Too Young To Get Over: Earthquake Exposure and Educational Attainment

Pu Sun *

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Abstract

I use the exogenous exposure to the 2008 Wenchuan earthquake and the age of students at the time of the disaster to estimate its impact on educational attainment. The findings reveal that students younger than 15 years old in severely affected counties experience a reduction of 0.36 years in schooling, equivalent to a 3.7% decline. I propose one mechanism to explain this outcome: the protective role of compulsory education, which helps prevent early dropouts but ends after junior high school. In summary, this analysis provides insights into how natural disasters can disrupt human capital formation of young students.

Keywords: earthquake exposure; age; education

*Department of Economics, University of Ottawa. Email address: psun032@uottawa.ca. I acknowledge and appreciate the financial support from the China Scholarship Council (CSC) in my Ph.D research. The opinions expressed in this research are solely my own and do not reflect the views of any affiliated institutions. I am grateful for insights and suggestions from Abel Brodeur, Louis-Philippe Beland, Jonthan Créchet, Jason Garred, Sonia Laszlo, Roberto Gillmore and attendees at the annual meetings of the 59th Canadian Economics Association. All faults are mine.

Disruptive events experienced at a young age can have profound and lasting consequences. For instance, children who have faced adversities may grow a few centimetres shorter (Dercon and Porter, 2014; Van den Berg et al., 2016), earn lower wages (Chen and Zhou, 2007; De Giorgi et al., 2023), or experience reduced likelihood of completing higher education alongside increased likelihood of mental health issues (Chen et al., 2019; Laird et al., 2020). These negative outcomes are predominantly concentrated in human capital accumulation. However, it usually remains a challenge to disentangle the impact of a specific adversity from other confounding factors, such as family socioeconomic status or regional economic development. To address this concern, I focus on an exogenous natural disaster in China to investigate how a destructive event can influence children's human capital accumulation.

The 2008 Wenchuan earthquake is the most destructive earthquake in contemporary China. The unpredictability and randomness of the earthquake provide a quasi-natural experiment, allowing for the isolation of its causal impact on children's educational outcomes from other endogenous factors. After the assessment organized by local governments, counties in Sichuan can be classified as "severe counties" and "non-severe counties", based on their exposure to the earthquake. The exogenous county-level exposure to the earthquake consists of the first source of variation to estimate the earthquake effect on educational attainment. The second source stems from the age of the students. In China, the Compulsory Education Law mandates that students complete nine years of education in primary and junior high school and prohibits dropouts during this period.[1] Students typically reach the final year of compulsory education at around age 15, after which they are legally permitted to join the labour force. In this study, I use the age-15 threshold to evaluate the earthquake effect on young students' educational attainment.

By combining these two sources of variation, I employ a cohort Difference-in-Differences (DID) approach to provide empirical evidence on the long-term effects of the Wenchuan earthquake on human capital accumulation. The empirical analysis suggests that the younger cohorts in severe counties achieve, on average, 0.36 fewer years of education following the

[1]Details can be found in Article 2 of the *Compulsory Education Law of the People's Republic of China* (1986 edition). The 9-year compulsory education comprises 6 years of primary school and 3 years of junior high school.

earthquake, representing a 3.7% reduction in educational attainment. I apply an event-study design to assess the by-cohort effect, using the educational outcome of the age-15 cohort as the reference group. The findings reveal negligible differences in years of schooling between older cohorts in severe and non-severe counties, supporting the validity of the cohort DID model. In contrast, the younger cohorts in severe counties display significant reductions in years of schooling. Overall, the results consistently demonstrate the adverse impact of the earthquake on youth education.

I propose that the end of compulsory education is the main mechanism underlying the declining effect on education. After the earthquake, the younger cohorts in severe counties display a higher likelihood of discontinuing their studies. However, the Compulsory Education Law delays such dropouts. Once this legal requirement ends, these younger students often choose to enter the labour market rather than remain in high school. By contrast, older cohorts are not constrained by the law; students in high school represent a self-selected group determined to pursue further education and are therefore less sensitive to the earthquake's impact. The empirical analysis supports the argument. Compared to the younger cohorts in non-severe counties, those in severe counties have a reduced likelihood of high school graduation, while the difference in junior high school education is absent. Additional evidence suggests a higher dropout rate after compulsory education among the younger cohorts in severe counties.

My study makes several key contributions to the existing literature. First, it expands our understanding of the educational consequences of the Wenchuan earthquake by providing evidence on age-related heterogeneous effects to students. Some literature also examine the impact of the Wenchuan earthquake on education but with different emphases. For example, Lu et al. (2023) and Leng and Liu (2022) study the impact on college entrance exam scores (the exam is usually set after high school graduation); another close study is Liu and Xu (2021) which focuses on the "unexpected" benefits for female students in affected poverty counties. Beyond the literature on the Wenchuan earthquake, both Wang et al. (2017) and Tian et al. (2022) explore the impact from the 1976 Tangshan earthquake in China on educational outcomes. Paudel and Ryu (2018), Shidiqi et al. (2023), Andrabi et al. (2023) investigate the impacts from earthquakes on education graduations in Nepal, years of schooling in Indonesia, and academic test performance in Pakistan, respectively. To the best of my knowledge, this study is the first to use the age-15 threshold to discover the heterogeneous impact of the Wenchuan earthquake on education. In China, education before high school is mandatory under the Compulsory Education Law, which prevents early dropouts. After the earthquake, young students in severe counties appear more likely to enter the labour market and discontinue their education, a pattern not observed among the older cohorts. The main findings in this study also corroborate the positive effect of the law on improving educational attainment (Fang et al., 2012; Xiao et al., 2017; Liu et al., 2024).

Next, this study is closely related to the discussion of disruptive events during early life, a period when children are particularly sensitive to external shocks. Studies has documented military conflict on the tolerance for domestic violence (La Mattina and Shemyakina, 2024), parental divorce and death on educational outcomes and cognitive development (Boggess, 1998; Chen et al., 2019; De Giorgi et al., 2023; Frimmel et al., 2024), and famine on physical health and risk preferences (Porter, 2010; Dercon and Porter, 2014; Chen and Zhou, 2007; Guo et al., 2024; Chen et al., 2024). Those studies focus on the long-term consequence, while this study offers medium-term evidence of the negative impact on education.

The remaining part of this paper is organized as follows: Section 1 introduces the study background. Section 2 and 3 describes the data set and identification strategy for the empirical analysis. Section 4 resents empirical evidence of the earthquake effect on educational attainment along with robustness checks. Section 5 discusses some mechanisms to explain the main finding. And Section 6 concludes the study.

1 Background

1.1 The 2008 Wenchuan Earthquake

According to the China Earthquake Administration, the official institution responsible for earthquake-related tasks, the epicentre of the Wenchuan earthquake was located in Wenchuan County, Sichuan Province (31°N, 103.4°E). The earthquake registered a magnitude of 8.0 on the Richter scale,[2] making it one of the most destructive natural disasters in modern China. Figure A1 in Appendix shows the epicentre on the national map. The Wenchuan earthquake caused tremendous damage to nearby counties. According to official assessments, around 70,000 people died and about 18,000 were reported missing. In terms of physical destruction, about 20 million square meters of urban residential areas and approximately 7,000 school buildings were destroyed (Compilation Committee of the Sichuan Earthquake Relief Chronicle of the Wenchuan Earthquake, 2018). By September 2008, the central government estimated that the financial losses, including damages to houses, buildings, roads, and bridges, reached 845 billion RMB (≈122 billion USD), a level comparable to the destruction caused by Hurricane Katrina (Deryugina et al., 2018).[3]

As a result from the Wenchuan earthquake, over 3 million students were forced to suspend their studies. On May 18th, just 6 days after the earthquake, the provincial government dispatched teams to assess school residences, designate temporary safe locations for students, and devise plans to restart education. Their swift responses yielded positive outcomes. For instance, students in Wenchuan where the epicentre locates gradually resumed schooling in safe places staring from May 27th. In addition, the college entrance exam of that year was postponed by a month later in some counties due to the earthquake. Once the immediate threat of earthquake disappeared, school reconstruction became a priority. Local governments initiated plans to build new schools and renovate existing ones. In Aba prefecture,[4] 132 out of 182 projects in total on education were scheduled for completion between 2008 and 2009.

1.2 Chinese Education System

Historically, China has developed and managed its education system. Education has long served as a key component of state services across ancient dynasties. The current education system consists of five educational stages: pre-school education, primary education, junior secondary education, senior secondary education, and higher education. During the pre-

[2] See `https://www.cea.gov.cn/cea/dzpd/zqsd/2815725/index.html`

[3] See `http://www.npc.gov.cn/zgrdw/npc/zt/2008-09/05/content_1448390.htm`.

[4] Wenchuan county is under the administration of Aba prefecture, along with other 11 counties.

school stage, children aged 3 to 6 attend kindergarten to prepare for school life. Primary and junior secondary education form the 9-year compulsory education period, during which most students spend 6 years in primary school and 3 years in junior high school.[5] Since the enactment of the Compulsory Education Law in 1986, children aged 6 to 15 must attend school, and neither individuals nor organizations are allowed to recruit students under the age of 16.[6] In 2007, 99% of the school-age students registered in primary and junior high schools across China, signifying a 8% increase from 2002.[7]

Beyond the compulsory education, students who choose to continue their studies advance to the next stage based on their scores on the selective high school entrance exam (“zhongkao"). Senior secondary education comprises two types of schools: regular high schools and secondary vocational schools. Regular high schools prepare students for the college entrance exam (“gaokao") by offering a broad academic curriculum, while secondary vocational schools provide training tailored to meet the needs of the production and service sectors.[8] The higher education or the tertiary education in China is more flexible in types and more selective in its admissions. Generally speaking, tertiary vocational education trains students in professional expertise over a three-year program, while undergraduate education requires four years to study a chosen major systematically. After that, qualified students may then pursue graduate studies to earn master's or doctoral degrees.

2 Data

I exploit different data sources in this study to conduct an empirical analysis. The primary dataset in this study is the 2015 National 1% Population Sample Survey. In China, a national population census is conducted every 10 years, while a population sample survey is carried out every five years. The 2015 survey provides detailed information on respondents, including name, gender, age, ethnicity, education level, industry, occupation, migration status, social

[5]In some regions, students spend 5 years in primary school and 4 years in junior high school, though this is less common.

[6]The exceptions to the restriction are regulated by the state.

[7]See from the Ministry of Education: `http://www.moe.gov.cn/jyb_xwfb/xw_fbh/moe_2069/moe_2070/moe_2126/moe_1968/tnull_33105.html`.

[8]For simplicity, both types are referred to as “high schools" throughout this study.

security, marriage, childbirth, death, housing situation, and more.[9]

I use the 2015 survey rather than the 2010 census because the 2015 survey is more distant from the earthquake, allowing me to capture medium- to long-term effects. focus on respondents born between 1985 and 2000, or those aged 8 to 23 in 2008. As noted earlier, age 15 marks the endpoint of compulsory education, and the youngest cohort in the 2015 survey that has reached this point consists of individuals born in 2000. In my analysis, I retain respondents in Sichuan province at the time of the survey and focus on those with local Hukou (registered residence). This study mainly examines students of different age cohorts at the time of the earthquake. One limitation of the dataset is that it does not directly record total years of schooling. Instead, it asks for the highest degree obtained and education completion status. To overcome this limitation, I follow the methodology used in previous studies such as Wang et al. (2017); Chen et al. (2020); Liu and Xu (2021) to code the years of schooling based on respondents answers to these two questions. The details of the coding process are outlined in Appendix A.3.

Next, I follow the official classification from *The Sichuan's Relief Chronicle of the Great Wenchuan Earthquake* and divide counties in Sichuan into severe and non-severe categories. The assessment assigns each county a disaster index based on five components: average earthquake intensity (30%), deaths and missing persons (30%), number of collapsed houses (20%), geological disaster risk (10%), and resettlement per ten thousand people (10%).[10] Counties with an index above a designated threshold are classified as severe. In total, Sichuan has 10 most severe counties and 29 severe counties out of 180.[11] Figure 1 shows the geographic distribution of severe and non-severe counties. Severe counties are generally closer to the epicentre. I then match respondents' places of residence with post-earthquake severity status.

