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Hidden costs of industrial disasters: Marriage market consequences of the Bhopal Gas Disaster

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Abstract

This paper examines the marriage market consequences of one of the world's deadliest industrial disasters, the 1984 Bhopal Gas Disaster in India. The gas leak resulted in casualties of upwards of 3,000 people and affected over 500,000 people. Using the 2015-16 National Family and Health Survey (NFHS) and a difference-in-difference (DID) strategy, we find that the Bhopal Gas Disaster reduced marriage rates of men and increased the age at marriage for those men who were able to get married. These results are driven by the negative health and employment outcomes of men exposed to the disaster. Additionally, we examine the quality of matches and find a decrease in the spousal educational gap and an increased likelihood of men being matched with women with similar adverse health issues. Our results highlight far-reaching demographic effects beyond the detrimental health effects resulting from industrial disasters.

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1. Introduction

On the night of December 2nd, 1984, forty tons of Methyl Isocyanate (MIC) gas leaked from a pesticide plant in Bhopal, India, giving rise to one of the worst industrial disasters to date. The immediate death toll from the gas leak was around 3,000, and over 500,000 individuals experienced prolonged and varied adverse health effects (Dhara and Dhara 2002). The health effects of the disaster have received extensive attention; however, studies documenting demographic outcomes such as marriages are scant. We attempt to fill this gap in the literature.

Disasters can bring large-scale destruction and disruption to the lives of the exposed population. While natural disasters such as earthquakes or hurricanes are largely unpreventable, it is possible to prevent and mitigate an industrial disaster, such as chemical spills, with adequate, updated safety regulations and technology. Additionally, industrial disasters carry a greater negative externality than natural disasters due to widespread environmental damage. The health consequences of these disasters can often be profound and long-lasting, even disrupting employment and education levels. For instance, individuals exposed to the 1986 Chernobyl nuclear disaster in Ukraine have poor physical and mental health, lower education and employment levels, and lower wages (Almond *et al*. 2009; Danzer and Danzer 2016; Lehmann and Wadsworth 2011; Yemelyanau *et al.* 2012). Adverse physical and mental health outcomes also surfaced among those impacted by the 1989 Exxon Valdez oil spill in Alaska and the 2010 Deepwater Horizon oil spill in the Gulf of Mexico (Fan *et al.* 2015; Palinkas *et al.* 1993).

Disasters can alter a region's demography beyond mortality patterns and migration responses. For instance, a disaster's negative human capital and employment effects can affect the likelihood and quality of marital matches. Apart from changing the probability of getting married and divorced (Cohan and Cole 2002; Hamamatsu *et al.* 2014), weather shocks and natural disasters can change the age of marriage (Corno *et al.* 2020; Das and Dasgupta 2019; Khanna and Kochhar 2020). Additionally, there could be changes in the socio-economic characteristics of the match such that women may marry into poorer households (Carrico *et al.* 2020) or husbands with lower education levels (Almond *et al.* 2007; Carrico *et al.* 2020).

So, how does the Bhopal Gas Disaster impact the marriage market? If individuals weigh physical and health attributes in their choice of spouses, survivors of the disaster with known health effects may find it particularly challenging to find a spouse. For example, the decline in marital attractiveness measured in health and education outcomes affected the marriage rates of cohorts exposed to the Great Chinese Famine of 1959 (Almond *et al.* 2007; Brandt *et al.* 2016). Conversely, following Hurricane Hugo in 1989, stress-induced attachment increased marriage rates in South Carolina (Cohan and Cole 2002). An individual could also find it challenging to get married due to the social taboo of just being associated with the disaster region. For instance, Heath (2013) documents possible marital discrimination against individuals exposed to radiation from the 2011 Fukushima nuclear disaster or just residing in that region in Japan. Such discrimination occurs if a survivor's true health status is unknown, and they are perceived as having poor health and hence of lower quality.

On the other hand, individuals who have not exhibited symptoms of toxic chemical exposure or who choose not to disclose their health conditions may experience expedited entry into marriage. Chowdhury and Singh (2021) find that an arsenic contamination awareness campaign in Bangladesh reduced the age at marriage for fear of arsenic-induced symptoms surfacing among marriage-age individuals. Thus, the direction of impact on marriage rates and age at marriage is theoretically ambiguous.

