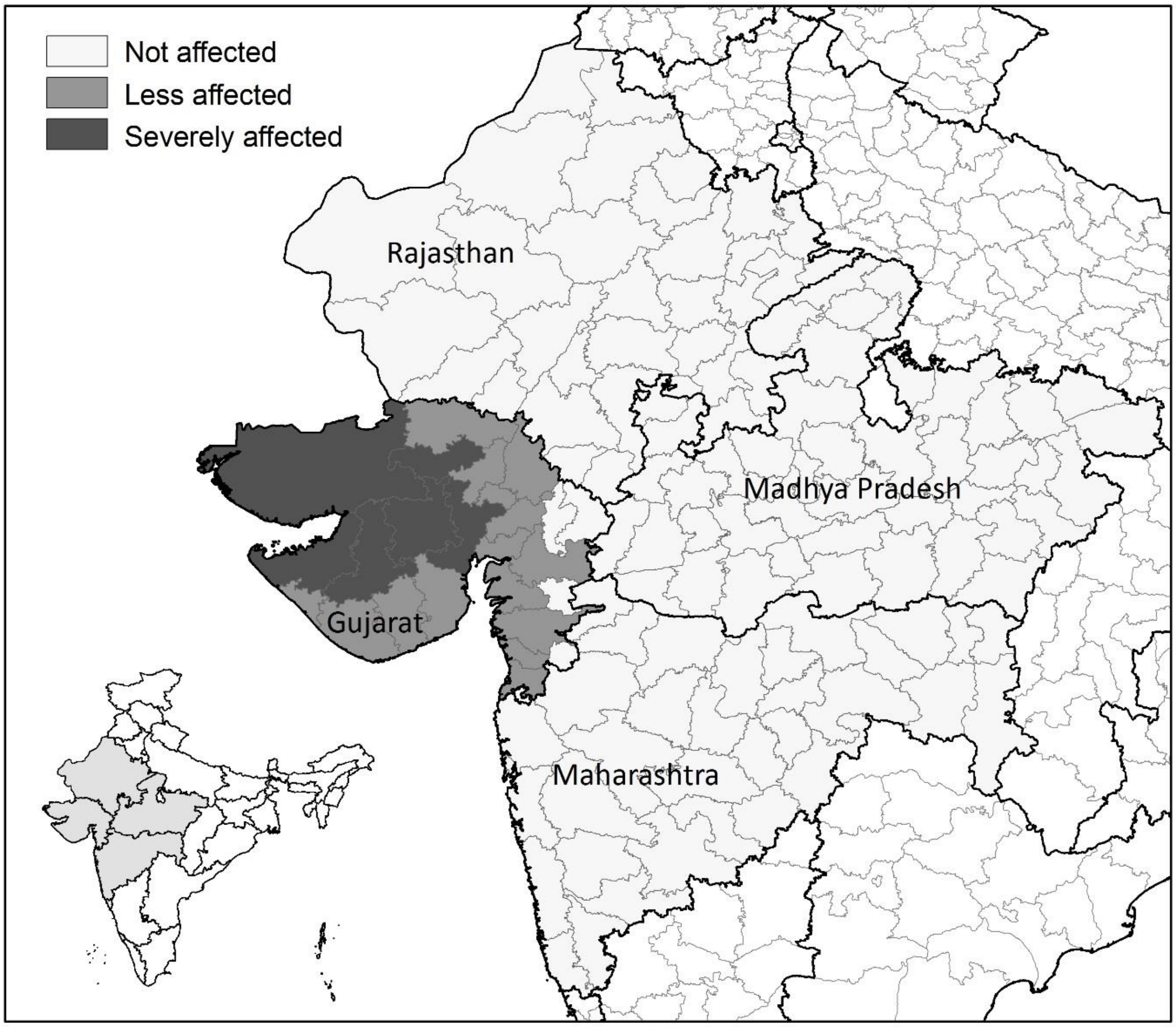
Thamarapani, Dhanuskha. 2017. "The Long-run Effects of the Yogyakarta Earthquake on Child Health Outcomes", Working Paper.

