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Long-term effects of malnutrition on early-life famine survivors and their offspring: New evidence from the Great Vietnam Famine 1944–45

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[Correction added on 21 May 2021, after first online publication: Last author's name and acknowledgment statement have been updated in this version.]

Abstract

We investigate the long-term effects of the 1944–45 Great Vietnam Famine on early-life survivors and their offspring using census data, household survey data and historical administrative data. Unlike previous famine studies, we measure famine severity using a unique, more direct, and "plausibly exogenous" metric of food availability: province-level excess paddy (rice) production per capita in 1944. Our study makes two novel contributions. First, we overcome several selection problems associated with the estimation of true famine effects, given the short duration and spatial variation of the Vietnamese famine. Second, we investigate the intergenerational effects of famine, focusing specifically on the occupation of the survivors' parents and the school participation of the survivors' offspring. Our preferred specification estimates generalized triple differences that allow us to control for birth-year and birth-province fixed effects and nation-wide shocks. Our findings suggest that the Vietnamese famine reduced literacy by around 3 percent, BMI by 5.6%–8.4%, arm-length by 4.5%–6.7% (1.1–1.7 cm), height by 2.2%–3.2% (3.4–5 cm), and weight by 10%–14% (4.7–6.9 kg) among the affected cohort. These detrimental famine effects also extended to economic welfare, in the form of lower household incomes and lower non-food household expenditures in adulthood. We also document a 4.9%–7.2% reduction in school participation among survivors' offspring, which has major implications for the exogenous origins of social mobility, inequality, and poverty.

KEYWORDS
famine, human capital, health, intergenerational transmission, Vietnam

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1 | INTRODUCTION

Studies on the long-term consequences of early-life shocks—such as malnutrition, worms, maternal anxiety, pollution, extreme weather, war, and even parents' alcohol consumption—are abundant and growing. The most notable strand of this literature finds that early-life nourishment shapes individuals' human capital through health and cognitive channels (Berg et al., 2016; Case & Paxson, 2008a, 2008b; Currie, 2011; Glewwe & Jacoby, 1995; Kim et al., 2017; Maluccio et al., 2009). Grantham-McGregor et al. (2007) estimated that more than 200 million children under 5 years in the developing world were unable to reach their full cognitive potential in 2004 due to malnutrition. In addition, in 2012–2016, around 9.5% of children were wasted while 27.8% of them were stunted (Towey et al., 2017). The United Nations declared that more than 20 million people in Nigeria, Somalia, South Sudan, and Yemen were at risk of famine in 2017. Indeed, malnutrition is present even in advanced economies. For instance, McCrindle (2017) estimated that 3.6 million Australians experience food insecurity at least once a year.

Several studies in the literature have exploited nationwide famines as natural experiments to identify the causal effects of malnourishment.[1] Some papers use only the cohort variation in their identification when the famine duration is very short, which reduces the fertility bias (Gørgens et al., 2012; Neelsen & Stratmann, 2011; Scholte et al., 2015). However, using only the cohort variation could be problematic because cohorts could face other shocks later in life differentially. More recent studies address this problem by exploiting the cohort variation in combination with spatial variation in the severity of famine exposure. These papers generally measure the famine severity using the famine-induced mortality in each geographic division (Almond et al., 2007; Ampaabeng & Tan, 2013; Chen & Zhou, 2007; Lindeboom et al., 2010). However, the use of famine-induced mortality may be misleading because of its sole focus on "starvation." Famine-related deaths occur at the extreme point of malnutrition and represent the extensive margin of famine severity. They also create mortality- and fertility-related selection problems. For instance, a recent body of literature reports that the long-term effects of the Great China Famine of 1959–1961[2] are very small when such selection problems are accounted for. Xu et al. (2016) report that the effects of the Chinese famine are highly sensitive to the choice of health outcome, famine severity measure, and regression model. The authors conclude that there is little evidence supporting the fetal origins hypothesis in the case of the Chinese famine.

Another important strand of this literature examines the intergenerational effects of early-life malnutrition. Hunger during fetal development and early childhood may cause metabolic syndromes that can transfer between generations through epigenetic inheritance (see Barker, 1990; Lumey & Stein, 1997). However, most of the available evidence is drawn from medical studies which have been criticized for their small sample sizes (see, for instance, Veenendaal et al., 2013). There is a paucity of studies on the intergenerational effects of famine exposure in the social sciences literature. Notably, Kim et al. (2014) focus on the intergenerational schooling effects of the Great China Famine and find that a mother's malnutrition reduced the second generation's entrance into junior secondary school by about 5%–7% points.[3] However, data limitations mean that the literature on the intergenerational effects of shocks may not identify all of the households' offspring. This leads to a sample selection bias in intergenerational transmission effects (Black & Devereux, 2011; Emran et al., 2018).

The key objective of the present paper is to investigate the long-term effects of the Great Vietnam Famine of 1944–45 on early-life survivors' adulthood outcomes and those of their offspring.[4] Our study empirically exploits this famine for the first time in the literature and makes two novel contributions. First, unique features of this famine and our high-quality data enable us to overcome several problems associated with the estimation of true malnutrition effects. The Vietnamese famine was caused by the combination of widespread crop failure in 1944 and the military actions of belligerent powers in WWII. A blockade of Vietnam's North–South railway as a result of U.S. air raids on Japanese troops stationed around the railway on the 17th parallel prevented food from the south being transported north of that point, which crippled the already food-short Northern provinces. However, the authorities reversed this imprudent intervention after a few months, making the famine short-lived. This short duration ensures that the fertility bias among famine-affected birth cohorts is limited while the treatment and control groups are quite similar. The short duration also ensures that the interprovince migration bias in our estimates is minimal. An additional advantage of the Vietnamese famine for our purposes is its strong spatial variation across the country. The famine occurred only above the 17th parallel, with the areas south of the 17th parallel experiencing no famine at all. This variation enables three-way interaction models that can isolate nationwide shocks at the time of the famine.

Second, we investigate the persistence of famine effects across survivors and their children. Specifically, we focus on the occupations of the survivors' parents and the school participation of the survivors' offspring. Importantly, a lack of school participation has direct implications for the child labor problem because famine survivors' children form a large proportion of the population of Vietnam today. We can generate a subsample of Vietnam census data that includes all of the famine survivors' children. Thus, we overcome the sample selection bias when studying intergenerational effects. Overall, our findings have major implications for our understanding of the exogenous origins of social mobility, income inequality, and poverty across individuals and geography in Vietnam.

Our empirical approach departs from the existing literature in two key dimensions. First, we use a unique, more direct, and "plausibly exogenous" metric of food availability to measure famine severity. We exploit province-level excess paddy production per capita in 1944 as a novel measure of the food supply and a distinct proxy for the famine severity. This measure is a reverse measure of the paddy production deficit and has major advantages over the mortality rate when studying malnutrition effects. One potential problem with its use is that rice production is not always equal to rice consumption. However, we discuss several historical anecdotes which suggest that rice production and consumption would have been roughly similar across Vietnamese provinces at the time of the famine. Second, we differ from the literature in terms of our identification approach. Most of the previous famine studies have been based on settings where the famine was widespread across the entire country. This made it difficult for those studies to isolate the effects of other concurrent nationwide shocks such as wars, coups, and diseases. The spatial dichotomy of the famine's presence in Vietnam (North vs. South) helps us to control for such concurrent nationwide shocks. We achieve identification through a three-way interaction of provincial excess paddy per capita, being born in North versus South Vietnam, and being born around the famine period.

We use two rich, high-quality datasets that provide complementary information for our investigation. The first is the 1989 National Population and Housing Census, which comprises 2.6 million person-observations, representing a random 5% sample of Vietnam's population. The Vietnamese census provides information on each respondent's month of birth, which allows us to match the treatment group with the famine period precisely. The census data also allow us to identify the survivors who live in the same household with their ever-born children. Thus, we can isolate a potential selection bias in the intergenerational transmission estimates. The second dataset consists of the 1993 and 1998 rounds of the Vietnam Household Living Standards Survey (VHLSS). These waves include information on whether an individual had ever moved away from their birth province, as well as whether the respondent's birthplace was an urban or rural area. Thus, we can test for a potential bias in our estimates as a result of internal migration. The VHLSS also provides some rare outcome variables, such as individuals' arm-lengths, household income and non-food expenditures. This helps us to overcome the pitfalls associated with the outcome measures in the census dataset (literacy and education). Finally, the VHLSS includes background information (such as agricultural employment) for each parent of the famine survivors, even if they are deceased or not part of the household. This allows us to examine the effects of the famine on adult outcomes based on survivors' parental background.

We estimate two-way interactions between the treated cohort and excess paddy per capita in 1944 in famine-affected areas (i.e., North Vietnam). We also estimate three-way interactions among the treated cohort, excess paddy per capita in 1944, and an indicator of North versus South Vietnam. A positive and significant coefficient on the double interaction term implies that survivors who were exposed to famine in the Northern provinces with greater declines in food availability ended up with lower human and health capital than survivors from the Northern provinces with smaller declines in food availability. The three-way interaction is our preferred specification because it enables us to control for birth-year and birth-province fixed effects, as well as nationwide shocks. A positive coefficient on these triple interaction terms implies that survivors who were exposed to the famine in Northern provinces with greater declines in food availability ended up with lower human and health capital than those in Southern provinces with similar declines in food availability. Thus, our findings point to the detrimental (negative) effects of famine on survivors' human and health capital in famine affected areas.