Several studies have focused, quite importantly, on the effects of disasters on women since they face higher rates of casualty, lower life expectancy, and negative shocks to their reproductive and maternal health (Behrman and Weitzman 2016; Callaghan *et al.* 2007; Neumayer and Plümper 2007). However, in this paper, we focus on the impact of the Bhopal Gas Disaster on the marital outcomes of men for a few reasons. In general, higher-earning men are economically selected for marriage because they are seen as more attractive candidates in the marriage market (Nakosteen and Zimmer 1997; Xie *et al.* 2003). In South Asia, women value both high education levels and earnings potential in prospective grooms, and family-arranged marriages deem important the economic standing of marital households (Anukriti and Dasgupta 2018; Buchmann *et al.* 2021). Thus, if the gas leak induced a negative shock to men's employability, it could alter their chances of finding a spousal match. Lastly, since women have high migration rates due to patrilocality norms and given that we only have information on their current residence, it would be challenging to assess their exposure to the disaster correctly.[1]

To our knowledge, we are the first to systematically investigate the impact of a large-scale industrial disaster on marital unions. Our study uses data from the 2015-16 round of the National Family Health Survey (NFHS) and employs a difference-in-differences (DID) estimation method to analyze the effects of the Bhopal Gas Disaster on the marriage market. We utilize two sources of variation. First, we use regional variation by comparing residents of the Bhopal district, where the disaster occurred, to residents of other districts in Madhya Pradesh. Second, we use cohort variation by examining three groups: those born before the disaster but were unmarried in 1984 (cohort 2), those born after the disaster (cohort 3), and a comparison group (cohort 1) consisting of individuals who were already married before the disaster in 1984.

Our main results suggest that the disaster impacted the two cohorts along different margins. We find no significant changes in the probability of marriage for those who were born before the disaster but were unmarried at the time of the disaster. However, we do find that their entry into marriage is delayed by approximately three years. For men born after the disaster, the effects are two-fold: they are 30 percentage points less likely to be married and conditional on getting married; their entry into marriage is earlier by about six months.

We hypothesize that our results operate through changes to individuals' health, education, and employment outcomes. Both cohorts affected by the disaster exhibit a higher likelihood of asthma, and cohort 2 has a higher incidence of cancer. Overall education increases by over two years for cohort 2. We posit that this increase in years of schooling is to increase their marital attractiveness to compensate for their adverse health effects, thus leading to a delay in marriage. Lastly, the group born after the disaster is 26 percentage points less likely to be employed, whereas cohort 2 is 8 percentage points less likely to be employed. This result suggests that the reduced likelihood of getting married for cohort 3 is driven by their lack of employability, which captures earnings potential. We extend the study to examine the quality of matches and find a decrease in the spousal education gap and an increased likelihood of men being matched with women who also suffer from asthma and cancer. Additionally, we find that fewer children are born to men directly exposed to the disaster (cohort 2).

[1] Nevertheless, the patterns for marriage rates and age at marriage for women echo what we find for men, which remain preserved even when we limit the sample (4.4% of respondents) to non-movers (results upon request).

2. The Bhopal Gas Disaster

In 1969, Union Carbide India Limited (UCIL) set up a plant in Bhopal, Madhya Pradesh, to manufacture carbamate pesticides. One of its intermediate ingredients is MIC. In the early 1980s, decreased profitability of UCIL led to cutbacks in safety protocols (Broughton 2005). Despite multiple safety violations before the disaster, Union Carbide Corporation (UCC), the parent company, took no action to address the issues (Eckerman 2005).

On the night of December 2nd, 1984, about 40 tons of MIC gas leaked from the pesticide plant. Approximately 520,000 people, 200,000 of whom were children under 15, were affected by the toxic air. The official death count was 3,000 in the immediate hours of the gas leak, and 15,000 in the subsequent years. However, many independent organizations report a death toll of 25,000 over several years (Amnesty International 2004). In 1989, UCC and the Government of India settled for $470 million towards victim compensation (Mandavilli 2018).

The health effects of the disaster have been well-documented. Chronic respiratory problems among the exposed population have been studied quite extensively (Cullinan *et al.*1996; Dhara and Dhara 2002). De *et al.* (2020) examined chronic respiratory morbidity among various cohorts. Respiratory morbidity among children (below the age of 10) and teenagers (between 10-20 years of age) was high during the first decade of exposure, which declined thereafter. Younger adults (20-40 years) and older adults (above 40 years of age) had higher and more prolonged respiratory morbidities that lasted over 30 years.