As an alternative measure, I use the county-level earthquake intensity as a continuous indicator of exposure.[12] China uses its own standard for measuring earthquake intensity,

[9]See from https://www.stats.gov.cn/zt_18555/zdtjgz/cydc/xw/202302/t20230221_1917242.htm.

[10]Resettlement refers to the evacuation of residents from high-risk areas and the temporary housing of families whose homes were destroyed. It typically occurs within the same county.

[11]There are an additional 12 severe counties in neighbouring provinces.

[12]The intensity data comes from the China Earthquake Administration. See from https://www.gov.cn/wszb/zhibo262/content_1085953.htm.

known as the China Seismic Intensity Scale (CSIS). Similar as the Modified Mercalli Intensity Scale (MMI), CSIS has 12 scales, with higher ones indicating stronger earthquake intensity. In Appendix A.4, I introduce the description of each scale and its translation to peak ground acceleration which measures the maximum intensity observed at one point. I also supplement the dataset with each county's longitude and latitude from the National Geomatics Center of China and the relief degree of land surface from You et al. (2018), which captures local elevation differences.

In Appendix, table A1 provides the summary statistics of the final sample. On average, respondents spend 10 years of schooling. About 46% of them were younger 15 years old in 2008, and 50% are male. The majority are Han Chinese (89%), slightly below the national average of 92%. Besides, over 62% hold rural Hukou status, and about 21% report living in severe counties.

3 Identification Strategy

Individual educational attainment is shaped by a variety of factors, including personal endowments, family socioeconomic status, macroeconomic conditions, and even unexpected random events (Boggess, 1998; Heckman and Rubinstein, 2001; Lundberg, 2013; Wang et al., 2017; Witteveen, 2021). Isolating the influence of one specific factor is challenging due to their interdependence. Building on these studies, I exploit two sources of exogenous variation: earthquake exposure and age in the year of earthquake.

On one hand, the Wenchuan earthquake provides an exogenous shock, as its occurrence and severity are unpredictable, generating random damage across counties in Sichuan province. On the other hand, students within in the same county may respond differently to the impact of earthquake depending on their age. In this study, I assume that the older cohorts (students above 15 years old in 2008) achieve similar educational outcomes in severe and non-severe counties, conditional on personal and family socioeconomic factors. I will discuss the validation of this assumption in 5.

The age-15 cutoff is widely accepted in the Chinese context (Wang et al., 2017; Yin et al., 2022; Huang, 2015), and the assumption above is reasonable for two reasons. First, the

Compulsory Education Law serves as a legal barrier that retains students who otherwise leave school prematurely. The implementation of the Compulsory Education Law is successful in China; By 2001, over 90% of primary school graduates advanced to junior high school.[13] Once the restriction of the law no longer applies, the external shock could motivate more graduates in junior high schools to enter the labour market instead of continuing their education, either due to loss of family assets or a pessimistic outlook on the returns to education. Second, the older cohorts, such as those already in high school or university, are more likely to continue their education. Since they are no longer bound by the compulsory education, their willingness to study can be driven either by family expectations or self-motivation.

I provide a simple mathematical framework to understand the intuition behind the identification strategy. Two representative groups of students reside in either severe counties (S) or non-severe counties (NS) at the time of the earthquake. Besides, they are further categorized as the younger cohorts (Y) or the older cohorts (O) based on the age 15 cutoff. Q denotes years of education. Given a set of controls, X, and then the earthquake effect on educational attainment can be expressed as the summation of the expected difference between students in severe counties and non-severe counties:

$$\begin{aligned}\text{Earthquake Effect} &= \overbrace{E(Q_Y^S|X) + E(Q_O^S|X)}^{\text{severe counties}} - \overbrace{(E(Q_Y^{NS}|X) + E(Q_O^{NS}|X))}^{\text{non-severe counties}} \\ &= \overbrace{E(Q_Y^S - Q_Y^{NS}|X)}^{\text{the younger cohorts}} + \overbrace{E(Q_O^S - Q_O^{NS}|X)}^{\text{the older cohorts}}\end{aligned}$$

Under the assumption, the younger cohorts (students below and including 15 years old in 2008) are the group most affected by the earthquake. The older cohorts are positioned as a counterfactual scenario where the younger cohorts would have achieved in the educational outcome if without the earthquake, or $E(Q_O^S - Q_O^{NS}|X) = 0$ (this assumption will be proved in the next section). Lin and Long (2020) express a similar argument and suggest that China's admission to the WTO reduces youth schooling as more students in high export-exposed regions opt to enter the labour market after turning 15, rather than staying in school. In this study, the earthquake effect comes from the difference in the outcome between the

[13]See from `https://www.gov.cn/gongbao/content/2001/content_60920.htm`.

younger cohorts in severe counties and non-severe counties:

$$\text{Earthquake Effect} = \overbrace{E(Q_Y^S - Q_Y^{NS}|X)}^{\text{the younger cohorts}}$$

I employ a cohort Difference-in-Differences (DID) model to estimate the impact of the Wenchuan earthquake on educational attainment among young students. This approach draws on the foundational work of Duflo (2001), which evaluates the effect of school construction on years of schooling and future earnings using a cohort DID model. In the context of China, Chen et al. (2020, 2024) adopt similar methodologies to analyze policy implications on educational outcomes during the Cultural Revolution (1966-1976). In summary, the following equation describes the cohort DID model:

$$y_{igc} = \alpha + \beta Severe_c \times \mathbb{1}(Age_g \leq 15) + x_{igc}^{'}\gamma + \eta_g + \sigma_c + \varepsilon_{igc} \tag{1}$$

where y_{igc} denotes the educational outcome for individual i belonging to cohort g in county c. Individuals are grouped by age, and g represents their ages in 2008. $Severe_c$ is a severity dummy which equals to 1 only if a county was reported as severe in the official documents. $\mathbb{1}(Age_g \leq 15)$ is an indicator function conditional on individual age in 2008. It is equal to 1 if an individual of cohort g was younger than 15 years old in 2008 (or the treatment group). x_{igc} represents a set of individual and household control variables, such as gender, ethnicity, or household conditions. Last, ε_{igc} captures unobservable and random shocks to the outcome of interest. Standard errors are clustered at the county level.

A caveat in this specification is the age effect. Since students in the youngest cohort are only 15 years old at the time of the 2015 survey, they may continue their education beyond junior high school, thus the survey does not capture their final educational attainment. I address this issue by including cohort-fixed effects, η_g, which control for differences across age cohorts and ensure that comparisons are made within same age cohorts. This effectively mitigates concerns regarding the age effect. Besides, σ_c represents the county-fixed effects that absorb other time-invariant county characteristics. The coefficient β captures the earthquake effect, measuring the difference in educational outcomes between the younger cohorts in severe counties and those in non-severe counties.

One condition for a valid causal estimation is that the older cohorts in severe and non-severe counties should be comparable to serve as a counterfactual for the younger cohorts. Table 1 presents a summary of their characteristics. Panel A details individual and household characteristics, while Panel B compares county-fixed characteristics. The last column reports the differences between the older cohorts in severe and non-severe counties conditional on prefecture and cohort, except in Panel B. From the table, the older cohorts in severe and non-severe counties are similar in terms of education level, age, gender, ethnicity, and Hukou status. The only discrepancy is in number of rooms, where the older cohorts in severe counties have more rooms in their residence. There are significant differences among earthquake-related variables in Panel B. Severe counties received stronger earthquake intensity and registered much higher earthquake-related death rates. Severe counties are 121 kilometres closer to the earthquake epicentre than non-severe counties. Overall, the criterion for the cohort-DID model to provide causal estimation is already satisfied.

Next, I propose the by-cohort DID model to understand how the earthquake would influence students of different ages. Similarly, the model is specified as follows:

$$y_{igc} = \alpha + \sum_{j=8, j\neq 15}^{20} \beta_j Severe_c \times \mathbb{1}(Age_g = j) + x_{igc}^{'}\gamma + \eta_g + \sigma_c + \varepsilon_{igc} \tag{2}$$

where j denotes the individual's age in 2008 ranging from 8 to 20. The rest settings remain the same as in Eq. (1), and standard errors are clustered at the county level. The coefficients, β_j, capture the differential impact of the earthquake on educational outcomes for cohorts residing in severe versus non-severe counties, relative to the age 15 cohort in the earthquake year. Under my assumption, I expect β_j (where $j \in [16, 20]$) will be insignificant. This is because the older cohorts usually already completed compulsory education by the time the earthquake struck, making them less susceptible to the variation in earthquake severity. The insignificance also indicates the parallel trends of the older cohorts in severe and non-severe counties, making them the counterfactual scenario for the younger cohorts in the absence of earthquake.

4 Empirical Evidence on the Earthquake Effect

The empirical analysis evaluates the impact of the Wenchuan earthquake on educational attainment in Sichuan province, with a particular focus on changes in years of schooling to estimate the earthquake effect. Before presenting the regression results, figure 2 depicts trends in average years of schooling. The horizontal axis indicates birth cohorts, while the vertical axis represents the cohort-average years of schooling. A vertical dashed line marks the birth year, 1993. Students born in this year would reach 15 years old when the earthquake occurred. Students from severe counties generally demonstrate higher average years of schooling compared to those in non-severe counties. However, a declining trend in years of schooling is evident among the younger cohorts, likely reflecting the age effect: these students may still be completing compulsory education or pursuing studies in high school or university. The gap between the younger cohorts in severe and non-severe counties appears narrower but requires further investigation. The subsequent analysis employs regression-based methods to provide empirical evidence on the causal relationship between the Wenchuan earthquake and educational attainment.

4.1 Baseline Results

The primary assumption of the empirical framework is that the older cohorts are statistically similar across severe and non-severe counties. Therefore, any changes in the educational attainment of the younger cohorts in severe counties can be attributed solely to the earthquake. Table 2 reports the estimates from a standard cohort Difference-in-Differences (DID) model. Column (1) shows a significantly negative coefficient of -0.353, indicating that the younger cohorts in severe counties attained fewer years of schooling due to the earthquake. Including individual and household-level control variables in columns (2) and (3) does not alter the result, as the estimates remain negative and their sizes are close.

Using the specification in column (3), the reduction represents approximately 3.78% of the average 9.86 years of schooling observed for the younger cohorts in non-severe counties. Compared to the literature, the size of this decline can offset about half of the educational gains attributed to school construction in Duflo (2001) and exceed the adverse effect of

China's access to the WTO on educational attainment documented in Lin and Long (2020). This comparison highlights the substantial impact of the Wenchuan earthquake on education.

$\hat{\beta}$ here should be considered as an conservative estimation of the negative impact on educational attainment. First, although I have excluded migrated individuals from the sample, migration may still occur between the earthquake year and the survey year, particularly in severe counties. Better-educated students are likely relocate for education or employment, which would result in an underestimation of the negative impact on the younger cohorts remaining in severe counties. In robustness checks, I will fix this issue and test the consistency of the baseline results. Second, the older cohorts in severe counties could also be negatively affected by the earthquake. For instance, some might be still in junior high school when the earthquake struck because they have repeated grades before. Others may choose not to pursue higher education, such as university, due to the earthquake. This will be discussed in robustness checks as well. Taken together, the earthquake effect might be more powerful than the baseline estimation.

Next, I present the by-cohort results from the Wenchuan earthquake on youth education, using the specification of Eq. (2). Figure 3 plots the estimates with their 95% confidence intervals when considering all controls.[14] Each dot represents the estimated coefficient of the interaction term between the severe dummy and the age dummy in 2008. Since β_{15} is omitted due to multicollinearity, any cohort-level difference in the outcome between severe and non-severe counties has already been adjusted to the difference of the age 15 cohort. One advantage of analyzing the by-cohort effect is to understand the impact of the Wenchuan earthquake on students across different ages. From the figure, those insignificant estimates for students above the age of 15 indicate the Wenchuan earthquake barely influences educational attainment of the older cohorts, which reinforces the parallel trends assumption. By comparison, the younger cohorts in severe counties attain significantly fewer years of education, which is aligned with the cohort-DID results described above.