Evaluating the effect of famine in the preferred three-way interaction models, we find that literacy declined by around 3% relative to the outcome mean. This is a sizeable effect compared to previous findings. BMI declined by 5.6%–8.4% due to famine, while arm-length decreased by 4.5%–6.7% (or 1.1–1.7 cm). Similarly, famine reduced height by 2.2%–3.2% (3.4–5 cm) and weight by 10%–14% (4.7–6.9 kg) among the affected cohort. The detrimental famine effects also extended to economic welfare, with lower household incomes and lower non-food household expenditures in adulthood.

We also find significant intergenerational effects of famine. Famine effects are transmitted to the second generation in the form of lower school participation at school-appropriate ages. Our findings indicate that children whose parents were born in famine-affected areas around the famine period have a 4.9%–7.2% lower school attendance than other children. These outcomes seem to be driven by famine-survivor cohorts who were born in rural areas and whose parents (i.e., grandparents of the offspring) worked in the agricultural sector. This means that individuals from lower socioeconomic backgrounds were hit harder by the famine and their children were affected more negatively in terms of human capital accumulation.

We investigate the potential for bias as a result of postfamine internal migration[5] using VHLSS. We estimate a regression of whether an individual *ever* moved from his/her birth-province on our triple interaction term controlling for other factors. We find insignificant effects for the full sample, as well as for the rural and urban samples. This finding implies that the famine did not cause any individuals *ever* to leave their birth-provinces. As both the VHLSS and census data are representative samples of the Vietnamese population, this finding confirms that triple differences are doing good job of alleviating the migration bias, and neither temporary nor permanent internal migration would bias the famine effects significantly. Our results are also robust to different specifications, a variety of selection issues, falsification tests, and alternative famine-severity indicators.

The rest of this paper is organized as follows: Section 2 discusses the historical context of the Vietnamese famine. Data are presented in Section 3, and the identification strategy is provided in Section 4. Section 5 discusses the results. Section 6 concludes.

2 | THE GREAT VIETNAM FAMINE OF 1944–45

The Great Vietnam Famine of 1944–45 was unquestionably one of the worst human tragedies of modern times. Different accounts provide different death toll figures, ranging between 1 and 2 million human lives. The famine occurred between October 1944 and May 1945, only in areas to the north of the 17th parallel.[6] Previous studies have argued that crop failures from 1943 to 1945, the disruption of trade between North and South due to the U.S. bombing of the "Transindochinois" railway line during WWII (Figure 1), and adverse climatic conditions all played critical roles in

FIGURE 1 Railway network in Vietnam 1944–45. U.S. bombing of the "Transindochinois" railway line during WWII. Strategic bombing by the United States disrupted the rice trade between the famine-affected and famine-unaffected areas of Vietnam [Colour figure can be viewed at wileyonlinelibrary.com]

the emergence of this famine.[7] Several historical accounts attribute the plummeting rice supply to crop failure. This adverse supply shock was caused by natural calamities.[8] Figure 2 presents per-capita paddy production in 1944 for 48 provinces in Vietnam. The 20 provinces in the famine-affected areas lie to the left of the vertical line, while the 28 provinces in the famine-unaffected areas are situated to its right.[9] Clearly, the average paddy production per capita was much lower in the affected areas (182 kg/year) than in the unaffected areas (343 kg/year). Indeed, several provinces in the affected areas produced amounts that were well below subsistence levels. For example, Nam Dinh, Ha Nam, and Phu Tho produced only 120 kg/year per capita.[10] Conversely, the provinces located in the Mekong River Delta (those at the far right of the figure) produced more than 700 kg/year per person. Typically, Vietnamese authorities transported rice from the South to the North via the North–South railway to even out consumption across the country.

Figure 3 displays the "detrended" paddy production per capita in 1944 for each province. This is the difference between paddy production per capita in 1944 and the average paddy production per capita in the previous 2 years (1943 and 1942). The figure shows two relevant facts. First, Vietnam overall experienced a sharp decline in rice production in

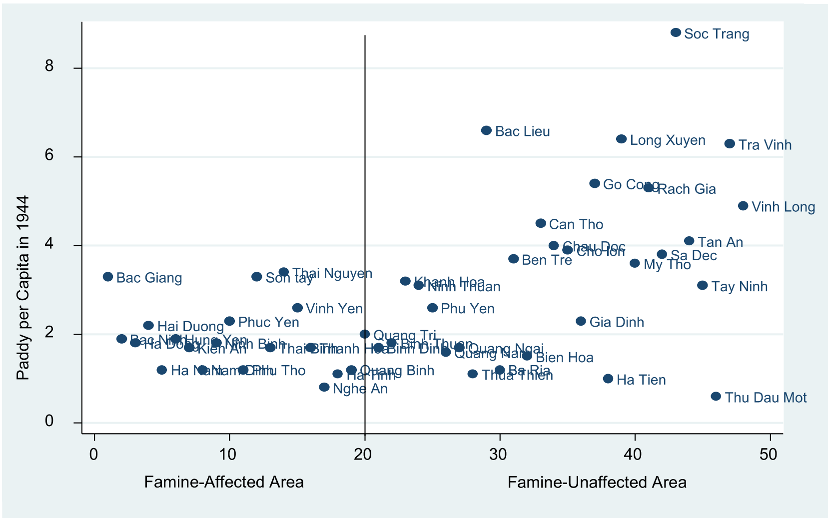

FIGURE 2 Distribution of provincial paddy production per capita in 1944 in Vietnam. The *x*-axis represents the provincial code, while the *y*-axis is the paddy per capita in 1944. *Famine-affected area* refers to the regions which are located to the north of the 17th parallel, namely the Red River Delta, Northeast, Northwest, and North Central Coast, which make up the famine-affected part of Vietnam. *Famine-unaffected area* refers to the South East and Mekong River Delta regions, which were not affected by the famine [Colour figure can be viewed at wileyonlinelibrary.com]

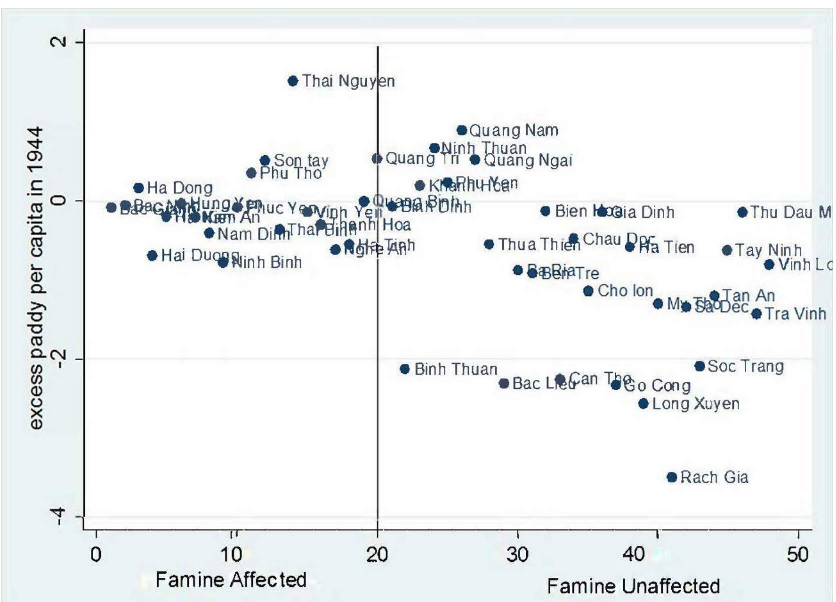

FIGURE 3 Distribution of provincial excess paddy production per capita in 1944 in Vietnam. The *x*-axis represents the provincial code, while the *y*-axis is the excess paddy per capita in 1944. *Famine-affected* refers to the regions which are located to the north of the 17th parallel, namely the Red River Delta, Northeast, Northwest and North Central Coast, which make up the famine-affected part of Vietnam. *Famine-unaffected* refers to the South East and Mekong River Delta regions, which were not affected by the famine [Colour figure can be viewed at wileyonlinelibrary.com]

1944 compared to the previous 2 years. The unaffected areas experienced higher levels of decline compared to the affected areas, which is not surprising because production levels are higher in South Vietnam. Second, several provinces in the affected areas experienced declines to levels below their 1942 and 1943 production amounts.