The exposed population also experienced an increase in menstrual problems (Sathyamala 1996) and adverse pregnancy outcomes such as stillbirth (Cullinan *et al.*1996), a higher risk of cancer (Ganguly *et al.* 2017; Mishra *et al.* 2015), and higher rates of ocular problems such as cataracts and eyelid infections (Andersson *et al.* 1990). The poisonous MIC gas entered groundwater bodies such as wells and tubewells, and people who used these as drinking water sources suffered from gastrointestinal issues (Sourav 2019).

Survivors also suffered neurological and mental health issues from experiencing the disaster. Cullinan *et al.* (1996) report that the exposed population complained of fatigue, anxiety, and difficulty in concentration. Children who had witnessed death in their families or had been presumed dead were found to be apprehensive, jittery, and depressed (Irani and Mahashur 1986). Overall, psychiatric morbidity was more prevalent in the exposed areas compared to unexposed regions (Basu and Murthy 2003).

The negative health effects extended to individuals who were in-utero at the time of the disaster. Ranjan *et al.* (2003) found a decrease in anthropometric measures for boys, the effect greater for those who were exposed in-utero and the least for those born prior to the disaster. However, no significant impacts on girls were found, irrespective of exposure status. Sarangi et al. (2010) report high rates of infant mortality in the first five years following the gas leak, as well as stunting among male children exposed in-utero. Additionally, they report evidence of lower head circumference and lower body mass index among females exposed to the disaster in-utero. McCord *et al.* (2021) report an increase in the incidence of cancer among children who were in-utero at the time of the disaster.

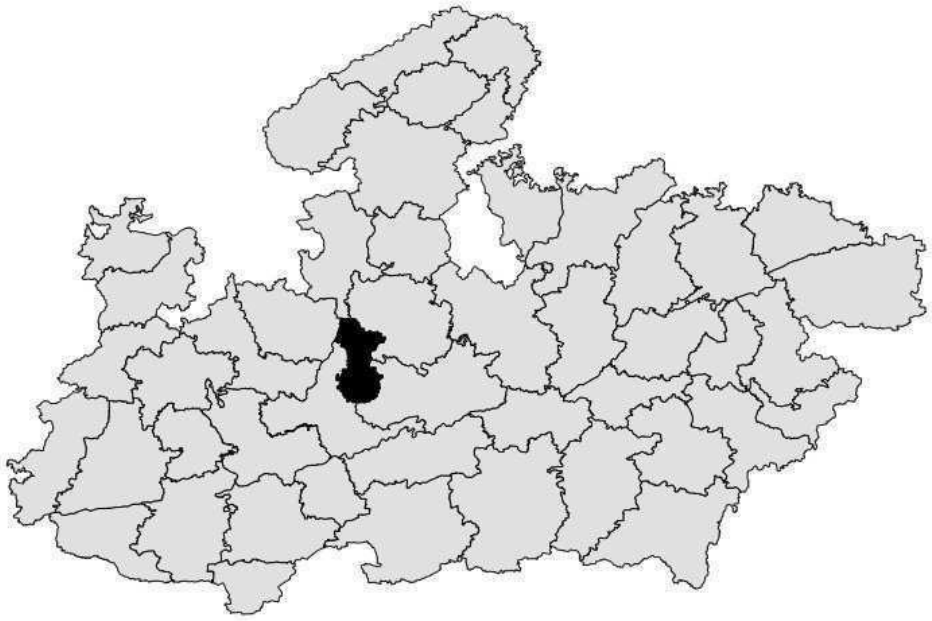
A very thin strand of literature has evaluated the impact of the gas leak on other socio-economic outcomes. McCord *et al.* (2021) find a decrease in educational attainment and a higher level of employment disability for the cohort of individuals in-utero in 1984. Our paper contributes to further understanding of how the negative health and employment effects of the Bhopal Gas Disaster influenced the marriage market outcomes.

3. Data and Empirical Strategy

We use the 2015-16 round of the National Family and Health Survey (NFHS), a nationally representative cross-sectional household survey conducted in India. The survey collects information on the year of birth, education, employment, district of residence, marital status, year of marriage, and health status of individuals. As mentioned earlier, we focus on men in this analysis because of the high post-marriage migration rates of Indian women.

Our study sample is restricted to residents of Madhya Pradesh. Figure 1 shows the map of Madhya Pradesh: the dark region represents the district of Bhopal, the location of UCIL, and the primarily affected region. The remaining districts of Madhya Pradesh are largely unaffected by the disaster and constitute the comparison districts.[2]

Figure 1: Map of Madhya Pradesh



Notes: The dark region is the affected district of Bhopal, the location of the Union Carbide factory.