[14] In Appendix, table A2 documents the detailed estimations.

4.2 Heterogeneity Tests

In the last section, I find the significantly negative effect on educational attainment of a representative respondent from the younger cohorts in severe counties. However, such a reduction in years of education might vary in subsamples based on respondents' characteristics. Table A3 presents three heterogeneity tests when dividing the sample by gender, residence location (in urban or rural), and family size.

I estimate the earthquake effect separately for male and female subsamples in columns (1) and (2). The estimates are slightly different in magnitude, but a bootstrap test shows this difference is not statistically significant from zero.[15] The gender-based heterogeneous effect on education does not exist. This finding contrasts with Liu and Xu (2021), which report an unexpected positive effect of the Wenchuan earthquake on female education in poor counties, as well as Bertrand and Pan (2013); Autor et al. (2019), which suggest male students are more vulnerable to adverse environments.

The second heterogeneity test divides the sample by rural and urban residence. Rural students might face greater negative impacts due to limited access to educational resources. However, the results in columns (3) and (4) record similar estimates of the earthquake effect. A further bootstrap test also indicates no significant difference between the two subgroups.

In the final heterogeneity test, I examine whether family size moderates the earthquake effect. I define a large family as one with more family members than the sample median. Columns (5) and (6) report that the affected students from large families attain fewer years of education, consistent with Booth and Kee (2009); Tan (2019). However, the p-value from the bootstrap test again confirms that the gap is not statistically significant.

4.3 Robustness Checks

In this section, I conduct a battery of robustness checks for the baseline results to deal with any threats to the identification strategy.

[15]The p-values of difference tests in this table are all obtained after 1,000 repetitions.

4.3.1 Migration

The identification assumes that respondents' counties of residence when the survey was conducted in 2015 match their counties of residence in 2008 when the earthquake occurred, thereby overlooking migration during the 7 years. In the 2015 survey, respondents also report their permanent residence from 5 years earlier. Then I define migrants as those who indicate a change in county of residence during that period, accounting for less than 8% of the sample. Although this method does not capture migration between 2008 and 2010, it represents a significant improvement over the original assumption.

First, I remove migrants from the sample and re-estimate the specification in Eq. (1), which leads to a small loss of observations. Still, table 3 columns (1) and (2) document similar estimates as the baseline results both in magnitude and significance.

Alternatively, I match respondents' reported residence from 5 years ago with the county severity status. Compared with the first method, this procedure does not change the sample size, while some observations could be assigned with a different severity dummy. Columns (3) and (4) present the estimates under this revised specification.[16] The estimates suggest a significant reduction of 3.29-3.42% in years of schooling, slightly lower than the baseline estimation.

Last, I test whether having lived in severe counties after the earthquake increases the likelihood of migration between 2010 and 2015. In columns (5) and (6), the outcome variable is then replaced by a binary indicator of migration. The results indicate that respondents in severe counties 5 years ago are not significantly different from those in non-severe counties when it comes to migration decisions.[17] Overall, those robustness checks in this part imply that the post-disaster migration does not pose a major threat on the identification strategy.

In Appendix A.5, I provide a theoretical model to explain the low-scale migration in severe counties after the Wenchuan earthquake. One reason is the administrative cost incurred by the migration, while the another is the compensations offered by local governments.

[16] Note that "county" in the county-fixed effects refers to the county of residence five years earlier. It is the same in columns (5) and (6) as well.

[17] The county fixed effects are dropped not to absorb the severity dummy. Besides, the controls only include personal characteristics and exclude household conditions which were reported in 2015.

4.3.2 Alternative Timings

In table 2 column (4), I revise the definition of the older cohorts by excluding individuals older than 18 in 2008. This restricted control group enhances comparability, as the new older cohorts are only slightly older than the younger cohorts. Both of them were exposed to a similar educational environment and are unlikely to have been affected by major policy changes. As expected, the estimate remains consistent with the baseline result, although the magnitude implies a larger decline in educational attainment among younger cohorts in severe counties.

Next, students may complete compulsory education at ages earlier or later than 15, which introduces noises into the assumption that students finish at 15. To address this, I exclude individuals aged 14 to 17 in the sample in column (5). Likewise, the estimate remains significantly negative and shows a larger decline in education outcomes.

I then conduct placebo tests by assuming the earthquake occurred in 2003, 2004, or 2005. In these cases, the younger cohorts are defined as students under age 15 in each respective year. Columns (6) to (8) report insignificant estimates, suggesting that the timing of the earthquake is crucial for identifying its effect on education. These results support the validity of the baseline findings.

4.3.3 Alternative Treatment

Another concern is that the treatment dummy ("severe county") may capture endogenous factors that correlate with educational outcomes. For instance, the evaluation of geological disaster risk, contributing 10% to the disaster index, may not be entirely objective and could be influenced by subjective judgment. To address this concern and complement the baseline results, I present the estimates in table 4 by altering the treatment dummy to three continuous variables: earthquake-related death rate, earthquake intensity scale, and the linear distance to the epicentre. To account for counties with no recorded deaths, I modify the death rate by taking the natural log of 0.0001 plus the death rate per ten thousand persons.

Columns (1) and (2) report significantly negative estimates when using the earthquake-related death rate, with or without control variables. This indicates that the younger cohorts in counties with higher death rates from the earthquake tend to have fewer years of schooling, highlighting the adverse effect of the earthquake on education. This claim is also supported in the negative estimates in columns (3) and (4) when using earthquake intensity scale. The stronger the younger cohorts' exposure to earthquake is, the larger the reduction in educational attainment will be.

The third specification replaces the treatment with the linear distance to the epicentre, shown in columns (5) and (6). The estimates are significantly positive, suggesting that the younger cohorts in counties further from the epicentre attain more years of schooling. The different signs are consistent with the expectation that counties closer to the epicentre experience more severe impacts.

4.3.4 Alternative Specifications

I conduct several additional robustness checks to further validate the main findings, as presented in table A4. In column (1), I redefine the cohort cutoff by using age 18 instead of 15. The estimate becomes insignificant, suggesting that high school students are less affected by the earthquake than students in primary or junior high school. This supports the view that the negative effect on education is concentrated among younger students (Dercon and Porter, 2014; Wang et al., 2017; Shidiqi et al., 2023; Huang and Dong, 2025).

In column (2), I re-estimate the model using the inverse of county-level distance to the epicentre as weights. This approach gives more weight to counties closer to the epicentre and better reflects the reality of disaster exposure. The estimate is only slightly larger than the baseline size, reinforcing the robustness of the main results.

In column (3), I cluster standard errors at the prefecture level. Since a prefecture usually consists of several county-level units, this change reduces the number of clusters in estimation, which might enlarge the standard errors. The estimate is consistent with the baseline one, despite slightly larger standard errors.

In column (4), I exclude individuals living in county-level city districts. Urban districts often receive more public investment in education, thus removing them may improve estimation precision. The estimate not only remains significant and but also suggests a larger effect for younger cohorts in non-district severe counties who prove to be even more vulnerable than the affected in city districts .

In column (5), I estimate a Poisson regression model (Correia et al., 2020), as the education variable is a count measure. The results are consistent with the baseline and further support the main conclusion. Together, these robustness checks reinforce the credibility of the baseline findings.

4.3.5 Alternative Control Groups

The Wenchuan earthquake also caused damage in several counties across neighbouring provinces.[18] However, the seismic impact weakened significantly beyond a certain distance from the epicentre. To strengthen the identification strategy, I supplement the sample with respondents from the same age cohorts in Hubei province.[19] Two reasons support this choice. First, Hubei was minimally affected by the earthquake and does not border Sichuan (see figure A1). Second, Hubei and Sichuan had comparable economic conditions at the time. In 2007, Hubei's GDP per capita was 16,593 RMB, while Sichuan's was 12,963 RMB. Respondents from Hubei therefore serve as a pure control group, or the "never treated" group (Wang et al., 2017).

Table A5 records the estimates after integrating Hubei respondents into the sample. Columns (1) to (3) report significantly negative estimates, further confirming the robustness of the earthquake's negative effect on educational attainment. The results are stable across specifications, including those with control variables and province-cohort fixed effects. In column (3), the estimate suggests that the younger cohorts in severe counties attain 0.35 fewer years of schooling, or a 3.37% reduction relative to the mean of 10.40 in non-severe counties. The effect is consistent with the baseline estimate in column (4). Figure A3 depicts the by-cohort effect after adding Hubei respondents. The revised estimates with their 95% confidence intervals are nearly identical to the baseline.

An alternative approach to constructing a pure control group is to include respondents aged 24 and 25 whose education was likely completed in 2008. Thus, the earthquake would

[18] For example, 12 counties from Gansu and Shaanxi were also severely destroyed.

[19] Hubei lies east of Sichuan, with a distance of over 1,100 kilometres between their provincial capitals.

not have influenced their schooling decisions. Table A6 presents the estimates after including this older cohorts. The results again indicate a reduction in years of schooling among the younger cohorts in severe counties. In column (3), when comparing the younger cohorts with the unaffected group, the estimated effect is 32.5% larger than that in column (2). This suggests that the baseline estimate may represent a lower bound of the earthquake's true impact. Figure A4 shows the by-cohort effect with the additional control group, further supporting the baseline findings.

5 Discussion

In this section, I explore potential mechanisms behind the decline in educational attainment following the Wenchuan earthquake. One possibility is that the disaster leads to school repetition, which in turns reduces years of education. Following the similar approach in Shidiqi et al. (2023), I test this in table A7. The estimates are insignificant and not sensitive to controls, suggesting that school repetition is unlikely to be a key factor behind the observed decline in educational attainment.

Another argument claims that the greater financial loss in severe counties reduces affordability of education. This claim holds some validity, but it fails to explain why the older cohorts in severe counties achieve similar years of schooling as those in non-severe counties, especially considering that the former are also more likely to suffer from financial loss.

Instead, I intend to explore the mechanisms from the protective role of the Compulsory Education Law. In China, age 15 marks as a critical threshold because students typically finish the 9-year education by that age. This threshold distinguishes the older cohorts from the younger ones in this study. The Compulsory Education Law prevents young students from dropping out early, regardless of personal preferences. The students only leave school after fulfilling the mandatory requirement. In contrast, education beyond junior high school is optional. The older cohorts face no such legal restriction and may enter the labour market if they choose not to pursue further education. Consequently, those who continue their education among the older cohorts form a self-selected group that is less vulnerable to external shocks compared with the younger cohorts.

5.1 Different Educational Stages

I begin by examining whether the Wenchuan earthquake affects school completion at different stages for the younger cohorts. I use the framework of Eq. (1), replacing the original outcome with binary indicators for the completion of various education levels.

Table 5 reports the corresponding estimates. Column (1) uses a binary indicator equal to 1 if a respondent has completed or is currently enrolled in tertiary education. A key limitation is that students born after 1997 were often still in high school at the time of survey. It remains unclear whether they will receive tertiary education years later. To partly mitigate this issue, I restrict the sample to individuals with at least 9 years of schooling.[20] The estimate only suggests a moderate decline in tertiary education attainment for the younger cohorts in severe counties, but the result is not statistically significant.

Column (2) assesses the earthquake effect on high school graduation, while column (3) expands the definition of high school education to include current high school students. Besides, the sample remains restricted to individuals with at least 9 years of schooling. The estimates suggest that younger cohorts in severe counties are 6.3% less likely to graduate from high school, and 7% less likely to pursue high school education under the broader definition, compared to their peers in non-severe counties. These results suggest that many students in severe counties end their education once compulsory schooling is complete. Figure 4 shows cohort trends in high school attendance under the broader definition. Among older cohorts, students in severe counties have higher high school participation rates than those in non-severe counties. However, this advantage disappears for cohorts born after 1993, except for the outlier 1998 birth cohort. The figure suggests that fewer students in severe counties continue their education beyond the compulsory level.