Human interventions subsequently aggravated the impacts of these adverse supply shocks. We identify at least three human factors in this vein. The first is the increased scale of the Japanese invasion in Vietnam during WWII. Japanese authorities compelled peasants to sell a predetermined quantity of rice to the state at a flat procurement rate during their invasion period (September 1940–October 1945). This flat rate was between 2% and 9% of the market value (Phong, 2002, p. 106). Vien (1975) says that the inhabitants of the affected areas were forced to supply 130,000 and 186,000 tonnes of rice to the Japanese authorities in 1943 and 1944, respectively. In addition, peasants who experienced low rice yields and could not meet their obligatory quotas had to purchase rice on the open market at a higher price and sell it to the state at the lower procurement rate to meet their quotas.[11]

The second human intervention occurred in Tonkin in 1941–44, where Japanese authorities chose to uproot rice and plant industrial crops, to provide gun bags and other equipment for their troops in WWII. According to the General Statistics Office of Vietnam (GSO, 2004, p. 67), jute plantations in Tonkin increased from 3000 hectares in 1942 to 12,993 hectares in 1944. Analogously, areas for cotton cultivation were extended from 1000 hectares in 1942 to 2990 hectares in 1944. Moreover, sesame cultivation increased from 1200 hectares in 1942 to 3219 hectares in 1944. The increased planting of industrial crops alone decreased the amount of arable land that was available for rice by more than 6% between 1942 and 1944. This caused an adverse supply shock in the rice market in famine-affected areas (GSO, 2004, p. 51). Coupled with the disrupted market mechanism mentioned above, this supply shock reduced the availability of rice substantially for thousands of rural households.

The third intervention was the strategic bombing of Vietnam's central provinces by the United States, to weaken the Japanese troops stationed there. The bombing specifically targeted the "Transindochinois" railway line, which was the only railway network that connected the South to the North. This led to a significant reduction in freight movement between famine-affected and -unaffected areas. As a result, annual rice shipments from the South to North fell by 77% from 1943 to 1944 (Marr, 1997). The sudden decrease in both rice production and the transportation of rice from the South to the North led to large increases in the price of rice in the North. The market price of rice in the North increased by 1400% (Marr, 1997, p. 98), while that in the South did not rise noticeably until the U.S. bombing ended.[12] People in the North attempted to cope with this situation by turning to substitute goods (corn, yams, manioc, beans). However, the price of substitutes became prohibitive for ordinary citizens, eventually triggering the famine.

Food scarcity varied significantly in the affected regions. Japanese officials allocated most of the grain in the warehouses to the urban population. Moreover, the winter of 1944 was unusually cold. As a result, households living in rural areas and far from urban areas experienced the famine more severely (see Marr, 1997, p. 101). The Japanese authorities finally abolished the system of obligatory rice sales in June 1945. Later, in October 1945, the French Government transported at least 60,000 tonnes of rice from the unaffected areas to the affected areas, which reduced the food scarcity (Marr, 1997, p. 99).

The famines in Greece and China were widespread across the country and triggered secondary disasters. However, the famine in Vietnam was experienced only in the provinces that lie to the north of the 17th parallel (famine-affected area), whereas the provinces to the south of the 17th parallel (famine-unaffected area) did not suffer famine at all. In addition, the Vietnamese famine did not trigger secondary catastrophes such as epidemics that might have affected individuals' long-term cognitive and socioeconomic outcomes (Hionidou, 2006).

3 | DATA

Our first data source is the 1989 Vietnamese Census, which we obtained from Minnesota Population Center (2013) and includes a wide array of demographic information for each household member. The major advantage of the census is its large sample size. However, it does not provide information on individuals' birth provinces. Thus, our estimates using the census data are subject to a migration bias because individuals might have moved from their birth provinces. We overcome this disadvantage by complementing the census data with the 1993 and 1998 rounds of the VHLSS. The latter includes critical information on current and birth provinces, along with emigrating provinces during the life cycle. Using this information, we measure whether individuals *ever* moved from their birth provinces and show that temporary/permanent migration from the birth province was not driven by famine severity (see Section 5.3).

It is also important to control for parental characteristics in order to estimate true famine effects. The census data include information on parents who are alive and live with the respondent in the same household. However, the VHLSS includes information on both parents of respondents, regardless of whether they are dead or alive and whether or not they are present in the household at the time of the survey. Furthermore, VHLSS indicates whether respondents were living in an urban or a rural area at the time of their birth. This enables us to link the food supply shock to affected individuals more precisely. Finally, VHLSS includes information on BMI, height, weight, the unique measure of arm-length, and food and non-food expenditures. The latter two help to shed a stronger light on the socioeconomic consequences of famine. Meanwhile, the Vietnamese census provides information on the total number of children born in the household. Using this information, we can generate a sufficiently large subsample of survivors who live with all members of their offspring and remove any potential sample selection bias in intergeneration transmission effects.

3.1 | Definitions of treatment and control groups

We define our treated cohort relative to the most severe period of the famine between October 1944 and May 1945, following Neelsen and Stratmann (2011). Figure A1 summarizes the definitions of the treatment and control groups. Our regression sample in the 1989 census data includes individuals who were born between May 1939 and July 1949. Thus, our treatment group includes those born between October 1, 1942 and February 28, 1946, while our control group includes those born in the periods May 1, 1939 to September 30, 1942 and March 1, 1946 to July 31, 1949.

3.2 | Dependent variables

Literacy is defined as 100 if a person is literate and 0 otherwise. Figure 4 presents significant evidence about the adverse effects of famine based on the adjusted means (controlling for gender) of literacy by birth year for the famine-affected and -unaffected areas.[13] The figure indicates that the affected areas experienced a sharp decline in literacy rates for cohorts born in 1943 and 1944. In contrast, literacy in the unaffected areas exhibits a unidirectional increase during the same period.

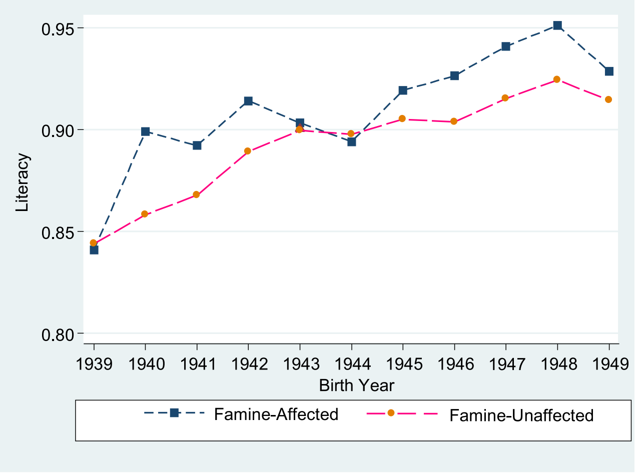

FIGURE 4 Literacy by birth year around famine (Census round 1989). *Famine-affected* refers to areas which are located to the north of the 17th parallel, namely the following provinces: Ha Noi, Ha Tay, Hai Phong, Hai Hung, Thai Binh, Ha Nam Ninh, Ha Tuyen, Cao Bang, Lang Son, Hoang Lien Son, Bac Thai, Vinh Phu Ha Bac, Quang Ninh, Lai Chau, Son La, Thanh Hoa, Nghe Tinh, Quang Binh, Quang Tri, Thua Thien–Hue. *Famine-unaffected* refers to the areas which are located to the south of the 17th parallel, namely the following provinces: Quang Nam–Da Nang, Binh Dinh, Quang Ngai, Phu Yen, Khanh Hoa, Gia Lai–Kon Tum, Dac Lac, Thuan Hai, Lam Dong, Ho Chi Minh City, Song Be, Tay Ninh, Dong Nai, Vung Tau–Con Dao, Long An, Dong Thap, An Giang, Tien Giang, Ben Tre, Cuu Long, Hau Giang, Kien Giang, Minh Hai [Colour figure can be viewed at wileyonlinelibrary.com]

Outcome variables from the VHLSS enable us to study a wide array of adult well-being indicators beside education. These include BMI, weight (in kg), height, and arm length (the latter two in cm). Arm-length is an unusual piece of information, but has been suggested to be a much better indicator of malnutrition than height (Grellety & Golden, 2016).

3.3 | Independent variables

Data on paddy per capita in 1944 (kg/capita) are obtained from *Vietnam Statistical Data in the 20th Century* (GSO, 2004); the measure is calculated as the total rice production divided by the population for each province. Vietnam was an agricultural society during this period and depended heavily on rice for its food. However, the only rice available to residents of Vietnam in the early days of the famine was the poor summer harvest of 1944, since, for various reasons, paddy production in the affected areas was already at subsistence levels before 1944 (see Figure 2). Due to bad weather conditions, there was no harvest in the winter months of 1944 and 1945, and the next harvest was not possible until June 1945. The blockade and the destruction of the North–South railway during WWII made it impossible to transport rice from south to north. This left the North in dire circumstances, able to consume only the paddy produced within its borders in 1944. The huge inflation (1400%) was a testament to its dramatic rice shortage. Under these conditions, it is reasonable to assume that the sharing of provincial paddy harvests among Northern provinces would have been restricted severely; thus, paddy consumption per capita in 1944 would not have differed dramatically from paddy production per capita at the province level.