United Nations. 2015. "Global assessment report on disaster risk reduction 2015," United Nations Office for Disaster Risk Reduction.

Zhao, Zhongwei, and Anna Reimondos. 2012. "The Demography of China's 1958-61 Famine: A Closer Examination," *Population* (English edition), 67(2): 281-308.

Figure 1:

Map showing treatment (*affected*) and control (*unaffected*) districts



Notes: Based on information from Lahiri et al. (2001). *Severely affected* districts in Gujarat include Ahmedabad, Jamnagar, Kutch, Patan, Rajkot, and Surendranagar. *Less affected* districts are: Amrelli, Anand, Banaskantha, Bharuch, Bhavnagar, Gandhinagar, Junagadh, Kheda, Mehsana, Navasari, Porbandar, Sabarkantha, Surat, Vadodara, and Valsad. The four *unaffected* districts in Gujarat are Dahod, Dangs, Narmada, and Panch Mahals. This map was created using ArcGIS (version 10.3). GIS shapefiles were downloaded from https://international.ipums.org/international/

Table 1:

Summary Statistics of Treatment (Affected) and Control (Unaffected) Groups

	Treatment group		Control group	
	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)
Age of woman	24.34	3.65	23.04	3.33
Age of spouse	28.23	4.36	27.45	4.26
Education of woman	6.65	5.14	5.84	4.82
Education of spouse	8.62	4.62	8.07	4.33
Religion				
Hindu	0.86	0.35	0.87	0.34
Muslim	0.13	0.33	0.08	0.27
Other	0.02	0.13	0.05	0.21
Caste				
General	0.41	0.49	0.32	0.47
Scheduled Caste (SC)	0.11	0.32	0.21	0.41
Scheduled Tribe (ST)	0.05	0.22	0.11	0.32
Other Backward Classes (OBC)	0.42	0.49	0.36	0.48
Log of household total income	10.64	1.08	10.49	0.97
Log of monthly consumption per capita	6.75	0.59	6.40	0.64
Urban	0.51	0.50	0.33	0.47
Observations	**436**		**1,753**	

Table 2:

Descriptive Statistics of Outcome Variables by District Treatment Status

	Treatment group			Control group		
	Mean	SD	**N**	Mean	SD	**N**
	(1)	(2)	(3)	(4)	(5)	(6)
Woman's age at marriage	19.02	2.93	**436**	17.80	2.90	**1,753**
Spouse age at marriage	22.91	3.47	**436**	22.21	3.89	**1,753**
Age difference	3.89	2.50	**436**	4.41	2.53	**1,753**
Spouse from same village	0.09	0.29	**435**	0.11	0.31	**1,744**
Spouse from same caste	0.90	0.30	**435**	0.98	0.15	**1,748**
Difference in education	1.97	3.37	**436**	2.23	3.84	**1,753**
Spouse more educated	0.56	0.50	**436**	0.58	0.49	**1,753**
Spouse family worse off status	0.07	0.26	**436**	0.07	0.26	**1,753**
Self-arranged marriage	0.11	0.31	**436**	0.03	0.16	**1,750**
Parent-arranged marriage with consent	0.85	0.35	**434**	0.60	0.49	**1,738**
Parent-arranged marriage w/o consent	0.04	0.19	**434**	0.38	0.48	**1,738**
Knew spouse	0.37	0.48	**434**	0.20	0.40	**1,748**
Related to spouse	0.09	0.29	**189**	0.19	0.39	**1,376**

Table 3A:

Effect of the Earthquake on Marriage Market Outcomes

	Woman's age at marriage	Spouse age at marriage	Age difference	Spouse from same village	Spouse from same caste	Difference in education	Spouse more educated	Spouse family worse off status
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post×Affected	−0.82	−0.55	0.27	−0.065**	0.014	−1.56*	−0.25	0.13***
	(0.51)	(0.57)	(0.28)	(0.026)	(0.040)	(0.86)	(0.17)	(0.037)
Post	3.12**	2.83**	−0.30	0.051	0.027	−0.12	−0.12	−0.015
	(1.23)	(1.15)	(1.38)	(0.12)	(0.030)	(2.46)	(0.23)	(0.025)
Affected	0.19	0.66	0.47*	−0.037	−0.072**	1.33**	0.14	−0.036
	(0.53)	(0.52)	(0.27)	(0.059)	(0.034)	(0.66)	(0.14)	(0.024)
Observations	**2,189**	**2,189**	**2,189**	**2,179**	**2,183**	**2,189**	**2,189**	**2,189**
R-squared	0.276	0.278	0.127	0.054	0.045	0.109	0.045	0.036