We use a DID approach to examine marriage market outcomes after the 1984 disaster with two sources of variation to identify the disaster's impact: regional variation (Bhopal versus other districts of Madhya Pradesh) and variation among different cohorts. The control group (cohort 1) includes individuals who got married before December 1984 – their marriage outcomes were unaffected by the disaster. Therefore, by construction, the marriage rate prior to the disaster is 100 percent. We divide the potentially disaster-affected individuals into two treatment cohorts, cohort 2 and cohort 3. Cohort 2 includes those who were born prior to 1984 but were unmarried at the time of the disaster – this cohort was directly exposed to the gas leak. Cohort 3 consists of individuals born in and after 1985 – this cohort experienced the gas leak

[2] Intensity of disaster exposure could be calculated using NFHS' geolocation information. However, the location coordinates of NFHS clusters are randomly displaced to ensure respondent confidentiality (Perez-Heydrich *et al.* 2013). Such spatial errors can bias estimates, which is why we choose not to use the geolocation information.

indirectly via in-utero exposure, for example. We limit our sample to those aged 25 years and older to deal with the issue of right truncation for the youngest individuals in the study, cohort 3.

Our estimation equation takes the following form:

$$y_{itd} = \alpha_0 + \alpha_1(Cohort\ 2_{itd} \times Bhopal_d) + \alpha_2(Cohort\ 3_{itd} \times Bhopal_d) + \alpha_3(Cohort\ 2)_{itd} + \alpha_4(Cohort\ 3)_{itd} + X_{itd}\theta + \pi_t + \gamma_d + \varepsilon_{itd} \quad (1)$$

where y_{itd} is the marriage outcome of man *i* born in year *t* and currently residing in district *d*. Our primary outcome variable is an indicator of whether a man was ever married. To ensure that this outcome is more comparable across the birth cohorts, we also examine whether a man was married by ages 25 and 21 respectively. Conditional on marriage, we additionally examine the impact on age at marriage. *Bhopal* is an indicator for individuals in the affected district of Bhopal. *Cohort 2* and *Cohort 3* are the two disaster-affected groups, and *Cohort 1* forms the omitted category. Thus, the coefficients of interest are α_1 and α_2, which pick up the differential effect on the treatment cohorts. The underlying identifying assumption is that, in the absence of the disaster, the difference in the marriage market outcomes of men in Bhopal versus other districts would remain constant over time.

X_{itd} controls for household characteristics that may influence marriage outcomes and includes caste indicators and dummies for urban household location, Hindu religion, and household wealth quintiles.[3,4] The district of residence dummies (γ_d) capture time-invariant district-level features that can influence marriage outcomes, such as socioeconomic factors and local traditions. It also absorbs the exposure to gas disaster variable. Year of birth dummies (π_t) are included to net out any age-related effects that are common across districts. Standard errors are clustered at the district level. All regressions are estimated using sampling weights.

Before discussing the results, we consider some limitations of our analysis. The NFHS only contains information on the district of current residence but not the district of birth or the complete set of districts where individuals have ever lived. Thus, possible migration and/or displacement following the disaster can introduce bias in our estimates. In the next section, we elaborate on two robustness checks that we conduct to account for such migration possibilities. In addition, our model only estimates the marriage market effects for those who survived the disaster and not the entire population exposed to the disaster, which would need to account for deaths and possible effects on fertility post-disaster.