To further supplement this argument, column (4) tests whether junior high school graduation could be affected by the Wenchuan earthquake. The estimate is insignificant, reinforcing the protective role of China's compulsory education law.

[20] Alternatively, the younger cohorts can be limited to those born between 1993 and 1997, as they are more likely to have completed high school if they could. The result remains similar.

5.2 After Compulsory Education

The earlier analysis of different education stages suggests that fewer students from the younger cohorts in severe counties continue to high school after completing compulsory education. This section provides direct empirical evidence for that pattern.

In table A8 column (1), I investigate whether the earthquake increases the likelihood of dropout after the 9-year compulsory education. I restrict the sample to respondents with at least 9 years of schooling as well, as they have to decide between continuing education and entering the labour market. Consistent with the previous analysis, the younger cohorts in severe counties display a higher propensity to dropping out after compulsory education than their peers in non-severe counties. Figure A5 shows trends in dropout rates after compulsory education. Among older cohorts, respondents from severe counties have significantly lower dropout rates than those from non-severe counties. In contrast, younger cohorts show no difference across county types. The narrowing gap supports the conclusion that more students in severe counties leave school after completing compulsory education.

Column (2) further examines the potential effect on marriage. The sample is limited to respondents who had reached the legal ages by the survey year.[21] Although the estimate is only marginally significant, it suggests that the younger cohorts in severe counties are about 5.4% more likely to get married, which may interfere continued education (Field and Ambrus, 2008; Chari et al., 2017). However, the result in column (3) shows no difference in the number of children, ruling out child-rearing as an explanation for disrupted education.

Overall, these findings support that the earthquakes negative impact on education is most pronounced at the high school level among younger cohorts. The Compulsory Education Law has effectively prevented dropouts prior to high school. However, once the legal requirement ends, students in severe counties show a higher likelihood of discontinuing their education.

6 Conclusion

Experiencing disruptive events during childhood can have negative consequences, yet isolating their specific effects from other socioeconomic factors poses a significant challenge. In

[21] In China, the legal ages of marriage are 20 for women and 22 for men.

this study, I exploit the exogenous exposure to the 2008 Wenchuan earthquake to examine how such a large-scale disruption influences educational attainment.

I employ a cohort Difference-in-Differences (DID) model that exploits variation in both earthquake exposure and student age at the time of the disaster. The leading hypothesis is that students younger than 15 years old at the time of the earthquake , typically in the last year of compulsory education, respond differently to the earthquake compared to the older cohorts.

The result reveals that the younger cohorts (15 years old and below) in severe counties attain 0.36 fewer years of schooling relative to their counterparts in non-severe counties, a reduction of 3.7% in educational attainment. In contrast, the older cohorts display no significant differences in schooling between severe and non-severe counties. These main findings remain consistent under a battery of robustness checks.

The completion of compulsory education offers a plausible explanation. After the earthquake, more junior high school gradates in severe counties choose not to receive education at high school. In contrast, the older cohorts who continue their education are a self-selected group that is less affected by the earthquake. Overall, this study thus provides novel evidence on the impact of an early-life disruptive event on human capital accumulation.

References

Andrabi, T., Daniels, B., and Das, J. (2023). Human capital accumulation and disasters: Evidence from the Pakistan earthquake of 2005. *Journal of Human Resources*, 58(4):1057–1096.

Autor, D., Figlio, D., Karbownik, K., Roth, J., and Wasserman, M. (2019). Family disadvantage and the gender gap in behavioral and educational outcomes. *American Economic Journal: Applied Economics*, 11(3):338–381.

Bertrand, M. and Pan, J. (2013). The trouble with boys: Social influences and the gender gap in disruptive behavior. *American economic journal: applied economics*, 5(1):32–64.

Boggess, S. (1998). Family structure, economic status, and educational attainment. *Journal of Population Economics*, 11:205–222.

Booth, A. L. and Kee, H. J. (2009). Birth order matters: the effect of family size and birth order on educational attainment. *Journal of population economics*, 22(2):367–397.

Boustan, L. P., Kahn, M. E., and Rhode, P. W. (2012). Moving to higher ground: Migration response to natural disasters in the early twentieth century. *American Economic Review*, 102(3):238–244.

Chari, A. V., Heath, R., Maertens, A., and Fatima, F. (2017). The causal effect of maternal age at marriage on child wellbeing: Evidence from India. *Journal of Development Economics*, 127:42–55.

Chen, Y., Fan, Z., Gu, X., and Zhou, L.-A. (2020). Arrival of young talent: The send-down movement and rural education in China. *American Economic Review*, 110(11):3393–3430.

Chen, Y., Fan, Z., Gu, X., and Zhou, L.-A. (2024). Evaluating the effects of a massive rural school expansion in pre-reform China. *Journal of Population Economics*, 37(1):28.

Chen, Y. and Zhou, L.-A. (2007). The long-term health and economic consequences of the 1959–1961 famine in China. *Journal of Health Economics*, 26(4):659–681.

Chen, Y.-C., Fan, E., and Liu, J.-T. (2019). Understanding the mechanisms of parental divorce effects on childs higher education. Working Paper 25886, National Bureau of Economic Research.

Compilation Committee of the Sichuan Earthquake Relief Chronicle of the Wenchuan Earthquake (2018). *The Sichuan's Relief Chronicle of the Great Wenchuan Earthquake (in translation)*. Sichuan People's Publishing House.

Correia, S., Guimarães, P., and Zylkin, T. (2020). Fast Poisson estimation with high-dimensional fixed effects. *The Stata Journal*, 20(1):95–115.

De Giorgi, G., Severgnini, B., and Prado, M. (2023). The Long Goodbye: the Economic Effects of Early Parental Death. Working Paper 18475, CEPR Discussion Papers.

Dercon, S. and Porter, C. (2014). Live aid revisited: long-term impacts of the 1984 Ethiopian famine on children. *Journal of the European Economic Association*, 12(4):927–948.

Deryugina, T., Kawano, L., and Levitt, S. (2018). The economic impact of Hurricane Katrina on its victims: Evidence from individual tax returns. *American Economic Journal: Applied Economics*, 10(2):202–233.

Duflo, E. (2001). Schooling and labor market consequences of school construction in Indonesia: Evidence from an unusual policy experiment. *American Economic Review*, 91(4):795–813.

Fang, H., Eggleston, K. N., Rizzo, J. A., Rozelle, S., and Zeckhauser, R. J. (2012). The returns to education in China: Evidence from the 1986 compulsory education law. Technical report, National Bureau of Economic Research.

Field, E. and Ambrus, A. (2008). Early marriage, age of menarche, and female schooling attainment in Bangladesh. *Journal of political Economy*, 116(5):881–930.

Frimmel, W., Halla, M., and Winter-Ebmer, R. (2024). How does parental divorce affect childrens long-term outcomes? *Journal of Public Economics*, 239:105201.

Gallagher, J. and Hartley, D. (2017). Household finance after a natural disaster: The case of hurricane katrina. *American Economic Journal: Economic Policy*, 9(3):199–228.

Gröger, A. and Zylberberg, Y. (2016). Internal labor migration as a shock coping strategy: Evidence from a typhoon. *American Economic Journal: Applied Economics*, 8(2):123–153.

Guo, S., Gao, N., and Liang, P. (2024). Winter is coming: Early-life experiences and politicians decisions. *The Economic Journal*, 134(657):295–321.

Heckman, J. J. and Rubinstein, Y. (2001). The importance of noncognitive skills: Lessons from the GED testing program. *American Economic Review*, 91(2):145–149.

Huang, W. (2015). Understanding the effects of education on health: evidence from china.

Huang, Z. and Dong, X. (2025). When the levee breaks: The impact of floods on educational outcomes in China. *Journal of Development Economics*, 174:103450.

La Mattina, G. and Shemyakina, O. N. (2024). Growing up amid armed conflict: Women's attitudes toward domestic violence. *Journal of Comparative Economics*.

Laird, J., Nielsen, N. F., and Nielsen, T. H. (2020). Differential Effects of the Timing of Divorce on Childrens Outcomes: Evidence from Denmark. Working Paper No. 11/20, CEBI Working Paper.

Leng, X. and Liu, X. (2022). Better School, Better Score? Evidence From a Chinese Earthquake-Stricken County. *The BE Journal of Economic Analysis & Policy*, 22(3):409–437.

Lin, F. and Long, C. X. (2020). The impact of globalization on youth education: Empirical evidence from China's WTO accession. *Journal of Economic Behavior & Organization*, 178:820–839.

Liu, S., Zhang, X., and Zhou, S. (2024). The compulsory education law, female education and fertility: An empirical study in China. *Journal of Comparative Economics*.

Liu, X. and Xu, Y. (2021). Unexpected opportunity for girls: Earthquake, disaster relief and female education in China's poor counties. *China Economic Review*, 70:101701.

Lu, W., Yang, P., Zheng, S., and Zhou, S. (2023). Natural disasters and high-stakes exam performance: Evidence from the 2008 Wenchuan earthquake. *China Economic Review*, 77:101899.

Lundberg, S. (2013). The college type: Personality and educational inequality. *Journal of Labor Economics*, 31(3):421–441.

Noy, I. and Vu, T. B. (2010). The economics of natural disasters in a developing country: The case of Vietnam. *Journal of Asian Economics*, 21(4):345–354.

Paudel, J. and Ryu, H. (2018). Natural disasters and human capital: The case of Nepals earthquake. *World Development*, 111:1–12.

Porter, C. (2010). Safety nets or investment in the future: Does food aid have any long-term impact on children's growth? *Journal of International Development*, 22(8):1134–1145.

Shidiqi, K.-A., Di Paolo, A., and Choi, Á. (2023). Earthquake exposure and schooling: Impacts and mechanisms. *Economics of Education Review*, 94:102397.

Tan, H. R. (2019). More Is Less?: The Impact of Family Size on Education Outcomes in the United States, 1850–1940. *Journal of Human Resources*, 54(4):1154–1181.

Tian, X., Gong, J., and Zhai, Z. (2022). Natural disasters and human capital accumulation: Evidence from the 1976 Tangshan earthquake. *Economics of Education Review*, 90:102304.

Van den Berg, G. J., Pinger, P. R., and Schoch, J. (2016). Instrumental variable estimation of the causal effect of hunger early in life on health later in life. *The Economic Journal*, 126(591):465–506.

Wang, J., Yang, J., and Li, B. (2017). Pain of disasters: The educational cost of exogenous shocks evidence from Tangshan Earthquake in 1976. *China Economic Review*, 46:27–49.

Witteveen, D. (2021). Encouraged or discouraged? The effect of adverse macroeconomic conditions on school leaving and reentry. *Sociology of Education*, 94(2):103–123.

Xiao, Y., Li, L., and Zhao, L. (2017). Education on the cheap: The long-run effects of a free compulsory education reform in rural china. *Journal of Comparative Economics*, 45(3):544–562.

Yin, Z., Yan, Y., Chen, X., and Liu, T. (2022). Earthquake and household energy consumption –Evidence from the Wenchuan earthquake in China. *Energy Economics*, 111:106061.

You, Z., Feng, Z., and Yang, Y. (2018). Relief degree of land surface dataset of China (1 km). *Journal of Global Change Data & Discovery*, 2(2):151–155.