Notes: All controls are included but not reported. State, year of marriage, and state×year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis.
*** p<0.01, ** p<0.05, * p<0.10.

Table 3B:

Effect of the Earthquake on Marriage Market Outcomes

	Self - arranged (1)	Parent arranged with consent (2)	Parent arranged w/o consent (3)	Knew spouse (4)	Related to spouse (5)
Post×Affected	−0.26***	0.28***	−0.026	0.021	0.17
	(0.031)	(0.042)	(0.023)	(0.18)	(0.11)
Post	−0.011	0.28	−0.26	0.018	0.020
	(0.011)	(0.25)	(0.25)	(0.10)	(0.028)
Affected	0.11***	−0.30***	0.18**	−0.46*	−0.16
	(0.040)	(0.10)	(0.075)	(0.26)	(0.11)
Observations	**2,186**	**2,172**	**2,172**	**2,182**	**1,565**
R-squared	0.045	0.251	0.335	0.112	0.122

Notes: All controls are included but not reported. State, year of marriage, and state×year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis.
*** p<0.01, ** p<0.05, * p<0.10.

Table 4A:
Effect on Marriage Market Outcomes by Intensity of Earthquake

	Woman's age at marriage	Spouse age at marriage	Age difference	Spouse from same village	Spouse from same caste	Difference in education	Spouse more educated	Spouse family worse off status
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post×MostAffected	−1.37**	−0.84	0.54*	−0.078*	−0.020	−1.52*	−0.15	0.12***
	(0.53)	(0.60)	(0.27)	(0.040)	(0.065)	(0.87)	(0.17)	(0.041)
Post×LessAffected	−0.42	−0.34	0.074	−0.058**	0.040	−1.58*	−0.33	0.14***
	(0.60)	(0.69)	(0.34)	(0.024)	(0.035)	(0.90)	(0.20)	(0.043)
Post	3.12**	2.82**	−0.30	0.050	0.026	−0.12	−0.12	−0.015
	(1.23)	(1.15)	(1.38)	(0.12)	(0.030)	(2.46)	(0.23)	(0.025)
MostAffected	0.38	0.65	0.27	−0.091	−0.042	1.41*	0.082	0.00016
	(0.49)	(0.60)	(0.28)	(0.059)	(0.040)	(0.72)	(0.15)	(0.021)
LessAffected	0.039	0.65	0.61**	−0.0044	−0.092**	1.28*	0.18	−0.059***
	(0.53)	(0.50)	(0.29)	(0.057)	(0.043)	(0.66)	(0.14)	(0.020)
Observations	**2,189**	**2,189**	**2,189**	**2,179**	**2,183**	**2,189**	**2,189**	**2,189**
R-squared	0.277	0.278	0.127	0.059	0.046	0.109	0.046	0.038

Notes: All controls are included but not reported. State, year of marriage, and state×year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis.
*** p<0.01, ** p<0.05, * p<0.10.

Table 4B:
Effect on Marriage Market Outcomes by Intensity of Earthquake

	Self-arranged	Parent-arranged with consent	Parent-arranged w/o consent	Knew spouse	Related to spouse
	(1)	(2)	(3)	(4)	(5)
Post×MostAffected	−0.24***	0.25***	−0.012	0.021	0.081
	(0.033)	(0.032)	(0.022)	(0.19)	(0.12)
Post×LessAffected	−0.27***	0.31***	−0.039	0.016	0.23**
	(0.037)	(0.057)	(0.032)	(0.19)	(0.090)
Post	−0.011	0.28	−0.26	0.018	0.020
	(0.011)	(0.25)	(0.25)	(0.10)	(0.028)
MostAffected	0.12**	−0.27***	0.15**	−0.56**	−0.093
	(0.059)	(0.100)	(0.074)	(0.26)	(0.12)
LessAffected	0.11**	−0.32***	0.20**	−0.40	−0.21*
	(0.043)	(0.12)	(0.085)	(0.26)	(0.10)
Observations	**2,186**	**2,172**	**2,172**	**2,182**	**1,565**
R-squared	0.046	0.251	0.336	0.118	0.124