Excess paddy per capita in 1944 (kg/capita) is calculated as the difference between paddy production per capita in 1944 and the average of paddy production per capita in the previous 2 years (1943 and 1942) for each province. The objective here is to detrend the rice production in 1944 and capture its deviation from the previous 2 years. We believe that this "excess" measure is "plausibly exogenous" to other provincial characteristics and enables us to estimate the true effects of famine.[14]

4 | EMPIRICAL FRAMEWORK

Some of the previous studies exploit only the cohort variation when investigating famine effects. Despite the short duration of the Vietnamese famine, relying on only cohort variation in the estimations could be misleading. This is because some of our outcome variables, such as literacy, could also change in response to other events later in life. For example, Vietnam undertook a few literacy and education reforms after the end of French colonial rule in 1954. Moreover, cohorts born between 1939 and 1949 also experienced the Vietnam–American War, which led to significant disruptions to schooling. Our estimates might not reflect true famine effects if the treatment and control groups responded to these shocks differently. We hedge against such problems by exploiting variations across cohorts along with variations in food availability (i.e., famine intensity) across provinces. Specifically, we estimate the following model[15]:

$$Y_{ijt} = \text{cons} + \alpha_j + \mu_t + \gamma_1 \left(\text{Treated Cohort Dummy} * FI_j\right) + \gamma_2 \text{ Treated Cohort Dummy} + \gamma_3 FI_j + \gamma_4 X_{it} + \gamma_5 P_{it} + \varepsilon_i, \quad (1)$$

where the dependent variable Y_{ijt} is an adulthood outcome of individual i born in province j and in year t. Treated Cohort Dummy is a binary variable that is equal to 1 if individual i was born between October 1942 and February 1946 and 0 if individual i was born between May 1939 and September 1942 or between March 1946 and July 1949. FI denotes famine intensity, as measured by excess province-level paddy production per capita. α_j stands for birth-province-fixed effects, while μ_t stands for birth-year-fixed effects. X_{it} includes a male dummy, year of birth, year of birth squared (to account for nonlinearities in the outcome trends; see Neelsen & Stratmann, 2011), a dummy for urban residence, and a dummy for belonging to Kinh ethnicity. P_{it} includes parental controls, including mother's schooling, father's schooling, a dummy for whether or not mother works in agriculture, and a dummy for whether or not father works in agriculture.[16] Parental controls are available only for parents who live in the same household as the respondent in the census; however, in the VHLSS data they are available for all parents regardless of their residence and mortality status. Our tables report only the coefficients and the *t*-statistics of γ_1.

Unlike other famines studied in the literature, the Vietnamese famine occurred only in some parts of the country. However, in such times of political and economic turmoil, there could have been other nationwide shocks. Indeed, paddy production went down even in unaffected areas of Vietnam in 1944 (see Figure 3). This implies that our results might simply reflect differences between affected and unaffected areas. Our preferred specification hedges against such possibilities by exploiting the variations across cohorts, the famine intensity across provinces, and the affected–unaffected dichotomy in famine presence. Hence, we estimate a three-way interaction model as follows:

$$\begin{aligned} Y_{ijt} = {} & \text{cons} + \alpha_j + \mu_t + \delta_1 \text{Treated Cohort Dummy} + \delta_2 \text{Famine Affected Area} + \delta_3 FI_j \\ & + \delta_4 (\text{Treated Cohort Dummy} * \text{Famine Affected Area}) + \delta_5 \left(\text{Treated Cohort Dummy} * FI_j\right) \\ & + \delta_6 \left(\text{Famine Affected Area} * FI_j\right) + \delta_7 \left(\text{Treated Cohort Dummy} * \text{Famine Affected Area} * FI_j\right) \\ & + \delta_8 X_{it} + \delta_9 P_{it} + \varepsilon_i, \end{aligned} \tag{2}$$

where Famine Affected Area is a dummy variable that takes a value of 1 if the respondent lived in a province that lay to the north of the 17th parallel (experienced famine) and 0 otherwise. We present the estimates of δ_7 in our tables.

5 | EMPIRICAL RESULTS

5.1 | Descriptive statistics

Table 1a presents the summary statistics of key variables in the census data for our regression sample, which includes approximately 185,000 individuals. Almost 90% of the sample is literate, with a standard deviation of 30.6%. Fifty percent of the sample lives in famine-affected areas, while 30% belongs to the treated cohort group. Seventeen percent of the sample was aged 1–2 during the famine, 7% was born during the famine, and 7% was born within 9 months after the famine. Ninety-five percent of the sample had lived in the same district for the past 5 years before the census. The average paddy production per capita and excess paddy per capita for 1944 are 283 and −56 kg, respectively. The mean mortality rate famine affected areas in 1944 is 32% (Tao & Moto, 1995). Unfortunately, data on the death rate before the famine is not available to enable us to calculate the excess mortality caused by the famine. Table 1b presents the summary statistics of the variables in the VHLSS data.

5.2 | Validity of excess paddy per capita as a famine intensity measure

Column 1 in Table 2 provides the pairwise correlations between the death rate and paddy production from different years, and for famine-affected and unaffected areas. The correlations show that the death rate in 1944 is negatively associated with paddy per capita in 1944 (−0.215) and excess paddy per capita in 1944 (−0.498). The latter association is 2.3 times as strong as the former. This shows that the sudden decline in food availability could capture the famine intensity correctly. However, the death rate in 1944 is associated positively with paddy per capita in both 1942 (0.443) and 1943 (0.201).[17] These contrasting correlations support our argument that our famine intensity measures do not capture some fixed provincial characteristic, and therefore, are "plausibly exogenous" to some provincial characteristics. In addition, there is no association between excess paddy per capita in 1944 and distance to 17th parallel, which rules out the possibility that our measure could be capturing factors related to provincial development, social capital, degree of communism or severity of bombing during the Vietnam–American war (Miguel & Roland, 2011). Finally, although paddy per capita in 1944 has low correlations with paddy per capita in 1942 and 1943 (around 0.4) in the *affected* areas, it has very high correlations with paddy per capita in 1942 and 1943 (around 0.96) in the *unaffected* areas. This observation provides further support for our argument that there was rice crop failure in the famine-affected areas over time while rice production declined radically in the famine-unaffected areas only in 1944.

TABLE 1A Summary statistics in the census data. [Correction added on 21 May 2021, after first online publication: This table has been updated in this version.]

Census round 1989	Mean	Standard deviation	Minimum	Maximum
Literacy (%)	89.514	30.637	0	100
Famine-affected area	0.507	0.500	0	1
Treated cohort dummy	0.302	0.459	0	1
1–2-Year old during famine	0.168	0.374	0	1
Born during famine	0.066	0.244	0	1
Born within 9 months after famine	0.070	0.255	0	1
Age (years)	44.009	3.081	39	49
Birth year	1944.251	3.088	1939	1949
Male	0.456	0.498	0	1
Kinh	0.849	0.358	0	1
Urban	0.432	0.495	0	1
Paddy per capita in 1944 (100 kg/person)	2.834	1.644	1.05	7.7
Excess paddy per capita in 1944 (100 kg/person)	−0.563	0.877	−2.2025	1.515
Death rate in famine-affected areas in 1944 (%)	32.036	20.264	8.4	72.9
Mother's literacy	0.348	0.476	0	1
Migration status with respect to 5 years ago (1/4/1984)				
Live in the same district	0.953	0.212	0	1
Live in the same province but in another district	0.020	0.139	0	1
Live in another province	0.027	0.164	0	1
Number of observations	185,315			

Note: The sample in this table includes individuals who were living in Vietnam at the time of the 1989 census round and were born between May 1939 and July 1949. Treated Cohort Dummy equals 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area equals 1 if the individual lives in regions which are located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest and North Central Coast, and 0 otherwise. Paddy per Capita in 1944 (100 kg/person), Excess Paddy per Capita in 1944 (100 kg/person) and Death Rate in Famine-Affected Areas in 1944 (%) are province-level variables while all others are individual-level variables. All individual variables are dummies unless otherwise mentioned.

5.3 | Long-term effects of famine on literacy

Table 3 presents the estimated effects of malnutrition in the famine-affected areas of Vietnam.[18] Columns 1–6 present the estimation results of Equation (1). The interaction between the treatment dummy and provincial paddy per capita in 1944 is positive. It is also strongly significant across the full, rural, and urban samples (columns 1–3). The estimated coefficient of 0.655 in the full sample implies that each additional 100 kg/year of paddy per capita in a province increases the famine-stricken cohorts' probability of being literate by 0.66%. Columns 4–6 report the results where the treatment dummy is interacted with excess paddy per capita in 1944. The effect is significant at the 10% level with the expected positive sign in the full sample. The effects are also positive in both rural and urban areas, with their *t*-statistics hovering around 1.6–1.8.[19]

Table 4 examines triple interaction models and ensures that our estimates are not biased due to North–South differences or countrywide shocks that could be related to both famine and adulthood outcomes. Recall that the entire country was at war and experienced crop failure in 1944. We show estimates of Equation (2) that provide a three-way interaction effect if such a shock could have had similar effects on both famine-affected and -unaffected areas. Overall, the results remain mostly similar with this specification (columns 1–6). However, focusing on the most significant result in column 6, the interaction term involving excess paddy per capita in 1944 in the rural sample is 1.221,

TABLE 1B Summary statistics in the VHLSS. [Correction added on 21 May 2021, after first online publication: This table has been updated in this version.]