Tables

Table 1: Summary Statistics of the Older Cohorts

	(1) Non-Severe Counties	(2) Severe Counties	(3) Conditional Difference
Panel A: Individual and Household Characteristics			
Years of Schooling	9.886	10.864	-0.303
	(3.276)	(2.984)	(0.307)
Age in 2008	19.484	19.651	-0.046
	(2.203)	(2.231)	(0.116)
Male	0.517	0.502	0.020
	(0.500)	(0.500)	(0.026)
Han People	0.896	0.925	-0.035
	(0.305)	(0.263)	(0.023)
Rural Hukou	0.646	0.710	-0.111
	(0.478)	(0.454)	(0.067)
Number of Rooms	4.520	4.890	-0.939**
	(2.465)	(2.778)	(0.473)
House Area (m^2)	138.608	138.102	-10.645
	(69.720)	(72.112)	(10.288)
Household Size	4.568	4.080	0.305
	(1.669)	(1.425)	(0.187)
Car Ownership	0.142	0.212	-0.006
	(0.349)	(0.409)	(0.038)
Observations	5292	1483	
Panel B: County-Fixed Characteristics			
Share of Earthquake Intensity Scale > 5	0.679	1	-0.321**
	(0.469)	(0.00)	(0.076)
Death Rate (/10k persons)	0.260	132.091	-131.8***
	(1.199)	(407.683)	(34.956)
Distance to Epicentre (km)	273.096	151.812	121.3***
	(120.053)	(87.641)	(20.912)
Altitude Difference	2.020	2.446	-0.426
	(1.911)	(1.813)	(0.347)
Observations	134	38	

Note: This table documents the statistical description of the older cohorts (above 15 years old in 2008) between severe and non-severe counties in Sichuan province. In the last column, the mean difference of each variable is calculated conditional on the cohort- and prefecture-fixed effects (except those in Panel B), while *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

Table 2: The Earthquake Effect on Years of Schooling to Young Students

Dependent Variable: Years of Schooling	Age in 2008: 8-23			Age in 2008: 8-18	Age in 2008: 8-13 and 18-23	If Earthquake was in 2003/2004/2005		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severe × $\mathbb{1}(\text{Age} \leq 15)$	-0.353**	-0.355**	-0.363***	-0.476***	-0.481***			
	(0.139)	(0.137)	(0.137)	(0.167)	(0.153)			
Severe × $\mathbb{1}(\text{Age} \leq 15 \text{ in } 2003)$						-0.175		
						(0.163)		
Severe × $\mathbb{1}(\text{Age} \leq 15 \text{ in } 2004)$							-0.178	
							(0.142)	
Severe × $\mathbb{1}(\text{Age} \leq 15 \text{ in } 2005)$								-0.169
								(0.141)
Mean of Non-Severe Counties	9.860	9.860	9.860	9.923	9.730	9.860	9.860	9.860
Personal Controls		✓	✓	✓	✓	✓	✓	✓
Household Controls			✓	✓	✓	✓	✓	✓
Cohort Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Observations	12536	12536	12536	8207	9415	12536	12536	12536

Note: The dependent variable is the coded years of schooling at the individual level. The whole sample is used in regressions in columns (1)-(3), but they differ in personal or household controls. In column (4), respondents aged above 18 are excluded. In column (5), respondents aged between 14 and 17 are excluded. Columns (6)-(9) are placebo tests if assuming that the earthquake occurred in 2003/2004/2005. Each column controls for cohort- and county-fixed effects. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

Table 3: Robustness Check and Migration Decision

Dependent Variable:	Years of Schooling				Migration	
	Exclude Migrants		Severity Before Migration			
	(1)	(2)	(3)	(4)	(5)	(6)
Severe × $\mathbb{1}(\text{Age} \leq 15)$	-0.355**	-0.361***				
	(0.140)	(0.137)				
Severe County 5 Yeas Ago × $\mathbb{1}(\text{Age} \leq 15)$			-0.325**	-0.337**		
			(0.131)	(0.129)		
Severe County 5 Years ago					-0.006	-0.008
					(0.010)	(0.009)
Mean of Non-Severe Counties	9.795	9.795	9.868	9.868	0.055	0.055
Controls		✓		✓		✓
Cohort Fixed Effects	✓	✓	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓		
Observations	11557	11557	12536	12536	12536	12536

Note: The dependent variable is individual years of schooling from columns (1)-(4). Migrants are excluded in columns (1) and (2); the severity status is changed as the status of county where respondents resided five years ago in columns (3) and (4). In columns (5) and (6), the dependent variable is the binary indicator of migration. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

Table 4: Alternative Measures of Earthquake Exposure

Dependent Variable: Years of Schooling	Death Rate		Earthquake Intensity		Distance to Epicentre	
	(1)	(2)	(3)	(4)	(5)	(6)
ln(0.0001+Death Rate) $\times$ $\mathbb{1}$(Age $\leq$ 15)	-0.042***	-0.044***				
	(0.015)	(0.014)				
ln(Distance to Epicentre) $\times$ $\mathbb{1}$(Age $\leq$ 15)			0.445***	0.446***		
			(0.104)	(0.099)		
Earthquake Intensity Scale=6 $\times$ $\mathbb{1}$(Age $\leq$ 15)=1					-0.558***	-0.629***
					(0.196)	(0.191)
Earthquake Intensity Scale=7 $\times$ $\mathbb{1}$(Age $\leq$ 15)=1					-0.856***	-0.898***
					(0.240)	(0.235)
Earthquake Intensity Scale=8 $\times$ $\mathbb{1}$(Age $\leq$ 15)=1					-1.364***	-1.246***
					(0.257)	(0.258)
Earthquake Intensity Scale=9 $\times$ $\mathbb{1}$(Age $\leq$ 15)=1					-0.962***	-0.984***
					(0.269)	(0.267)
Earthquake Intensity Scale=10 $\times$ $\mathbb{1}$(Age $\leq$ 15)=1					-0.043	-0.395
					(0.471)	(0.354)
Earthquake Intensity Scale=11 $\times$ $\mathbb{1}$(Age $\leq$ 15)=1					-1.150***	-1.267***
					(0.257)	(0.276)
Mean of Non-Severe Counties	9.860	9.860	9.860	9.860	9.860	9.860
Controls		✓		✓		✓
Cohort Fixed Effects	✓	✓	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓	✓	✓
Observations	12536	12536	12536	12536	12536	12536

Note: This table presents the estimates from the robustness checks, where the dependent variable is individual years of schooling. Columns (1) and (2) record estimates if using the earthquake-related death rate, instead of the severe dummy; Columns (3) and (4) record estimates if using earthquake intensity scale; Columns (5) and (6) use the distance to the epicentre. Each column controls for cohort- and county-fixed effects. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

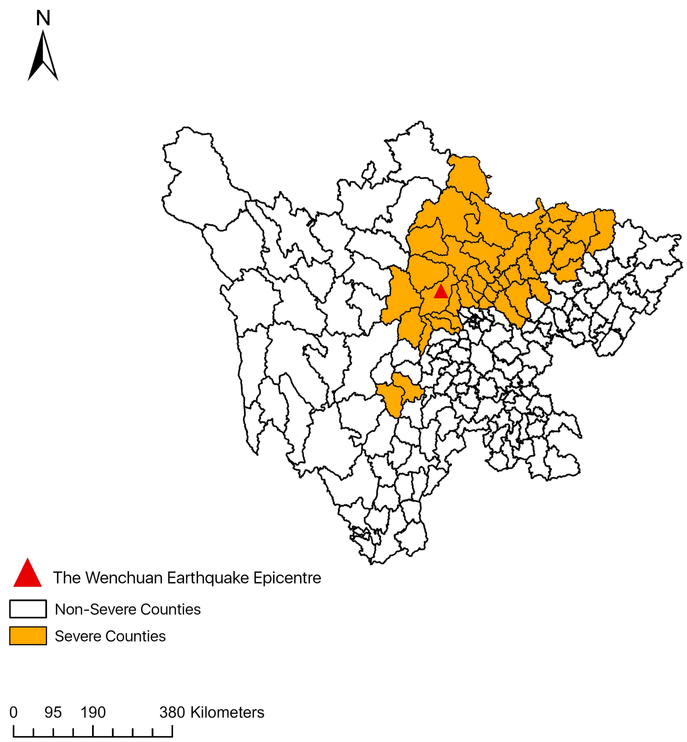
Table 5: The Earthquake Effect on Educational Stages

Dependent Variable:	Tertiary Education	High School Education		Junior High School Education
	(1)	(2)	(3)	(4)
Severe × $\mathbb{1}(\text{Age} \leq 15)$	-0.030	-0.063**	-0.070***	0.011
	(0.023)	(0.024)	(0.023)	(0.015)
Mean of Non-Severe Counties	0.190	0.371	0.529	0.813
Controls	✓	✓	✓	✓
Cohort Fixed Effects	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓
Observations	10438	10438	10438	12536

Note: This table presents the impact of the earthquake on the likelihood of holding an educational degree among young cohorts in severe counties. The dependent variable in column (1) is a binary indicator equal to 1 if a respondent has completed or is receiving tertiary education. Similarly, column (2) assesses the earthquake effect on high school education, while column (3) broadens the definition by including students currently attending high school. Only respondents with at least 9 years of schooling are kept from columns (1) to (3). In column (4), the binary indicator equal to 1 if a respondent has completed junior high school education. Standard errors are clustered at the county level, and *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