Notes: All controls are included but not reported. State, year of marriage, and state×year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis.
*** p<0.01, ** p<0.05, * p<0.10.

Table 5A:

Mechanism: Effect on proxy for dowry payment

	Gold	Cash	Gold	Cash	Gold	Cash
	(1)	(2)	(3)	(4)	(5)	(6)
Post×Affected	0.34***	0.20***	−0.75***	0.46	0.30***	0.20***
	(0.077)	(0.068)	(0.27)	(0.36)	(0.092)	(0.053)
Observations	2,185	2,170	156	156	2,029	2,014
R-squared	0.141	0.086	0.333	0.416	0.157	0.082

Table 5B:

Mechanism: Effect on proxy for dowry payment by intensity of treatment

	Gold	Cash	Gold	Cash	Gold	Cash
	(1)	(2)	(3)	(4)	(5)	(6)
Post×MostAffected	0.34***	0.14	−0.53**	0.38	0.29***	0.13
	(0.083)	(0.083)	(0.21)	(0.41)	(0.092)	(0.10)
Post×LessAffected	0.34***	0.24***	−1.03***	0.63	0.31***	0.25***
	(0.076)	(0.082)	(0.34)	(0.57)	(0.091)	(0.058)
Observations	**2,185**	**2,170**	**156**	**156**	**2,029**	**2,014**
R-squared	0.141	0.091	0.357	0.419	0.157	0.088

Notes: All controls are included but not reported. State, year of marriage, and state×year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis. Columns (1) and (2) present results for the full sample, Columns (3) and (4) for when a woman marries into a poorer household, and finally Columns (5) and (6) present results for when a woman's marital family is of similar or better off economic status as her natal family. *** p<0.01, ** p<0.05, * p<0.10.

Appendix

Table A1: Robustness Check: Simulating False Location for Earthquake

	Rajasthan as treatment	Maharashtra as treatment	Madhya Pradesh as treatment
	(1)	(2)	(3)
Woman age at marriage	1.37	−1.37	1.65
	(1.32)	(1.32)	(1.53)
Spouse age at marriage	0.94	−0.94	1.11
	(1.26)	(1.26)	(1.81)
Age difference	−0.42	0.42	−0.54
	(1.64)	(1.64)	(1.56)
Spouse from same village	−0.018	0.018	0.40
	(0.13)	(0.13)	(0.26)
Spouse from same caste	−0.0028	0.0028	0.021
	(0.036)	(0.036)	(0.038)
Difference in education	1.38	−1.38	−1.16
	(2.62)	(2.62)	(2.63)
Spouse more educated	0.088	−0.088	0.067
	(0.26)	(0.26)	(0.36)
Spouse family worse off status	0.046	−0.046	0.017
	(0.078)	(0.078)	(0.035)
Self-arranged	0.034	−0.034	−0.016
	(0.026)	(0.026)	(0.023)
Parent arranged with consent	0.049	−0.049	−0.16
	(0.28)	(0.28)	(0.37)
Parent arranged w/o consent	−0.085	0.085	0.17
	(0.28)	(0.28)	(0.37)
Knew spouse	0.027	−0.027	0.38
	(0.12)	(0.12)	(0.25)
Related to spouse	−0.041	0.041	−0.11**
	(0.14)	(0.14)	(0.049)

Notes: Each row represents a separate regression with the dependent variable as given. Only the coefficient on the interaction term *Post* × *Affected* is reported. All controls are included but not reported. State and year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.10.