	Mean	Standard deviation	Minimum	Maximum
Treated cohort dummy	0.30	0.46	0.00	1.00
Famine-affected area	0.45	0.50	0.00	1.00
Excess paddy per capita in 1944 (100 kg/person)	−0.57	0.77	−2.32	1.56
BMI	19.95	2.88	11.44	40.42
Arm length (cm)	24.75	2.89	14.50	40.00
Weight (kg)	47.88	8.44	25.10	116.80
Height (cm)	154.70	7.58	127.70	178.70
Household (HH) income (1-5 scale)	3.44	1.34	1.00	5.00
Male	0.44	0.50	0.00	1.00
Age	51.99	5.18	42.00	62.00
Kinh	0.91	0.28	0.00	1.00
Birth year	1943.58	4.47	1936.00	1950.00
Urban	0.28	0.45	0.00	1.00
Never moved from birth province	0.61	0.49	0.00	1.00
Both parents in agriculture	0.74	0.44	0.00	1.00
Neither parents in agriculture	0.15	0.36	0.00	1.00
Log non-food HH expenditures	7.83	0.91	3.88	10.60
Log non-food HH expenditures per person	6.15	0.85	2.78	9.46
Ever attended school	0.88	0.32	0.00	1.00
Number of observations	4320			

Note: The sample in this table includes individuals who were living in Vietnam at the time of the 1989 census round and were born between May 1939 and July 1949. Treated Cohort Dummy equals 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area equals 1 if the individual lives in regions which are located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest and North Central Coast, and 0 otherwise. Paddy per Capita in 1944 (100 kg/person), Excess Pady per Capita in 1944 (100 kg/person) and Death Rate in Famine-Affected Areas in 1944 (%) are province-level variables while all others are individual-level variables.

Abbreviation: VHLSS, Vietnam Household Living Standards Survey.

which is significant at the 5% level. This estimate means that a 100 kg per person decline in rice availability in a province decreases the probability of being literate by 1.221% for the treated cohorts living in famine-affected areas.

Table 5 presents the findings from two falsification exercises using the samples of respondents who lived only in famine-unaffected parts of Vietnam and those who were born abroad, estimating Equations (1) and (2). The estimates are not statistically significant. This supports our argument that our results are unlikely to be explained by factors other than famine-related malnutrition and cannot be attributed to simple North versus South differences.

A significant concern with respect to the validation of our results is the internal migration of famine-affected cohorts. The previous literature on other famines suggests that famine-affected individuals are highly likely to migrate out of their birth provinces. Our estimates will be biased if this migration decision is related to the famine intensity in a province. Table 6 checks this possibility using the VHLSS data. The outcome is a binary variable that indicates whether people have *ever* moved out of their birth provinces as of the survey time. We consider paddy per capita in 1944 and excess paddy per capita in 1944 as famine severity measures across the full, urban, and rural samples. The table reports that individuals' interprovince migration decisions are not related significantly to famine severity. As both the VHLSS and census data are representative samples of the Vietnamese population, this finding confirms that neither temporary nor permanent internal migration is likely to bias famine effects using the VHLSS and census data.[20]

TABLE 2 Pairwise correlations among famine exposure indicators among Vietnamese provinces

	Death rate during famine	Paddy per capita in 1942	Paddy per capita in 1943	Paddy per capita in 1944	Excess paddy per capita in 1944	Distance to the 17th parallel
Panel A: Famine-affected area						
Death rate during famine	1.000					
Paddy per capita in 1942	0.443	1.000				
Paddy per capita in 1943	0.201	0.726	1.000			
Paddy per capita in 1944	−0.215	0.407	0.367	1.000		
Excess paddy per capita in 1944	−0.498	−0.286	−0.299	0.731	1.000	
Distance to the 17th parallel	0.021	0.539	−0.050	0.300	0.085	1.000
Panel B: Famine-unaffected area						
Paddy per capita in 1942		1.000				
Paddy per capita in 1943		0.954	1.000			
Paddy per capita in 1944		0.956	0.973	1.000		
Excess paddy per capita in 1944		−0.893	−0.834	−0.751	1.000	
Distance to the 17th parallel		0.801	0.725	0.670	−0.856	1.000

Note: All variables are province-level indicators.

TABLE 3 Effects of malnutrition on survivors' literacy in famine-affected areas

Census round 1989 Sample→	(1) Full	(2) Urban	(3) Rural	(4) Full	(5) Urban	(6) Rural
Panel A: Coefficient on treated cohort dummy × paddy per capita in 1944						
	0.655** (2.96)					
		0.523*** (3.53)				
			0.735** (2.43)			
Panel B: Coefficient on treated cohort dummy × excess paddy per capita in 1944						
				0.377* (1.86)		
					0.382 (1.83)	
						0.360 (1.59)

Note: OLS regressions, estimating Equation (1). Outcome is a dummy variable that takes a value of 100 if literate and 0 otherwise. The Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

5.4 | Sample selection biases and sensitivity checks

There could be several selection issues in our analysis. The first possible bias is a fertility bias. We check for this by estimating a provincial regression of famine severity indicators on the cohort size differences between the treatment and control groups (Lleras-Muney, 2005). Table 7 reports insignificant coefficients using both paddy per capita in 1944 and excess paddy per capita in 1944 as famine severity measures. This result could be explained by the fact that famine in Vietnam happened suddenly and lasted for only a short time, and therefore may not have given people a chance to react. The second possible bias is an adult mortality bias. As the average age of respondents from the census data in our regression sample is 44 and the average life expectancy among the famine-affected cohort is around 45 (Figure 5), we

TABLE 4 Effects of malnutrition on survivors' literacy: Triple interaction models

Census round 1989 Sample→	(1) Full	(2) Urban	(3) Rural	(4) Full	(5) Urban	(6) Rural
Panel A: Treated cohort dummy × paddy per capita in 1944 × famine-affected area						
	0.676** (2.61)					
		0.399* (1.97)				
			0.903*** (2.83)			
Panel B: Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area						
				0.685* (1.77)		
					0.104 (0.32)	
						1.221** (2.46)

Note: OLS regressions, estimating Equation (2). The outcome is a dummy variable that takes a value of 100 if literate and 0 otherwise. The Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area is equal to 1 if the individual lives in a region which is located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest or North Central Coast, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE 5 Falsification tests: Estimations for people born in famine-unaffected areas or abroad

Census round 1989 Sample→	(1) Famine-unaffected area	(2) Abroad	(3) Famine-unaffected area	(4) Abroad
Panel A: treated cohort dummy × paddy per capita in 1944				
	0.127 (0.70)			
		8.095 (1.26)		
Panel B: Treated cohort dummy × excess paddy per capita in 1944				
			−0.175 (0.51)	
				5.963 (1.09)

Note: OLS regressions, estimating Equation (1). The outcome is a dummy variable that takes a value of 100 if literate and 0 otherwise. The Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Unaffected Area is equal to 1 if the individual lives in a region which is located to the south of the 17th parallel, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

assume that the potential adult mortality bias is probably not too severe for our estimates in the 1989 census data.[21] On the other hand, the adult mortality bias in the VHLSS 1993 and 1998 data could be significant because the famine-affected cohorts in VHLSSs are over 45. However, in an unreported regression we check for adult mortality bias, exploiting the longitudinal aspect of the VHLSS 1993–98 data, and estimate an equation of mortality risk (results available upon request). We find that the mortality risk from 1993 to 1998 at the person level is unrelated to famine exposure. The third possible bias is an infant mortality bias. Infants with weaker genetic endowments may have a lower chance of survival during the famine. However, no data on provincial infant mortality rates during the famine exist to allow us to investigate this possibility. Therefore, we acknowledge that this bias may lead to an underestimation of the true effect of early-life famine exposure.

Another concern is that provincial paddy per capita in 1944 might capture some unobserved characteristics of a province, such as trends in paddy production over time. We address this concern in Table 8 by estimating three-way interaction models where the paddy production per capita in 1944 is replaced with those of 1943, 1942, 1929, 1925, and 1921 (the years for which the paddy production data are available before the famine). The results in rows 1–5 show

TABLE 6 The effect of famine on the probability of ever moving in VHLSS 1993 and 1998

Outcome: Ever moved from birth province Sample→	(1) Full	(2) Urban	(3) Rural	(4) Full	(5) Urban	(6) Rural
Panel A: Treated cohort dummy × paddy per capita in 1944 × famine-affected area						
	−0.00826 (0.30)					
		−0.0679 (0.87)				
			−0.0232 (0.76)			
Panel B: Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area						
				−0.0123 (0.31)		
					−0.0551 (0.51)	
						0.0274 (0.73)
Number of observations	4464	1256	3208	4320	1211	3109

Note: OLS regressions. The outcome variable is a dummy variable that takes a value of 1 if a person has **ever** moved from their birth province and 0 otherwise. Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area is equal to 1 if the individual lives in a region that is located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest or North Central Coast, and 0 otherwise. Robust standard errors are clustered at province level. Absolute *t*-statistics are given in parentheses.

Abbreviation: VHLSS, Vietnam Household Living Standards Survey.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE 7 Famine and potential fertility response

Outcome: Population difference between the treated and untreated cohorts Census Round 1989	(1)	(2)
Paddy per capita in 1944	−15.45	
	(0.23)	
Excess paddy per capita in 1944		−90.56
		(0.70)

Note: Province-level OLS regressions. The outcome variable is the population difference between the treated and untreated cohorts for each province in the census data. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

statistically insignificant estimates of the triple interaction terms. This implies that our findings based on paddy production are likely to be driven by the year 1944 alone.

Table 9 presents a range of other results addressing potential explanations or biases. Rows 1–2 consider alternative definitions of the control group. Row 1 drops the cohorts born before the famine from the control group and considers only those born after the famine as the control group. Row 2 drops the cohorts born after the famine from the control group and considers only the people born before famine as the control group. We find that the statistical significance of the famine effect remains in both specifications.