4. Results

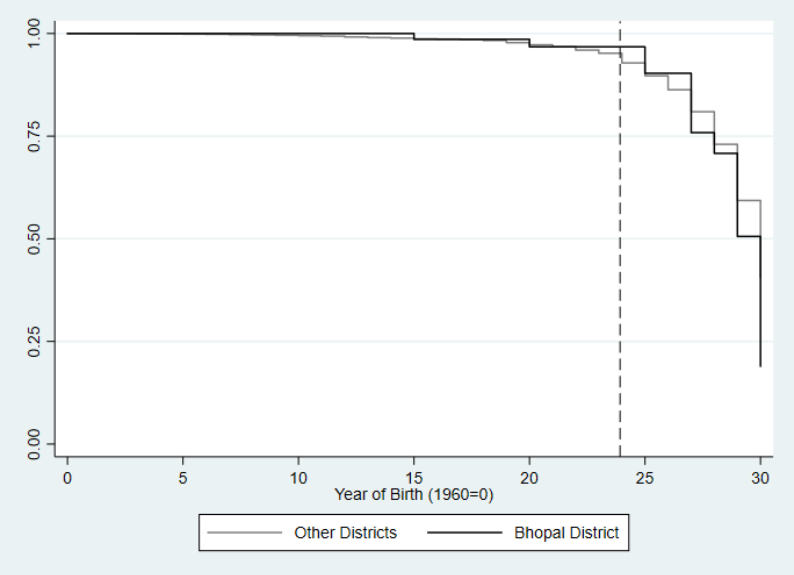
Our goal is to examine whether and how the Bhopal Gas Disaster affected men's marriage market outcomes. First, we check the validity of our estimation method by considering the parallel trends assumption. In Figure 2, we plot men's marriage rates by year of birth, separated by the district of residence. Prior to 1984, we observe no difference in marriage rates of men by the district of residence. Marriage rates decline for men born after 1984 and they do so differentially by the district of residence. The steepness of the decline in later years of birth is not unexpected since these are the youngest respondents in the sample. However, the decline is pronounced for men residing in the Bhopal district, which alludes to something particular to this district of residence. Similarly, Figure 3 plots the age at marriage for married men by year of

[3] NFHS reported wealth quintiles are constructed from information on household assets and proxy for household economic conditions.

[4] Appendix Table A1 provides summary statistics for the full set of outcome variables we examine and the controls we use in our regression specifications.

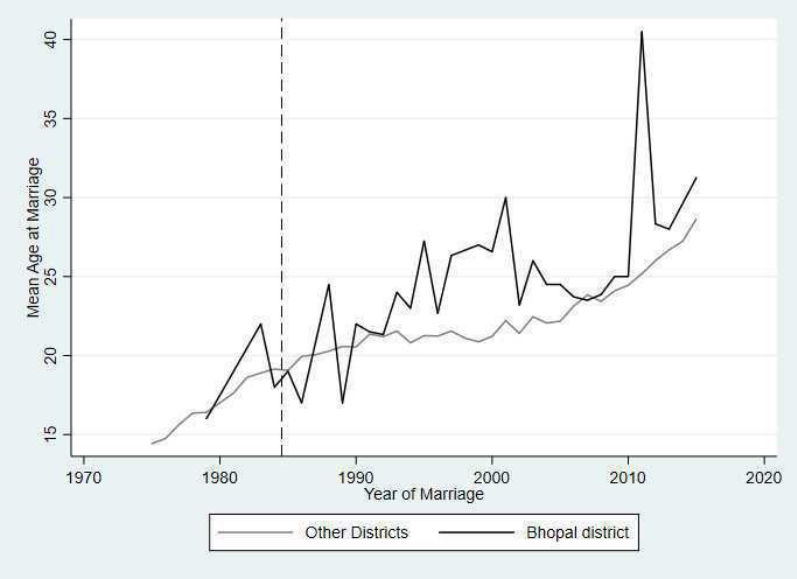
marriage and separated by the district of residence. The trends do not follow a very clean pattern as for marriage rates, nevertheless, we observe clear differential trends by district only for men who married after 1992.[5] These two graphs lead us to conclude that parallel trends are likely not violated for the main marriage outcomes.

Figure 2: Marriage Rates of Men by Year of Birth



Notes: The year 1984 is represented by the dotted line, the date of the Bhopal Gas Disaster.

Figure 3: Age at Marriage of Men by Year of Marriage



Notes: The year 1984 is represented by the dotted line, the date of the Bhopal Gas Disaster.

[5] The raw numbers from Appendix Table A1 indicate a lower probability of getting married for the disaster-affected cohorts (particularly cohort 3) compared to cohort 1. This is regardless of whether they got married by age 25 or by age 21. Additionally, we also see an increase in the age at marriage for both these cohorts.