Table A2: Robustness Check: Dropping Control States One at a Time

	Dropping Rajasthan (1)	Dropping Maharashtra (2)	Dropping Madhya Pradesh (3)
Woman age at marriage	−0.82	−0.75	−0.84
	(0.52)	(0.48)	(0.52)
Spouse age at marriage	−0.58	−0.43	−0.57
	(0.58)	(0.54)	(0.58)
Age difference	0.24	0.32	0.26
	(0.29)	(0.26)	(0.28)
Spouse from same village	−0.066**	−0.059**	−0.064**
	(0.026)	(0.028)	(0.025)
Spouse from same caste	0.013	0.013	0.014
	(0.040)	(0.041)	(0.040)
Difference in education	−1.52*	−1.73**	−1.55*
	(0.86)	(0.81)	(0.85)
Spouse more educated	−0.25	−0.27	−0.26
	(0.18)	(0.17)	(0.17)
Spouse family worse off status	0.13***	0.14***	0.13***
	(0.037)	(0.036)	(0.037)
Self-arranged	−0.25***	−0.26***	−0.25***
	(0.031)	(0.029)	(0.032)
Parent arranged with consent	0.28***	0.29***	0.28***
	(0.045)	(0.037)	(0.043)
Parent arranged w/o consent	−0.027	−0.023	−0.023
	(0.025)	(0.024)	(0.023)
Knew spouse	0.021	0.027	0.027
	(0.18)	(0.17)	(0.18)
Related to spouse	0.17	0.15*	0.17
	(0.11)	(0.084)	(0.11)

Notes: Each row represents a separate regression with the dependent variable as given. Only the coefficient on the interaction term *Post* × *Affected* is reported. All controls are included but not reported. State and year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.10.

Table A3:

Testing Sensitivity of Results to Choice of Study Time Period

	1998-2003	1991-2005
	(1)	(2)
Woman age at marriage	−1.40**	−0.33
	(0.62)	(0.54)
Spouse age at marriage	−1.02	0.49
	(0.72)	(0.57)
Age difference	0.38	0.81***
	(0.27)	(0.25)
Spouse from same village	−0.11	0.0076
	(0.10)	(0.019)
Spouse from same caste	0.0020	0.028
	(0.043)	(0.031)
Difference in education	−1.08	−1.79**
	(0.95)	(0.75)
Spouse more educated	−0.24	−0.30
	(0.17)	(0.19)
Spouse family worse off status	0.095	0.12***
	(0.084)	(0.035)
Self-arranged	−0.30***	−0.21***
	(0.025)	(0.019)
Parent arranged with consent	0.32***	0.23***
	(0.042)	(0.030)
Parent arranged w/o consent	−0.025	−0.019
	(0.031)	(0.019)
Knew spouse	−0.095	0.051
	(0.27)	(0.17)
Related to spouse	0.23	0.13*
	(0.14)	(0.068)

Notes: Each row represents a separate regression with the dependent variable as given. Only the coefficient on the interaction term *Post* × *Affected* is reported. All controls are included but not reported. State and year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis. *** p < 0.01, ** p < 0.05, *p<0.10.

Table A4:

Testing Parallel Trends Assumption

	t×Affected
	(1)
Woman age at marriage	−0.031
	(0.055)
Spouse age at marriage	0.014
	(0.055)
Age difference	0.045
	(0.037)
Spouse from same village	0.0067
	(0.0059)
Spouse from same caste	0.0019
	(0.0045)
Difference in education	0.033
	(0.051)
Spouse more educated	−0.00032
	(0.0066)
Spouse family worse off status	−0.0034
	(0.0049)
Self-arranged	0.0020
	(0.0039)
Parent arranged with consent	−0.015**
	(0.0055)
Parent arranged w/o consent	0.013***
	(0.0042)
Knew spouse	0.011
	(0.0070)
Related to spouse	0.0013
	(0.0091)

Notes: Each row represents a separate regression with the dependent variable as given. All controls are included but not reported. State and year of marriage fixed effects are included. Robust-clustered standard errors are reported in parenthesis.
*** p<0.01, ** p<0.05, * p<0.10.