Row 3 uses the interaction of province dummies and the urban dummy to control for the possibility that provinces' literacy outcomes might differ by urban–rural characteristics. The coefficient on the triple interaction term remains similar in these cases. Row 4 reports the results using siblings fixed effects estimation. As unobserved parental effects may drive literacy outcomes, siblings fixed effects estimation enables us to control for these effects by comparing only siblings. This is a very restrictive approach because the numbers of siblings living in the same residence are very low;

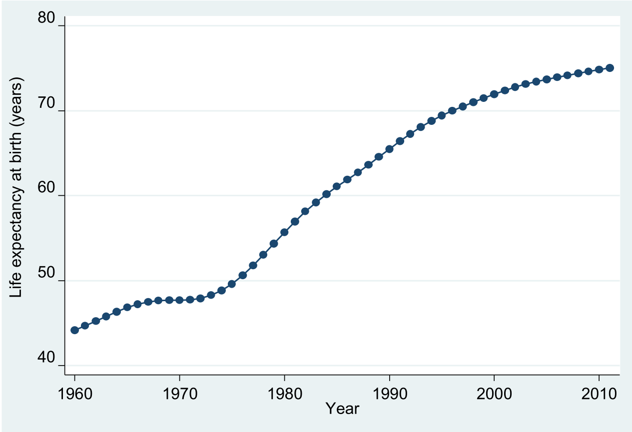

FIGURE 5 Life expectancy in Vietnam [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 8 Vietnamese famine and literacy: Addressing paddy production trends

Census round 1989 Cohorts Born in→	(1) All Vietnam	(2) All Vietnam Urban	(3) All Vietnam Rural
1. Using paddy per capita in 1943			
Treated cohort dummy × famine-affected area	−1.371* (1.81)	−0.545 (0.87)	−1.289 (1.15)
Treated cohort dummy × paddy per capita × famine-affected area	0.479 (1.44)	0.217 (1.00)	0.393 (0.74)
2. Using paddy per capita in 1942			
Treated cohort dummy × famine-affected area	−1.014 (0.94)	−0.854 (1.03)	−0.821 (0.57)
Treated cohort dummy × paddy per capita × famine-affected area	0.317 (0.67)	0.292 (0.82)	0.289 (0.45)
3. Using paddy per capita in 1929			
Treated cohort dummy × famine-affected area	0.864 (0.84)	0.924 (1.46)	1.416 (0.76)
Treated cohort dummy × paddy per capita × famine-affected area	−0.653 (1.68)	−0.578*** (2.91)	−0.886 (1.14)
4. Using paddy per capita in 1925			
Treated cohort dummy × famine-affected area	−1.119 (0.97)	−0.785 (0.95)	−1.236 (0.73)
Treated cohort dummy × paddy per capita × famine-affected area	0.231 (0.59)	0.177 (0.63)	0.322 (0.58)
5. Using paddy per capita in 1921			
Treated cohort dummy × famine-affected area	−0.983 (1.24)	−0.752 (1.29)	−0.809 (0.69)
Treated cohort dummy × paddy per capita × famine-affected area	0.132 (0.81)	0.132 (1.26)	0.102 (0.42)

Note: OLS regressions, estimating Equation (2). Outcome is a dummy variable taking the value of 100 if literate, 0 otherwise. Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area is equal to 1 if the individual lives in a region that is located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest or North Central Coast, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute t-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

nevertheless, we still find a positive coefficient on the triple interaction variable, with a t-statistic of 1.46 in the full sample. Rows 5–6 provide additional robustness tests with respect to possible internal migration by considering only those who have lived in the same district or the same province since 1984, respectively. The results are very similar to those provided in Table 4.

TABLE 9 Vietnamese famine and literacy: Sensitivity tests

Census round 1989 Cohorts born in→	**(1) All Vietnam**	**(2) All Vietnam Urban**	**(3) All Vietnam Rural**
1. Using only people born after the famine as control group			
A. Treated cohort dummy × famine-affected area	−0.844 (1.39)	−0.259 (0.37)	−1.158 (1.36)
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	0.665*** (3.00)	0.358* (1.85)	0.949*** (2.98)
B. Treated cohort dummy × famine-affected area	−0.526 (1.51)	−0.659* (1.83)	−0.194 (0.45)
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	0.693* (1.87)	0.119 (0.37)	1.243** (2.64)
2. Using only people born before the famine as control group			
A. Treated cohort dummy × famine-affected area	−3.052** (2.66)	−1.994** (2.44)	−3.396** (2.25)
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	0.789** (2.30)	0.603** (2.45)	0.854* (1.95)
B. Treated cohort dummy × famine-affected area	−1.540** (2.34)	−1.275** (2.11)	−1.317 (1.46)
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	1.840*** (3.14)	1.016* (1.94)	2.595*** (3.24)
3. Control for province × urban interactions			
A. Treated cohort dummy × famine-affected area	−1.586** (2.23)		
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	0.644** (2.61)		
B. Treated cohort dummy × famine-affected area	−0.475 (1.29)		
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	0.622* (1.74)		
4. Siblings FE			
A. Treated cohort dummy × famine-affected area	−16.22 (1.24)	−11.71 (0.42)	−37.76 (0.48)
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	10.57 (1.46)	6.350 (0.47)	24.70 (0.48)
B. Treated cohort dummy × famine-affected area	−5.027 (0.51)	−7.175 (0.58)	9.889 (0.27)
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	−7.563 (0.27)	−17.76 (0.51)	44.72 (0.49)
5. Sample living in the same district since 1984			
A. Treated cohort dummy × famine-affected area	−1.768** (2.40)	−0.881 (1.26)	−2.332** (2.44)
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	0.687** (2.68)	0.372* (1.75)	0.996*** (3.02)
B. Treated cohort dummy × famine-affected area	−0.573 (1.49)	−0.752*(1.94)	−0.188 (0.33)
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	0.676* (1.72)	0.119 (0.37)	1.219**(2.38)
6. Sample living in the same province since 1984			
A. Treated cohort dummy × famine-affected area	−1.800** (2.40)	−0.903 (1.32)	−2.328** (2.39)
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	0.700** (2.73)	0.391* (1.92)	0.986*** (2.97)
B. Treated cohort dummy × famine-affected area	−0.612 (1.55)	−0.764* (1.91)	−0.223 (0.39)
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	0.681* (1.74)	0.0851 (0.26)	1.249** (2.47)
7. Controlling for three-way interaction: Bombing during the Vietnam–American war			
A. Treated cohort dummy × famine-affected area	−0.644 (0.81)	−0.518 (0.61)	−0.327 (0.27)
Treated cohort dummy × paddy per capita in 1944 × famine-affected area	0.548** (2.19)	0.359 (1.67)	0.669** (2.20)
B. Treated cohort dummy × famine-affected area	0.121 (0.25)	−0.590 (1.22)	1.029 (1.42)
Treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	0.852** (2.26)	0.128 (0.39)	1.549*** (3.35)

(Continues)

TABLE 9 (Continued)

Census round 1989 **Cohorts born in→**	**(1) All Vietnam**	**(2) All Vietnam Urban**	**(3) All Vietnam Rural**
8. Replacing paddy per capita with distance to 17th parallel			
Treated cohort dummy × famine-affected area	−1.402 (1.48)	−1.279 (1.44)	−1.331 (1.04)
Treated cohort dummy × distance to 17th parallel × famine-affected area	0.125 (0.72)	0.153 (1.02)	0.126 (0.51)

Note: OLS regressions, estimating Equation (2). The outcome is a dummy variable that takes a value of 100 if literate and 0 otherwise. Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area is equal to 1 if the individual lives in a region that is located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest or North Central Coast, and 0 otherwise. Robust standard errors are clustered at province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

Another concern relates to the U.S. bombing of Vietnam during the Vietnam–American War (1967–1975). We test empirically whether this bombing is driving our results by including in our model the interaction among the treated cohort, famine-affected area dummy, and the intensity of U.S. bombing by province (data accessed from Miguel & Roland, 2011). The results (Table 9, row 7) show no difference in our own triple-interaction variable of interest, Treated Cohort Dummy ∗ Famine Affected Area ∗ Famine Intensity. Moreover, row 8 replaces paddy production per capita in 1944 in Equation (2) with the distance from the 17th parallel. This triple interaction is estimated to be insignificant, which suggests that paddy per capita in 1944 is unlikely to capture something related to the U.S. bombing during the Vietnam–American War. Overall, these sensitivity tests demonstrate that our baseline design is effective in capturing the true effects of the famine on the treated cohorts.

Our findings so far reveal significant adverse effects of the famine on survivors' literacy using the 1989 census. Additional results (Table A1), based on the 2009 census, report that these detrimental effects could persist even 20 years later. We believe that this exercise is informative despite large mortality selection in this specification, because the 2009 census provides information on 20 percent of the Vietnamese population. In Tables A3 and A4, we disaggregate the treatment dummy by infant, newborns and fetuses, as well as by the period of exposure. We find that survivors who were born within 9 months after the famine (in utero during famine) experienced the highest decline in literacy. In addition, those born within 7–9 months after the famine appear to be affected the worst among the treatment group.