Table 1 presents the DID estimates of the impact of the Bhopal Gas Disaster on men's marital outcomes using equation (1). Column (1) shows no statistically significant difference between the probability of getting married for men in cohort 2 and the control group. Thus, cohort 2 men from Bhopal also have almost a 100 percent marriage rate. In contrast, cohort 3 men in the Bhopal district are 30 percentage points less likely to have been ever married compared to the control group. Upon examining the results in columns (2) and (3), we find negative signs on both DID coefficients: this suggests reduction in probability of cohorts 2 and 3 getting married by ages 25 and 21 in Bhopal district. Column (4) presents the age at marriage results. The coefficient on *Cohort 2* × *Bhopal* is 2.69: this indicates that conditional on getting married, the age at marriage for cohort 2 men from Bhopal district has increased by about three years. The coefficient on *Cohort 3* × *Bhopal*, on the other hand, reveals an expedited entry into marriage by 0.47 years. Overall, these results imply that the disaster affected the marriage outcomes of the two groups along different dimensions. For cohort 2, there was a delay in the age at marriage by about 3 years. On the other hand, the disaster significantly reduced the likelihood of ever getting married for men born after the disaster (cohort 3). Additionally, conditional on getting married, the disaster expedited this cohort's age at marriage by about six months.[6]

Table 1: Effect on Men's Probability of Marriage and Age at Marriage

	Ever married (1)	Married by age 25 (2)	Married by age 21 (3)	Age at marriage (4)
Cohort 2 × Bhopal	0.01	−0.24***	−0.18***	2.69***
	(0.01)	(0.02)	(0.03)	(0.23)
Cohort 3 × Bhopal	−0.30***	−0.26***	−0.06*	−0.47*
	(0.03)	(0.03)	(0.03)	(0.26)
Observations	6,349	6,349	6,349	5,779
R-squared	0.17	0.17	0.21	0.28

Notes: *** and * denote significance at the 1% and 10% level respectively. Cohort 2 and cohort 3 are the two disaster-affected groups, and cohort 1 forms the omitted category Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of birth dummies.

Dhara and Dhara (2002) reveal that migration post-disaster was relatively low: about 91% of individuals continued to reside in the same area after 1984. Nevertheless, individuals may have subsequently moved to escape negative health consequences or to avoid the stigma of being from Bhopal. To ensure that our results are robust to such migration spells, we limit our sample to individuals who report that they have always lived in their current place of residence: this reduces our sample size by about 27.5%. The results from estimating equation (1) for non-

[6] Anecdotal evidence suggests that men in Bhopal district face social stigma for being from Bhopal. This discrimination extends beyond individuals who suffer from lasting health effects due to the gas leak and includes their family members who may be in good health. As a result, this population has witnessed difficulty in getting married, and hence there has been a reduction in marriages (Trivedi 2017).

movers are given in Panel A of Appendix Table A2, which we find to be quantitatively similar to the full sample results. Again, migration following the disaster is most likely to shift people in and out between Bhopal and its bordering districts. Thus, a second robustness check is to rule out the possibility that such a cross-district pattern of migration is driving our main results. We re-estimate equation (1) while excluding the bordering districts of Bhopal and again find from Panel B of Appendix Table A2 that the results are unchanged with this sample restriction.

5. Mechanisms

To understand the mechanisms underlying our findings on men's probability of being married and their age at marriage, we consider the impacts of the disaster on health, education, and employment, traits that are valued by potential brides and thus can affect men's attractiveness in the marriage market. Specifically, we look at whether the individual currently has asthma or cancer, their total years of education, and whether they are currently employed. We re-estimate equation (1) with these dependent variables and present these results in Table 2. The point estimates in Column (1) show that men from Bhopal are more likely to report having asthma.[7] In column (2), we find that cohort 2 men also have a higher likelihood of cancer incidence, but no statistically significant effect is found for the cohort born after the disaster (cohort 3).[8] These results corroborate findings from previous literature that document long-term respiratory problems among survivors as well as a greater incidence of cancer (De et *al.* 2020; Dhara and Dhara 2002; Ganguly *et al.* 2017).

Table 2: Effect on Men's Health, Education, and Employment

	Has asthma (1)	Has cancer (2)	Years of education (3)	Currently employed (4)
Cohort 2 × Bhopal	0.06***	0.01***	2.20***	−0.08***
	(0.02)	(0.00)	(0.28)	(0.03)
Cohort 3 × Bhopal	0.05***	−0.00	0.00	−0.26***
	(0.02)	(0.00)	(0.34)	(0.03)
Observations	6,349	6,336	6,349	6,349
R-squared	0.04	0.03	0.44	0.06

Notes: *** denotes significance at the 1% level. Cohort 2 and cohort 3 are the two disaster-affected groups, and cohort 1 forms the omitted category Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of birth dummies.