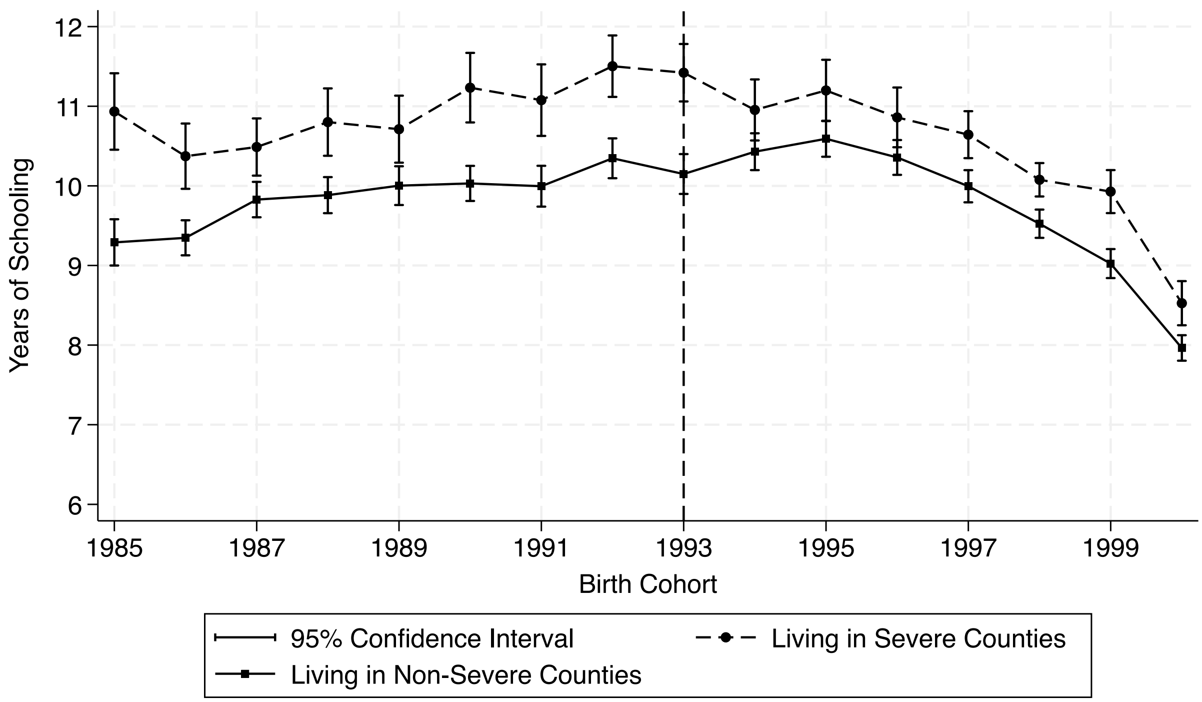
Figures

Figure 1: Counties in Sichuan Classified by Severity



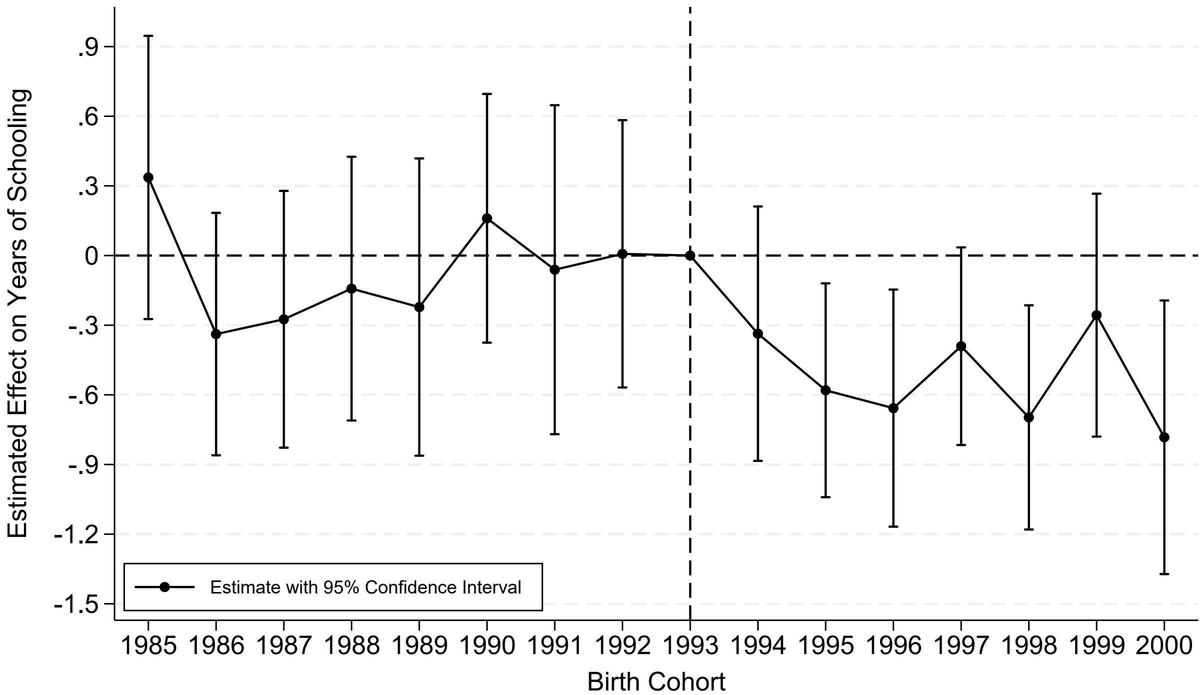
Note: Counties boundaries are plotted in black.

Figure 2: The Trend in Years of Schooling by Different Cohorts



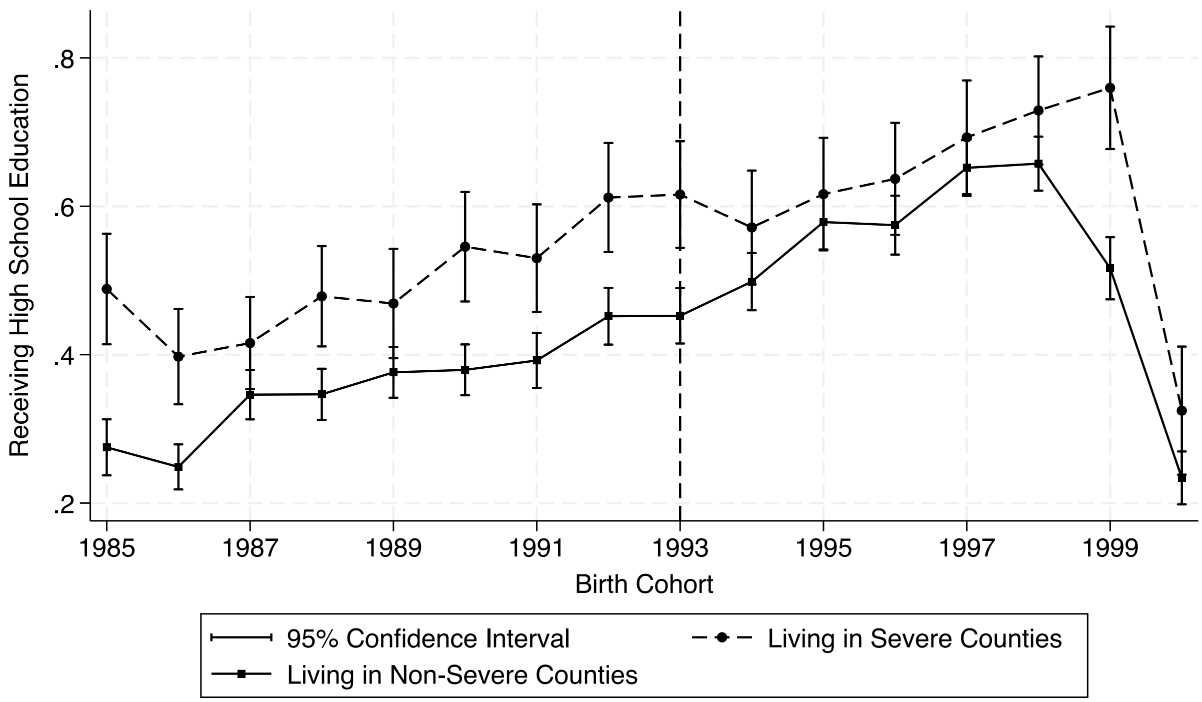
Note: In this figure, each point represents the average years of schooling for a given birth cohort, along with its 95% confidence interval. The vertical dashed line marks the birth cohort who were at age 15 at the time of the Wenchuan earthquake in 2008.

Figure 3: The Earthquake Effect on Years of Schooling by Cohorts



Note: The figure presents the estimates and their confidence intervals at 95% level from the event-study design. Each dot represents the point estimate, with the black solid line indicating the confidence interval. The horizontal axis indicates birth cohorts of respondents, while vertical dashed line marks the 1993 birth cohort who reach 15 years old in 2008. The regression model controls for personal and household characteristics, as well as cohort and county fixed effects. Standard errors are clustered at the county level.

Figure 4: The Trend in Receiving High School Education



Note: In this figure, each point represents the likelihood of receiving high school education (including those graduated) for a given birth cohort, along with its 95% confidence interval. The vertical dashed line marks the birth cohort who were at age 15 at the time of the Wenchuan earthquake in 2008.

A Appendix

A.1 Appendix Tables

Table A1: Summary Statistics of Sample

	Observations	Mean	Standard Deviation	Minimum	Maximum
Years of Schooling	12536	10.05	3.01	0.00	19.00
Age in 2008	12536	15.92	4.50	8.00	23.00
Younger Than 15 in 2008	12536	0.46	0.50	0.00	1.00
Male	12536	0.51	0.50	0.00	1.00
Han People	12536	0.89	0.32	0.00	1.00
Rural Hukou	12536	0.62	0.49	0.00	1.00
Number of Rooms	12536	4.56	2.51	1.00	30.00
House Area (m^2)	12536	138.36	70.42	5.00	850.00
Household Size	12536	4.46	1.57	1.00	15.00
Car Ownership	12536	0.15	0.35	0.00	1.00
Severe County	12536	0.21	0.41	0.00	1.00

Note: This table documents the statistical description of the sample in this study. Each column reports the number of observations, mean, standard deviation, minimum, and maximum values.

Table A2: Detailed Estimates in Event-Study Design

Dependent Variable: Years of Schooling			
	(1)	(2)	(3)
Severe × Age 23 in 2008	0.326	0.259	0.336
	(0.324)	(0.312)	(0.309)
Severe × Age 22 in 2008	-0.368	-0.373	-0.338
	(0.265)	(0.268)	(0.264)
Severe × Age 21 in 2008	-0.386	-0.332	-0.275
	(0.281)	(0.279)	(0.280)
Severe × Age 20 in 2008	-0.248	-0.209	-0.143
	(0.281)	(0.286)	(0.288)
Severe × Age 19 in 2008	-0.323	-0.237	-0.222
	(0.318)	(0.323)	(0.324)
Severe × Age 18 in 2008	0.052	0.047	0.160
	(0.276)	(0.274)	(0.271)
Severe × Age 17 in 2008	-0.192	-0.122	-0.061
	(0.386)	(0.374)	(0.359)
Severe × Age 16 in 2008	-0.045	-0.078	0.007
	(0.298)	(0.296)	(0.292)
Severe × Age 14 in 2008	-0.478	-0.402	-0.336
	(0.290)	(0.282)	(0.278)
Severe × Age 13 in 2008	-0.653***	-0.661***	-0.580**
	(0.250)	(0.242)	(0.233)
Severe × Age 12 in 2008	-0.715***	-0.715***	-0.657**
	(0.261)	(0.258)	(0.259)
Severe × Age 11 in 2008	-0.397	-0.425*	-0.391*
	(0.247)	(0.231)	(0.216)
Severe × Age 10 in 2008	-0.809***	-0.756***	-0.697***
	(0.252)	(0.249)	(0.245)
Severe × Age 9 in 2008	-0.449*	-0.356	-0.257
	(0.265)	(0.273)	(0.265)
Severe × Age 8 in 2008	-0.812***	-0.838***	-0.783***
	(0.300)	(0.295)	(0.298)
Personal Controls		✓	✓
Household Controls			✓
Cohort Fixed Effects	✓	✓	✓
County Fixed Effects	✓	✓	✓
Observations	12536	12536	12536

Note: This table presents the detailed estimates in the event-study design. Columns differ by controls included. All regressions include cohort and county fixed effects, with standard errors clustered at the county level. Standard errors are shown in parentheses, and *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table A3: Heterogeneous Tests by Gender, Residence, and Family Size

Dependent Variable: Years of Schooling	By Gender		By Residence		By Family Size	
	(1)	(2)	(3)	(4)	(5)	(6)
Severe × $\mathbb{1}(\text{Age} \leq 15)$	-0.327*	-0.397**	-0.453***	-0.466**	-0.419**	-0.272*
	(0.181)	(0.161)	(0.149)	(0.225)	(0.196)	(0.151)
Difference Test	0.381		0.495		0.251	
Type	Male	Female	Rural	Urban	Large	Small
Mean of Non-Severe Counties	9.846	9.876	9.586	10.277	9.247	10.403
Controls	✓	✓	✓	✓	✓	✓
Cohort Fixed Effects	✓	✓	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓	✓	✓
Observations	6413	6123	7759	4773	5542	6991

Note: This table presents the estimates from heterogeneity tests, where the dependent variable is individual years of schooling. All regressions include cohort and county fixed effects, with standard errors clustered at the county level. Standard errors are shown in parentheses, and *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table A4: Alternative Specifications

Dependent Variable: Years of Schooling	Age 18 as Cutoff	Distance Weight	Clustering at Prefecture	Excluding Districts	Poisson Regression Model
	(1)	(2)	(3)	(4)	(5)
Severe × $\mathbb{1}(\text{Age} \leq 18)$	-0.169				
	(0.141)				
Severe × $\mathbb{1}(\text{Age} \leq 15)$		-0.380**	-0.377**	-0.535***	-0.365***
		(0.171)	(0.149)	(0.151)	(0.134)
Mean of Non-Severe Counties	9.860	9.860	9.860	9.462	9.860
Controls	✓	✓	✓	✓	✓
Cohort Fixed Effects	✓	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓	✓
Observations	12536	12536	12536	9233	12536

Note: This table presents the estimates from the robustness checks, where the dependent variable is individual years of schooling. Column (1) uses 18 as the cutoff to differentiate the younger and older cohorts; Column (2) uses the inverse of the county-level distance to the epicentre as weight in the specification; Column (3) clusters the standard errors at the prefecture level; Column (4) excludes observations residing in city districts in the sample; And column (5) estimates the effect with a Poisson regression model. *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

Table A5: Additional Province as Pure Control

Dependent Variable: Years of Schooling	Sichuan + Hubei			Baseline (Sichuan Only)
	(1)	(2)	(3)	(4)
Severe × $\mathbb{1}$(Age $\leq$ 15)	-0.314**	-0.281**	-0.350**	-0.363***
	(0.130)	(0.126)	(0.135)	(0.137)
Mean of Non-Severe Counties	10.403	10.403	10.403	9.860
Controls		✓	✓	✓
Cohort Fixed Effects	✓	✓		✓
Province-Cohort Fixed Effects			✓	
County Fixed Effects	✓	✓	✓	✓
Observations	22560	22560	22560	12536

Note: The dependent variable in this table is individual years of schooling. Columns (1)-(3) presents the estimates if adding Hubei province as the pure control, while column (4) serves as the baseline result. *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

Table A6: Additional Older Cohorts as Pure Control

Dependent Variable: Years of Schooling	Age in 2008: 8-25		Age in 2008: 8-15 and 23-25	Baseline
	(1)	(2)	(3)	(4)
Severe × $\mathbb{1}(\text{Age} \leq 15)$	-0.358**	-0.357**	-0.473**	-0.363***
	(0.139)	(0.137)	(0.212)	(0.137)
Mean of Non-Severe Counties	9.809	9.809	9.693	9.860
Controls		✓	✓	✓
Cohort Fixed Effects	✓	✓	✓	✓
County Fixed Effects	✓	✓	✓	✓
Observations	13640	13640	7535	12536

Note: The dependent variable in this table is individual years of schooling. Columns (1)-(3) presents the estimates if adding the age cohort of 23 to 25 in 2008 as the pure control, while column (4) serves as the baseline result. *, **, and *** denote the significance levels at 10%, 5%, and 1% respectively.