5.5 | The Vietnamese famine, physical health, and economic well-being

The VHLSS provides information on various nurse-measured anthropometric measures that are free of subjectivity bias. The data also provide information on household income on a scale of 1–5, where higher values indicate higher income levels. VHLSS also includes a continuous measure of household non-food expenditures. We estimate regressions in Table 10 using Equation (2), where we also control for a survey year dummy and a dummy for whether an individual ever moved from their birth province. We begin by focusing on health outcomes, namely BMI (see Akbulut-Yuksel, 2017), arm-length, weight, and height (Table 10, Panel A). Previous research has determined arm-length to be more useful than height for measuring malnutrition, particularly for the elderly, because arm span, unlike height, does not vary significantly with age (De Lucia et al., 2002; Kwok & Whitelaw, 1991; Reeves et al., 1996). The results are quite informative. We find that famine has a significant negative impact on all four health indicators in both the full and rural samples. This result is consistent with the literacy effects found above. Significant famine effects in the rural sample and insignificant effects in the urban sample are informative regarding the major victims of famine. In addition, survivors whose parents worked in agriculture were affected much more adversely by the famine. This finding is consistent across all four health indicators. However, the famine effect is insignificant for survivors whose parents did not work in agriculture.[22] Overall, the adverse effects of the famine are largest among rural households whose parents worked in agriculture.[23]

Panel B of Table 10 focuses on economic well-being outcomes. These variables are household income, non-food household expenditure, and non-food household expenditure per person. We find that famine exposure had significant negative effects on both household income and non-food household expenditures (both overall and per person).

TABLE 10 Effects of famine on adult health and welfare using VHLSS 1993 and 1998: Coefficient on treated cohort dummy × excess paddy per capita in 1944 × famine-affected area

Sample→	(1) Full	(2) Urban	(3) Rural	(4) Both parents agriculture	(5) Neither parents agriculture
BMI					
	0.499** (2.48)	−0.591 (0.85)	0.714*** (2.71)	0.404 (1.61)	0.0205 (0.02)
Observations	4215	1183	3032	2840	589
Arm length (in cm)					
	0.601*** (3.15)	0.226 (0.32)	0.713** (2.49)	0.549** (2.13)	0.229 (0.21)
Observations	4215	1183	3032	2840	589
Weight (in kg)					
	1.753*** (2.71)	−2.085 (0.86)	2.994*** (3.20)	1.905** (2.06)	−3.639 (0.91)
Observations	4215	1183	3032	2840	589
Height (in cm)					
	1.017 (1.37)	−1.331 (0.64)	2.153** (2.41)	1.670* (1.71)	−5.820 (1.10)
Observations	4215	1183	3032	2840	589
HH income					
	0.608*** (3.78)	−0.206 (0.81)	0.760*** (5.24)	0.465*** (2.99)	0.338 (0.55)
Observations	4320	1211	3109	2911	599
ln non-food HH expenditure					
	0.307** (2.25)	0.255 (0.63)	0.252** (2.21)	0.250** (2.14)	−0.895 (1.24)
Observations	1970	437	1533	1384	186
ln non-food HH expenditure per person					
	0.394*** (3.78)	0.269 (0.61)	0.366*** (3.71)	0.316** (2.29)	−0.389 (0.56)
Observations	1970	437	1533	1384	186

Note: OLS regressions, estimating Equation (2). The controls include parental characteristics for all parents and an internal-migration dummy. Own education is not controlled for in the regressions. Robust standard errors are clustered at the birth-province and person levels. Absolute *t*-statistics are given in parentheses.

Abbreviation: VHLSS, Vietnam Household Living Standards Survey.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

Again, such negative effects exist only for survivors who were born in rural areas and whose parents worked in agriculture. Thus, our results document that the adverse effects of famine during adult life are not confined to physical health but also extend to economic welfare indicators such as income and expenditure. These results are an important indication of the intergenerational transmission effects of famines.

Table A5 examines the role of education in explaining the adverse health and welfare effects of the famine that are presented in Table 10. The same regressions are re-estimated, adding a control variable for survivors' schooling (as a categorical variable). The results show a slight decline in the sizes of the coefficients of the three-way interaction terms. We conjecture that this could provide suggestive evidence that lower educational attainments cannot entirely explain the detrimental health and welfare effects of the famine on survivors.

5.6 | Intergenerational legacy of the Vietnamese famine

So far, our findings suggest that the famine led to unfavorable outcomes in education, health, and economic well-being for early-life survivors in Vietnam. The famine cohorts ended up with lower health endowments, lower income, and lower non-food expenditures. Previous studies have found a strong relationship between parental and child health, as well as between parental resources and children's education. Accordingly, the Vietnamese famine might also have influenced the second generation (i.e., the survivors' children). Indeed, several studies have presented evidence that shocks experienced by parents are transmitted to children through a range of different mechanisms (Caruso & Miller, 2015; Kim et al., 2014; Song, 2013).

Of the second-generation individuals in the census data, 93% of children have mothers at home, while only 81% have their fathers in the household. Our analysis in Table 11 therefore focuses on mothers' famine exposures. Since the average age of the second generation in the census data is 12,[24] we focus on one important outcome: being at school (primary, secondary, or high school) at the time of the census survey for age-appropriate children. Age-appropriate is defined as being either 7–17 or 7–18 years old, because there is no consensus in the literature regarding the high-school leaving age during this period. Each column includes controls for the education, occupation, and mortality statuses of both parents. The identification of all members of offspring is important in intergenerational studies. Therefore, we provide two sets of regressions, one where sample selection is addressed and one where it is not. Fortunately, the Vietnamese census data provide information on the total number children born to each mother. We modify Equation (2) by replacing the treatment dummy with a "mother treated dummy." These specifications continue to use the triple-interaction term and the two usual famine severity measures.

The three-way interaction term in columns 1 and 2 shows that a mother's famine exposure has a significant and negative effect on her children's school attendance. The coefficient 1.915 suggests that for every 100 kg per person decline in rice availability for the mother, the probability of her child's participating in school decreases by 1.9% for the treated cohorts living in famine-affected areas. Columns 3 and 4 address the sample selection effect. Our estimates are strongly significant and show that the adverse intergenerational effects of famine are robust to sample selection. Indeed, the coefficients are even larger when sample selection is addressed, suggesting that sample selection is an important issue in social mobility studies.[25] The double-interaction terms are also significant and large. For instance, children whose mothers were treated and lived in famine-affected areas are around 6% less likely to be in school (Table 11, columns 3–4, panel A), regardless of the paddy per capita availability. We should note that the above findings are likely to be the lower bound of the true intergenerational effects, given that the truncation due to coresidency (see Emran et al., 2018).

TABLE 11 Intergenerational effects of famine on school attendance

Outcome: Being at school dummy 0–100 (mean = 69.8%) Census 1989 cohorts born in→ All ever born children alive and in the household→ Age restriction→	(1) All Vietnam No Aged 7–17	(2) All Vietnam No Aged 7–18	(3) All Vietnam Yes Aged 7–17	(4) All Vietnam Yes Aged 7–18
Panel A: Using paddy per capita in 1944				
Mother treated cohort dummy × famine-affected area	−2.538** (2.55)	−2.364** (2.22)	−6.353*** (4.77)	−5.893*** (3.86)
Mother treated cohort dummy × paddy per capita in 1944 × famine-affected area	1.400*** (4.85)	1.222*** (3.96)	2.334*** (5.45)	2.029*** (4.02)
Number of observations	137,394	149,591	61,915	66,935
Panel B: Using excess paddy per capita in 1944				
Mother treated cohort dummy × famine-affected area	0.387 (0.63)	0.0390 (0.06)	−2.381*** (3.04)	−2.722*** (3.32)
Mother treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	1.915*** (3.09)	1.759** (2.74)	2.170** (2.47)	2.172** (2.47)
Number of observations	132,277	143,909	59,697	64,481

Note: OLS regressions, estimating Equation (2). The regression sample includes all cohorts born in Vietnam. Mother Treated Cohort Dummy is equal to 1 if the individual's mother was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area equals 1 if the individual's mother lives in a region that is located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest or North Central Coast, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

What light do our results shed on the relative effects of income versus genetic endowments as the source of intergenerational transmission? We find that among the first generation (survivors), famine exposure is associated with worse physical health and lower levels of education, income and expenditure, while among the second generation, it is associated with lower school participation. However, without information on why the second generation is not attending school at appropriate ages, we cannot say much regarding the relative importance of the income and genetic endowments effects of famine.[26]

6 | CONCLUSIONS

For the first time in the literature, we empirically investigate the long-term effects of the 1944–45 Vietnam Famine on first- and second-generation survivors. Our paper makes two unique contributions to this line of research. First, the unique features of the Vietnamese famine and our high-quality data enable us to overcome several selection problems that are associated with the estimation of true famine effects. The Vietnamese famine was short-lived, and therefore the scope for fertility-related selection problems is limited. We exploit census data, household survey data and unique historical administrative data, and achieve identification in three-way interaction models using variations in birth cohorts around the famine period, provincial variation in paddy production per capita in 1944, and the dichotomy in famine presence in North Vietnam versus South Vietnam. Thus, our preferred specification estimates generalized triple differences that allow us to control for birth-year and birth-province fixed effects and nationwide shocks. Our findings suggest that the Vietnamese famine reduced literacy by around 3%, BMI by 5.6%–8.4%, arm-length by 4.5%–6.7% (1.1–1.7 cm), height by 2.2%–3.2% (3.4–5 cm), and weight by 10%–14% (4.7–6.9 kg) among the affected cohort. The detrimental effects of the famine also extended to economic welfare, in the form of lower household incomes and lower non-food household expenditures in adulthood.