[7] On-the-ground reporting suggests that the Bhopal Gas Disaster has significant intergenerational effects. Individuals exposed to the disaster, their children, and their grandchildren continue to suffer from the aftereffects of the leak (Pundir 2019).

[8] We exercise caution with the cancer results for two reasons: a) a very small proportion of the sample report currently suffering from cancer and b) the true effect on cancer incidence is likely to be underestimated because of the higher mortality risks associated with the disease and given we do not have data on cancer deaths.

Next, in column (3), we find that cohort 2 men from Bhopal have 2.2 more years of education: this is a result that aligns well with the age at marriage effect found for this cohort from Table 1. One potential explanation is that these individuals stay longer in school to increase their attractiveness in the marriage market.

There is a strong interplay between human capital and the probability of being employed. Any adverse health effects of the disaster would reduce the employability of individuals. However, it is not *a priori* clear how increased educational attainment is associated with the probability of being currently employed. While educated individuals are more attractive candidates in the labor market, they could also be substituting work with higher education. In column (4), we observe a negative sign on the interaction terms for both cohorts. Specifically, we find that cohort 2 and 3 men from Bhopal district are 8 percentage points and 26 percentage points, respectively, less likely to be currently employed vis-à-vis men in other districts and compared to individuals in cohort 1. The strong negative effect on the employment prospects of cohort 3 individuals aligns with results from McCord *et al.* (2021), who find that men who were in-utero at the time of the disaster had a higher likelihood of being disabled, which negatively impacted their employment opportunities.

In sum, the negative health consequences of the disaster and the weaker employment prospects of men make them less attractive in the marriage market, thereby reducing their likelihood of being married. Individuals who invest more in education can improve their marriage prospects but the prolonged search for a spouse increases their age at marriage.

6. Additional Marital Outcomes

The Bhopal Gas Disaster can have implications on household formation beyond marriage rates and age at marriage. Therefore, we examine additional marital outcomes in Table 3.

Table 3: Effect on Other Marital Outcomes

	Spousal education gap	Wife has asthma	Wife has cancer	Number of children
	(1)	(2)	(3)	(4)
Cohort 2 × Bhopal	−1.54***	0.11***	0.02***	−0.67***
	(0.28)	(0.02)	(0.01)	(0.13)
Cohort 3 × Bhopal	−0.63*	0.05***	0.00	−0.19
	(0.36)	(0.02)	(0.01)	(0.15)
Observations	5,213	5,203	5,206	5,212
R-squared	0.09	0.04	0.03	0.36

Notes: *** and * denote significance at the 1% and 10% level respectively. Cohort 2 and cohort 3 are the two disaster-affected groups, and cohort 1 forms the omitted category Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of birth dummies.

First, we analyze the quality of matches by measuring the spousal education gap and the wife's health. In column (1), we find that the spousal education gap has decreased by 1.54 years

for cohort 2 and 0.63 years for cohort 3 men. One plausible explanation is that women married to cohort 2 individuals are also investing more in education while awaiting marital matches, and this in turn has reduced the spousal education gap. The estimates from columns (2) and (3) denote a higher likelihood of men being matched with women who also suffer from asthma and cancer. Finally, we assess the fertility implications of the disaster in column (4). The DID coefficients indicate a reduction in fertility for cohort 2 men. No statistically significant effect is found for cohort 3 men. These results are externally valid to natural disasters, where changes in fertility have also been observed (Davis 2017; Nandi *et al.* 2018).

7. Concluding Remarks

The Bhopal Gas Disaster of 1984 continues to be one of the world's most devastating industrial disasters. The high death toll in the aftermath of the catastrophic gas leak and the persistence of negative health effects begs for careful evaluation of the demographic consequences of the industrial disaster. While the literature has heavily focused on the health effects of exposure to MIC, very few have explored education and labor market outcomes, and no study has systematically investigated the marital outcomes of the survivors.

Our study fills this gap by specifically looking at the marriage market effects of the disaster. Men who were unmarried at the time of the disaster experience a delay in their marriage, but we do not see any significant changes in their marriage rates. However, those born after the gas leak face a higher probability of not getting married. When we examine the pathways that drive our results, we find that adverse health effects and lower employment opportunities are likely responsible for the reduced marriage market attractiveness (as indicated by lower marriage rates and increase in age at marriage) of men from the district of Bhopal.

The results of our study show how industrial disasters can bring about significant changes in the marriage market. While it is important to document the health consequences of industrial disasters, there is an additional need for careful introspection of these disasters' impact on the demographic composition of the region. This will allow for a more comprehensive understanding of the impact of industrial disasters and may help instigate rapid prevention and mitigation efforts of any such future events.