Table A7: School Attendance

Dependent Variable: Study at School	(1)	(2)
Severe $\times$ $\mathbb{1}$(Age $\leq$ 15)	0.037	0.037
	(0.023)	(0.022)
Mean of Non-Severe Counties	0.250	0.250
Controls		✓
Cohort Fixed Effects	✓	✓
County Fixed Effects	✓	✓
Observations	12536	12536

Note: Column (1) presents the impact of the earthquake on the likelihood of school attendance in the survey year; Column (2) re-estimates the baseline specification after excluding those current students. Standard errors are clustered at the county level, and *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table A8: Dropout, Marriage, and Number of Children

Dependent Variable:	Dropout after Compulsory Education	Married	Number of Child(ren)
	(1)	(2)	(3)
Severe $\times$ $\mathbb{1}(\text{Age} \leq 15)$	0.070***	0.054*	0.078
	(0.023)	(0.031)	(0.055)
Mean of Non-Severe Counties	0.471	0.540	0.567
Controls	✓	✓	✓
Cohort Fixed Effects	✓	✓	✓
County Fixed Effects	✓	✓	✓
Observations	10438	8364	8364

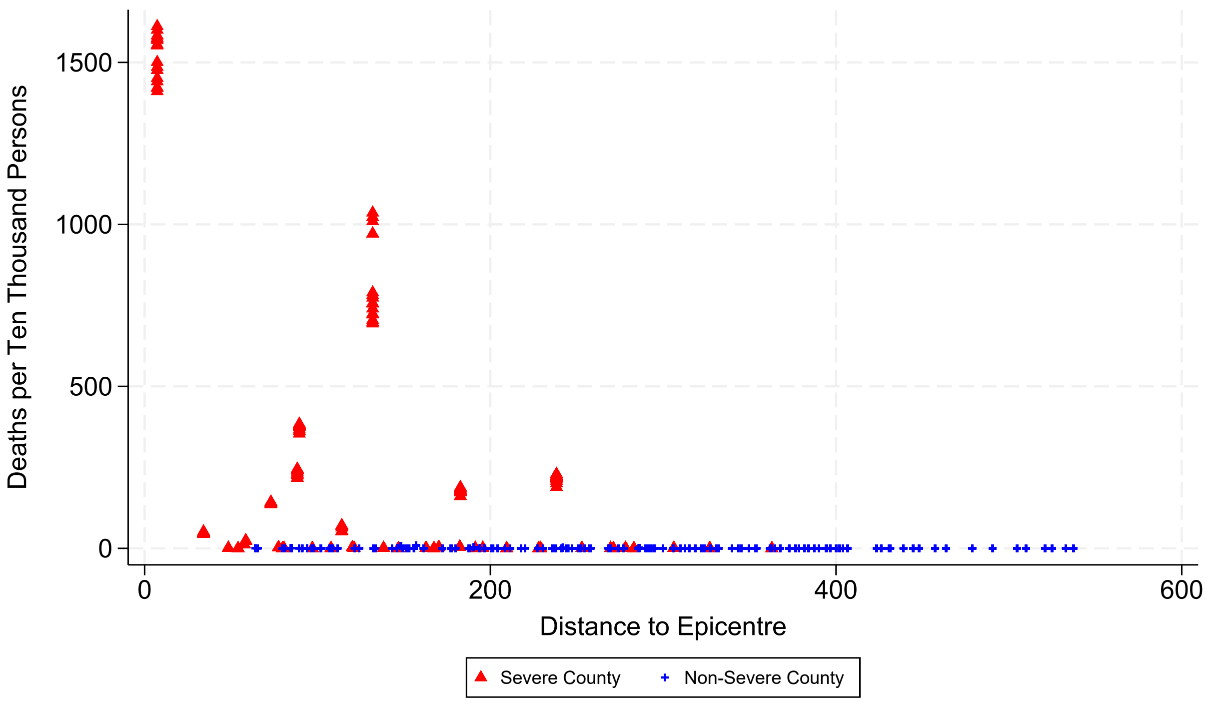
Note: This table presents the impact of the earthquake on the likelihood of dropping out after compulsory education, being married, and number of children. Standard errors are clustered at the county level, and *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

A.2 Appendix Figures

Figure A1: The Location of The Wenchuan Earthquake Epicentre

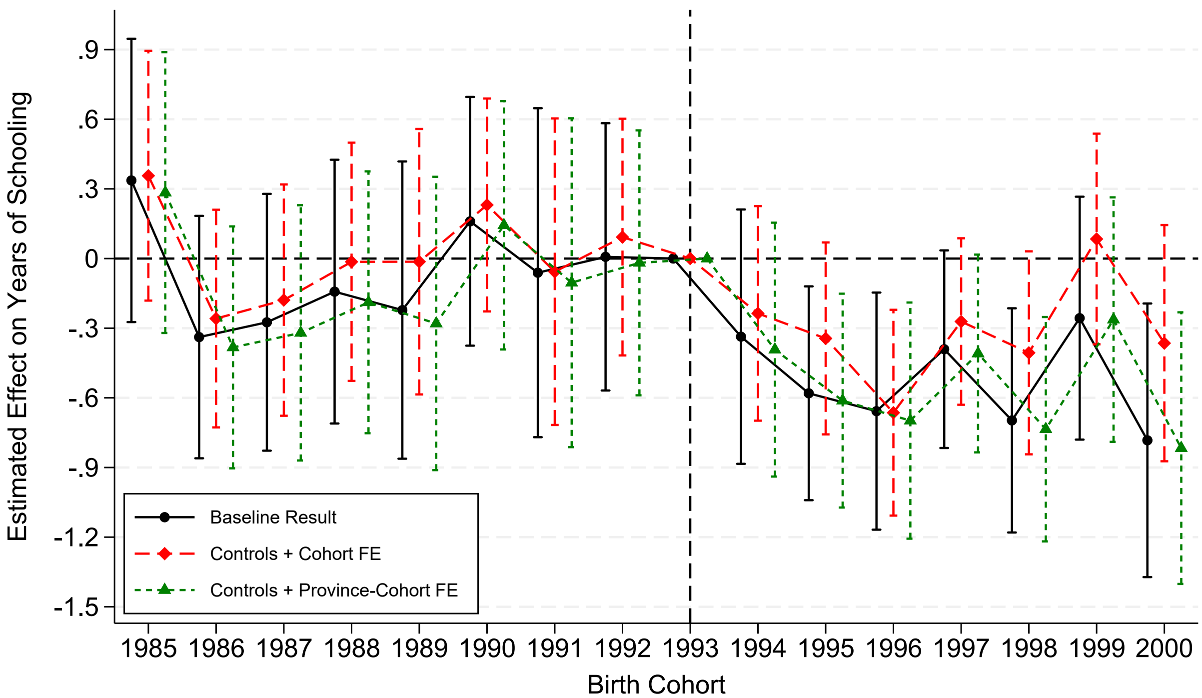
Note: This map shows the location of the Wenchuan earthquake epicentre in China, and the black lines plot the provincial boundaries.

Figure A2: The Correlation Between Earthquake-Related Death Rate and Distance to Epicentre



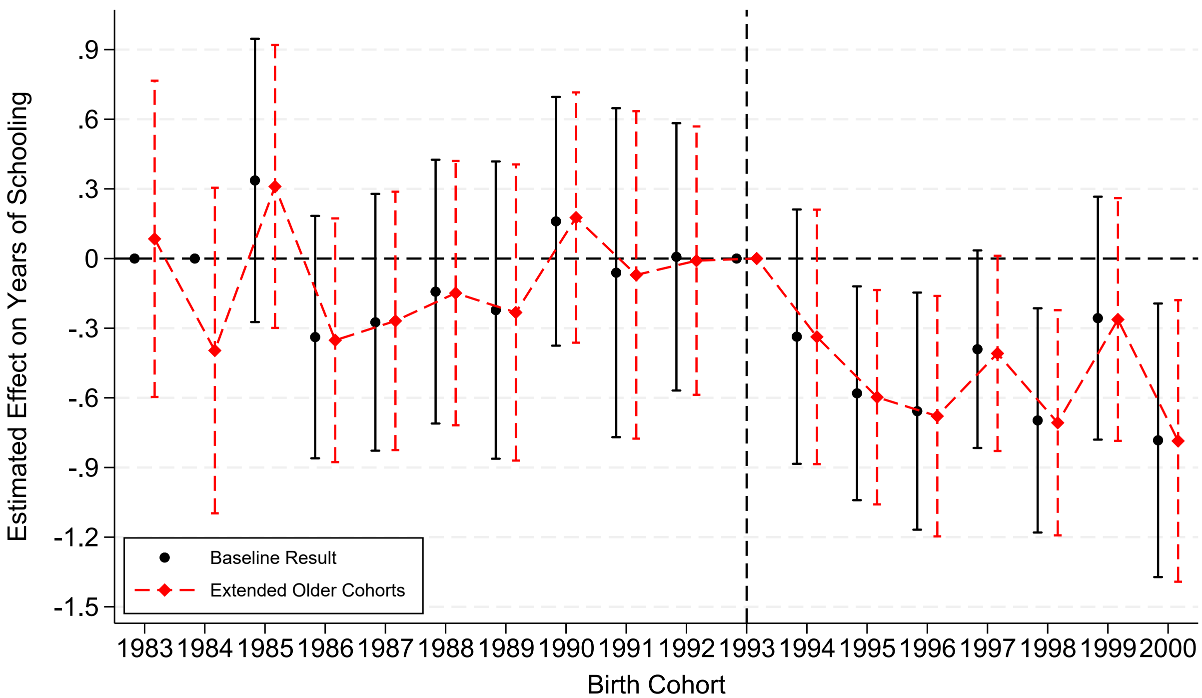
Note: The scatter plot depicts the correlation between the earthquake-related deaths and the distance to the earthquake epicentre at the county level. The triangle marker represents severe counties, while the plus marker is used for non-severe counties.

Figure A3: By-Cohort Effect with Additional Province



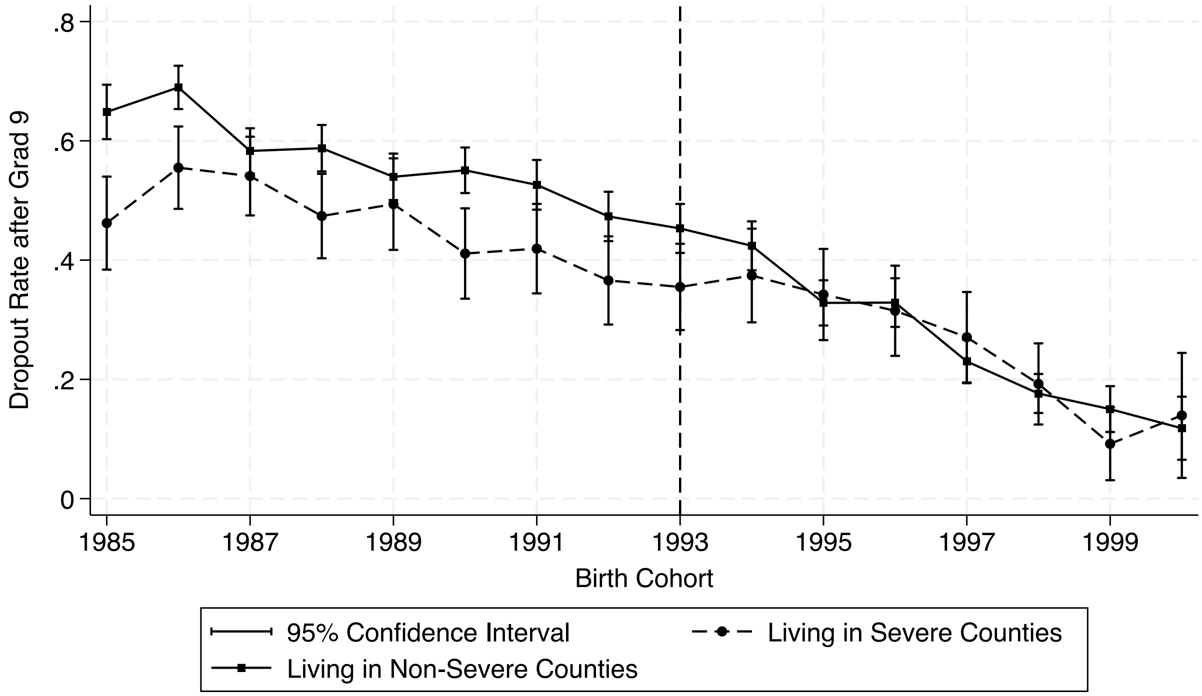
Note: The figure presents the estimates and their confidence intervals at 95% level from the event-study design. The horizontal axis indicates birth cohorts of respondents, while vertical dashed line marks the 1993 birth cohort who reach 15 years old in 2008. The black dot represents the point estimate from the baseline result. The red diamond represents the point estimate when the specification adds respondents in Hubei province as the pure control. The green triangle represents the point estimate when the revised specification absorb the province-cohort fixed effects, instead of the cohort fixed effects. Standard errors are clustered at the county level.

Figure A4: By-Cohort Effect with Additional Older Cohorts



Note: The figure presents the estimates and their confidence intervals at 95% level from the event-study design. The horizontal axis indicates birth cohorts of respondents, while vertical dashed line marks the 1993 birth cohort who reach 15 years old in 2008. The black dot represents the point estimate from the baseline result. The red diamond represents the point estimate when the specification adds the age cohort of 23 to 25 in 2008 as the pure control. Standard errors are clustered at the county level.

Figure A5: The Trend in Dropping Out after Compulsory Education



Note: In this figure, each point represents the likelihood of dropping out after compulsory education for a given birth cohort, along with its 95% confidence interval. The vertical dashed line marks the birth cohort who were at age 15 at the time of the Wenchuan earthquake in 2008.

A.3 Coding for Education

The translation of the questions about the highest degree achieved and education completion status is here:[22]

- Question 15: What is your level of education?
  Never attended school; Primary school; Junior high school; High school; Vocational school; College (Associate degree); University (Bachelor's degree); Graduate school
- Question 16: What is your academic completion status?
  Currently enrolled; Graduated; Incomplete; Dropped out; Other

In the Chinese education system, students typically spend 6 years in primary school, 3 years in junior high school, and 3 years in either high school or vocational school. After completing the 9-year compulsory education, students may choose to continue their studies by enrolling in either high school or vocational school. Following this, they are expected to spend 3 years in college or 4 years in university.[23] Lastly, I assume a standard duration of 3 years for graduate studies, as the questionnaire does not distinguish between masters and doctoral programs in graduate school. In summary, years of schooling can be coded in the following way based on the answer:

Never attended school $\rightarrow$ 0
Primary school $\rightarrow$ 6
Junior high school $\rightarrow$ 9
High school $\rightarrow$ 12
Vocational school $\rightarrow$ 12
College (Associate degree) $\rightarrow$ 15
University (Bachelor's degree) $\rightarrow$ 16
Graduate school $\rightarrow$ 19

In Question 16, it is unclear which grade respondents are currently in if they have not indicated "Graduated" as their completion status. Following the approach of Wang et al. (2017); Chen et al. (2020); Liu and Xu (2021), I assign half of the duration of the highest level of education if they have not yet graduated. For instance, if a respondent selects "High school" in Question 15 and "Currently enrolled" in Question 16, this indicates that

[22] The original questionnaire can be found: `https://www.stats.gov.cn/zt_18555/zdtjgz/cydc/xw/202302/t20230221_1917243.htm`.

[23] Certain disciplines, such as medicine, require 5 years of university study. However, this analysis focuses on the most common scenario.

the individual is still attending high school at the time of the survey. In this case, I assign 9 years (representing the completion of junior high school) + 1.5 years (representing half of the high school duration) = 11.5 years of schooling.

A.4 The China Seismic Intensity Scale

The first version of the China Seismic Intensity Scale (CSIS) was released by the Institute of Geology and Geophysics, China Academy of Science in 1957. Since then, the scale has undergone several revisions. The latest version prior to the Wenchuan earthquake was published in 1999.[24] I focus on this version and compare it with another measure of earthquake intensity.[25] The following table records the details.

China Seismic Intensity Scale of the 1999 Version

Intensity	Senses by People	Building Damage	Peak Ground Acceleration (m/s^2)
I	Insensible.	—	—
II	Sensible by very few still indoors.	—	—
III	Sensible by a few still indoors.	Slight rattle of doors and windows.	—
IV	Sensible by most people indoors; a few people outdoors; a few wake from sleep.	Rattle of doors and windows.	—
V	Commonly sensible indoors; sensible by most outdoors; most wake from sleep.	Noise from vibrating doors/windows/building frames; falling dust; small cracks in plaster; some roof tiles or bricks falling from a few chimneys.	0.31 (0.22-0.44)
VI	Most unable to stand stably; a few rush outdoors.	Cracks in walls; falling roof tiles; some roof-top chimneys crack or fall apart.	0.63 (0.45-0.89)
VII	Majority rush outdoors; felt by bicycle riders and occupants of moving vehicles.	Slight destructionlocalized cracks; may continue to be used with minor repairs.	1.25 (0.90-1.77)
VIII	Most sway; difficult to walk.	Moderate destructionstructural damage occurs; continued usage requires repair.	2.50 (1.78-3.53)
IX	Moving people fall.	Severe destructionstructural collapse; localized ruin; difficult to repair.	5.00 (3.54-7.07)
X	Bicycle riders may fall; people feel thrown up.	Most masonry and frame structures collapse; few remain standing.	10.00 (7.08-14.14)
XI	General destruction; railway tracks twisted; underground pipelines damaged.	Widespread collapse of most structures; few ruins remain.	—
XII	Landscape reshaped; ground breaks; rivers rerouted.	Total destruction; ground surface deformations everywhere.	—

[24] See from https://web.archive.org/web/20110707013136/http://www.dccdnc.ac.cn/html/zcfg/liedubiao.htm.

[25] In late 2008, a new version was released, incorporating evaluations of the Wenchuan earthquake. However, the two versions are similar in many aspects.

A.5 The Wenchuan Earthquake Migration Model

The Hukou (household registration) system in China restricts internal mobility by limiting access to local public services for residents without local registration, including education and healthcare. Introduced in 1951 under the planned economy framework, the system remains influential, although recent debates have called for its relaxation to reflect modern social and economic conditions.

In this study, the Hukou system helps explain the limited migration out of severe counties following the Wenchuan earthquake. This institutional feather sets China apart from other countries, where natural disasters often lead to large-scale population movements (Noy and Vu, 2010; Boustan et al., 2012; Gröger and Zylberberg, 2016; Gallagher and Hartley, 2017). In contrast, Chinese residents face mobility constraints due to Hukou policies and may choose to remain in place despite adverse conditions. Additionally, receiving compensation after the earthquake may reduce the incentive to migrate. The most significant form is housing reconstruction provided by local governments, which offers a partial offset to earthquake-related losses. These two factors together–mobility restriction and post-disaster compensation–may explain the low migration response. To formalize this, I develop a simple infinite-period model of migration that captures them.

I consider a representative household living in a severe county when the earthquake strikes at period $t = 0$. The household faces an infinite planning horizon for $t = 0, 1, 2, \ldots, \infty$. Let $u(c_t)$ denote utility in period t from consumption c_t, where $u(\cdot)$ is non-decreasing function and $u^{'}(\cdot) \geq 0$. Future utility is discounted at rate $\sigma \in (0, 1)$. The household's lifetime utility maximization problem is:

$$\text{Max } E_0 \left[\sum_{t=0}^{\infty} \sigma^t u(c_t) \right] \tag{3}$$

For simplicity, I assume the household does not save and consume its entire after-tax wage in each period, $c_t = w_t$.

The earthquake imposes a one-time loss D in period 0. If the household stays, it earns after-tax wage w_t^S. If it migrates, it pays a one-time cost M and earns wage w_t^M thereafter. Suppose the decision between migration and staying is irreversible. Staring in period 1, local governments provide compensations R_t to those who remain; migrants receive no transfer.[26]

[26]The compensations are assumed to decline over time: $\lim_{t\to\infty} R_t = 0$.

The lifetime expected utility from staying (U^S) and migrating (U^M) is given by:

$$U^S = u(w_0 - D) + E_0\left[\sum_{t=1}^{\infty}\sigma^t u(w_t^S + R_t)\right] \tag{4}$$

$$U^M = u(w_0 - D - M) + E_0\left[\sum_{t=1}^{\infty}\sigma^t u(w_t^M)\right] \tag{5}$$

The net gain from migration is:

$$U^M - U^S = u(w_0 - D - M) - u(w_0 - D) + E_0\left[\sum_{t=1}^{\infty}\sigma^t (u(w_t^M) - u(w_t^S + R_t))\right] \tag{6}$$

The partial derivatives with respect to the migration cost (M) and compensation (R_t) are:

$$\frac{\delta(U^M - U^S)}{\delta M} = -u^{'}(w_0 - D - M) < 0 \tag{7}$$

$$\frac{\delta(U^M - U^S)}{\delta R_t} = -E_0\left[\sum_{t=1}^{\infty}\sigma^t u^{'}(w_t^S + R_t)\right] < 0$$

These expressions show that higher migration costs and larger compensations reduce the net benefit from migration, thus discouraging relocation. If utility is linear, $u(a) = a$, I can solve for the threshold values of M and R_t under the condition $U^M = U^S$. Then:

$$w_0 - D + E_0\left[\sum_{t=1}^{\infty}\sigma^t (w_t^S + R_t)\right] = w_0 - D - M + \left[\sum_{t=1}^{\infty}\sigma^t w_t^M\right] \tag{8}$$

Solving for M^* and R_t^* gives:

$$M^* = E_0\left[\sum_{t=1}^{\infty}\sigma^t (w_t^M - w_t^S - R_t)\right] \tag{9}$$

$$E_0\left[\sum_{t=1}^{\infty}\sigma^t R_t^*\right] = \left[\sum_{t=1}^{\infty}\sigma^t (w_t^M - w_t^S)\right] - M \tag{10}$$

The model highlights two key conditions: (1) migration is optimal only if the discounted income gain minus compensations still exceeds the migration cost, and (2) staying is optimal only if the discounted value of compensations offsets the lifetime income gap minus migration cost.