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Appendix

Table A1: Summary Statistics by Cohort

	Cohort 1			Cohort 2			Cohort 3		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Outcome Variables									
Man ever married (=1)	1.00	0.00	491	0.95	0.21	4,323	0.74	0.44	1,535
Man married by age 25 (=1)	1.00	0.00	491	0.74	0.44	4,323	0.64	0.48	1,535
Man married by age 21 (=1)	0.88	0.32	491	0.46	0.50	4,323	0.36	0.48	1,535
Man's age at marriage	18.07	2.58	491	22.35	4.59	4,122	21.63	3.35	1,166
Man's years of education	4.89	4.58	491	7.02	5.15	4,323	8.39	4.67	1,535
Man currently working (=1)	0.88	0.32	491	0.90	0.30	4,323	0.85	0.36	1,535
Man has asthma (=1)	0.05	0.21	491	0.02	0.13	4,323	0.01	0.07	1,535
Man has cancer (=1)	0.00	0.00	490	0.00	0.05	4,313	0.00	0.05	1,533
Spousal education gap	3.60	4.15	390	2.38	4.16	3,803	1.47	4.23	1,019
Wife has asthma (=1)	0.04	0.20	388	0.02	0.15	3,795	0.01	0.10	1,019
Wife has cancer (=1)	0.00	0.06	388	0.00	0.05	3,798	0.00	0.04	1,019
Number of children	4.09	1.80	491	3.01	1.58	4,122	1.71	1.16	1,166
Controls									
Urban	0.24	0.43	491	0.34	0.47	4,323	0.31	0.46	1,535
Hindu	0.96	0.20	491	0.93	0.26	4,323	0.94	0.24	1,535
Caste									
Scheduled Caste (SC)	0.18	0.39	491	0.18	0.39	4,323	0.20	0.40	1,535
Scheduled Tribe (ST)	0.21	0.40	491	0.18	0.39	4,323	0.18	0.38	1,535
Other Backward Classes (OBC)	0.47	0.50	491	0.47	0.50	4,323	0.48	0.50	1,535
General caste	0.14	0.34	491	0.17	0.37	4,323	0.14	0.35	1,535
Wealth Quintile									
1 (poorest)	0.17	0.38	491	0.17	0.37	4,323	0.16	0.37	1,535
2 (poorer)	0.23	0.42	491	0.17	0.38	4,323	0.19	0.39	1,535
3 (middle)	0.19	0.39	491	0.18	0.39	4,323	0.18	0.38	1,535
4 (richer)	0.22	0.42	491	0.22	0.42	4,323	0.24	0.42	1,535
5 (richest)	0.19	0.39	491	0.25	0.43	4,323	0.23	0.42	1,535

Notes: Sample is restricted to the male residents of Madhya Pradesh. Cohort 1 consists of individuals already married by 1984, the date of the Bhopal Gas Disaster. Cohort 2 and cohort 3 are the two disaster-affected groups. Cohort 2 was born prior to 1984 but unmarried at the time of the disaster. Cohort 3 includes individuals born after the disaster.

Table A2: Robustness of Main Results

	Ever married (1)	Married by age 25 (2)	Married by age 21 (3)	Age at marriage (4)
Panel A: Non-Movers				
Cohort 2 × Bhopal	−0.02	−0.26***	−0.31***	3.39***
	(0.02)	(0.04)	(0.04)	(0.32)
Cohort 3 × Bhopal	−0.33***	−0.20***	−0.23***	0.48
	(0.03)	(0.04)	(0.05)	(0.36)
Observations	4,602	4,602	4,602	4,169
R-squared	0.18	0.19	0.21	0.29
Panel B: Excluding Bhopal bordering districts				
Cohort 2 × Bhopal	0.01	−0.23***	−0.17***	2.53***
	(0.01)	(0.02)	(0.03)	(0.23)
Cohort 3 × Bhopal	−0.31***	−0.25***	−0.05	−0.61**
	(0.03)	(0.03)	(0.04)	(0.27)
Observations	5,768	5,768	5,768	5,259
R-squared	0.17	0.18	0.22	0.29

Notes: *** and ** denote significance at the 1% and 5% level respectively. Cohort 2 and cohort 3 are the two disaster-affected groups, and cohort 1 forms the omitted category Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of birth dummies.