As a second contribution, we investigate the persistence of famine effects across survivors and their children. We find that the detrimental effects of famine were transmitted to the second generation in the form of lower school participation at school-appropriate ages. Specifically, children whose parents were born around the famine in famine-affected areas have a 4.9%–7.2% lower school attendance than other children. In addition, these effects seem to be driven by survivor cohorts which were born in rural areas or were from lower socioeconomic backgrounds. Our findings have important implications for the Vietnamese economy because famine survivors' offspring make up a considerable proportion of the current labor force in Vietnam. Our results also have ramifications for the understanding of intergenerational persistence between parents' and children's outcomes and the exogenous sources of social mobility, income inequality, and poverty across individuals and geography in Vietnam.

We check for potential biases that may arise from internal migration, fertility and adult mortality, and our findings survive these checks. Our results are also robust to different specifications, addressing a variety of selection issues, falsification tests, alternative definitions of the control group, and alternative famine-severity indicators.

One limitation of this study is the lack of information on paddy prices during the famine period. This information is vital in determining the deep causes of famine. Previous studies have engaged in hot debates regarding entitlement problems and food availability decline as explanations for the genesis of famines. The entitlement account (Sen, 1981) suggests that producers hoard food in times of hardship. This leads to severe adverse supply shocks and higher food prices in the market, and ultimately to starvation due to a lack of access to food. In the absence of data on food prices, we cannot either support or deny the entitlement argument. However, if our results were explained entirely by the entitlement hypothesis, we would expect that farmers and individuals residing in rural areas would have been affected less by the famine. Instead, we find that the adverse effects of the famine are consistently stronger in rural areas than in urban areas, and stronger among child survivors whose parents were farmers than among those whose parents were employed outside agriculture. In addition, our information on excess paddy per capita in 1944 demonstrates a sudden decrease in rice production during the famine period. Thus, a reduction in food production appears to be an important explanation in our results.

Another limitation of our study is that we cannot calculate the excess mortality rate during the famine, meaning that we cannot compare our estimates using excess paddy per capita to previous estimates using the excess mortality rate. Nevertheless, we believe that paddy per capita in 1944 is one of the best malnutrition indicators possible in our context, given the crop failure that occurred before the famine and the discontinued transportation of rice from South to North Vietnam in 1944.

CONFLICT OF INTEREST

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

The authors cannot share the data. Restrictions apply to the availability of these datasets, which were used under license for this study.

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END NOTES

[1] Ramadan fasting and violent conflicts are other natural experiments that are used to explore the effects of early-life (i.e., fetal) malnutrition on adulthood outcomes; see Almond et al. (2015), Duque (2017), Greve et al. (2017), Islam et al. (2017), and Almond et al. (2018). See also Akbulut-Yuksel and Yuksel (2015) on the long-term effects of the Jewish expulsions on children in Nazi Germany.

[2] The Chinese famine (1959–1961) has attracted considerable attention in this literature (Almond et al., 2007; Chen & Zhou, 2007; Gørgens et al., 2012; Huang & Zhou, 2013; Meng et al., 2015). Neelsen and Stratmann (2011) document that the 1941–42 Greek famine had adverse effects on survivors' literacy and schooling. Likewise, the Potato Famine in the Netherlands in 1846–47 (Lindeboom et al., 2010) and the Dutch Hunger Winter Famine (Scholte et al., 2015) had adverse effects on survivors' life expectancy, labor market outcomes, and hospitalization rates. Finally, the 1983 Ghanaian famine adversely affected survivors' cognition (measured by test scores) (Ampaabeng & Tan, 2013).

[3] Studying an earthquake, Caruso and Miller (2015) find that early maternal exposure to the 1970 Ancash earthquake reduced the next generation's schooling by 0.4 years, while early paternal exposure had no effect.

[4] No consensus has been reached on the definite number of victims of the famine. Long (1973) and Tao and Moto (1995) reviewed the extensive literature and concluded that approximately 2 million people in North Vietnam died during the famine; however, more conservative estimates claim that approximately 1 million, or 10% of the population of the affected areas, died from starvation (Marr, 1997).

[5] Internal migration bias was also minimal in the Chinese famine because most people were prohibited from migrating.

[6] Historically, the French had occupied all of Vietnam since 1885 and had divided Vietnam into three regions: Tonkin (northern Vietnam), Annam (central Vietnam) and Cochinchine (southern Vietnam).

[7] Dung (1995), Gunn (2011), Huff (2019), and Tao and Moto (1995) provide detailed surveys of the literature from a politicohistorical perspective in a multicause approach to explain the origins of the Vietnamese famine.

[8] These disasters were a drought and pest damage in spring 1944, catastrophic rainfall and floods in August–September 1944, and a series of typhoons in October 1944 (Huff, 2019; Pham, 1985).

[9] Note that there have been various province splits and mergers in Vietnam. For this figure, we merge the 48 provinces that existed in 1944 into the 32 provinces of 1989 to make it fit with the Population Census of 1989.

[10] Note that, when cooked, 100 g of paddy rice has around 110–160 kcal (depending on its type); thus, the basic daily calorie requirement for an adult person who lives totally on rice corresponds to 1.4–2 kg/day, or 510–730 kg/year. In other words, 182 kg/year provides a daily calorie amount of 550–800 kcal per day. An adult person typically needs 2200 calories a day.

[11] In a recent and innovative study, Meng et al. (2015) presented evidence of how increased food retention by the central government played a significant role in the emergence of the Chinese Famine of 1959–61.

[12] According to the GSO (2004), while the values of the food price index in Hanoi (North Vietnam) in 1943, 1944, and 1945 were 453, 896, and 3129, respectively, the same price index in Saigon (South Vietnam) increased only slightly, from 247 in 1943 to 342 in 1944 and 475 in 1945. However, it increased substantially to 1702 in 1946, possibly because the shipment of rice from South to North Vietnam resumed, thus increasing the demand for rice in Saigon, and hence its price.

[13] The famine-affected areas consisted of the Red River Delta, Northeast, Northwest, and North Central Coast regions, while the famine-unaffected areas included the Southeast and Mekong River Delta regions.

[14] We use the paddy per capita from 1942 and 1943 as our baseline in this measurement rather than that from the 1920s because these years are far from 1944. It is quite likely that the amounts of paddy production across provinces (excluding the famine effect) were similar during 1942, 1943, and 1944 for de-trending purposes, but provincial conditions and production technologies in the 1920s were probably quite different from those of the 1940s, meaning that the paddy production trends across provinces in the two decades are likely to have been very different too. Finally, there were no “in between” options (e.g., the 1930s), given the lack of data for this period.

[15] We also perform Probit estimations where applicable (unreported), and these yield similar results to OLS.

[16] We use “missing” dummies for those observations with missing information on parental characteristics.

[17] These positive associations are consistent with crop failure being observed in most of the Northern provinces before the famine and suggest that bigger rice producing provinces experienced larger declines in paddy production over time. Thus, they experienced more severe famine and had more deaths in 1944.

[18] For the interested reader, we provide the results of a simple treated cohort approach in the affected areas in Table A2. The results show that famine survivors ended up with lower levels of literacy as a result of famine exposure in childhood. The size of the literacy effect ranges from 1% to 3%, based on the definition of the treated cohort in Vietnam, where the mean literacy rate is 89%. This effect is similar to the Greek famine effect (1.1%) on literacy reported by Neelsen and Stratmann (2011), where Greece's literacy rate is 96%.

[19] It would be insightful to compare our estimates with previous studies in the literature, but this is impossible because most of them use the excess death rate as their measure of famine severity. Our intensity measure of excess rice per capita captures the intensive margin of malnutrition, and thus, our estimated famine effects are expected to be smaller than if we had used the excess death rate because the latter captures the extensive margin (extreme cases of malnutrition).

[20] In addition, we control for an internal-migration dummy directly in the VHLSS regressions. The results using the non-mover sample in the unreported regressions remain similar.

[21] Obviously, there is an age distribution of mortality, so some survivor individuals might have died before the census while others are still alive at the time of the census.

[22] We investigate whether the parent effect is due to the father or mother of the survivor, and find that the father and mother effects are similar.

[23] Unreported regressions find that our results using VHLSS are robust to the inclusion of marital status and household size as control variables.

[24] The 2009 census would have provided a longer life-span for the second generation, allowing various different outcomes to be analyzed, but the adult mortality problem among the first generation is pronounced with the 2009 census.

[25] Table A6 finds that fathers' famine exposure has no significant effect on their offspring's school attendance. However, as information on the total number children born is available only for mothers, this is working from a very limited sample because we can estimate this regression only for children who have both parents present at home on the census night. Therefore, the estimates are unlikely to reflect the true effects.

[26] The only insight that we can provide is based on the above finding suggesting that education cannot entirely explain the adverse health and welfare effects of famine. If education is a function of parental income, then both income and genetic effects might be at play.

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APPENDICES

FIGURE A1 Definition of Treated and Control Group

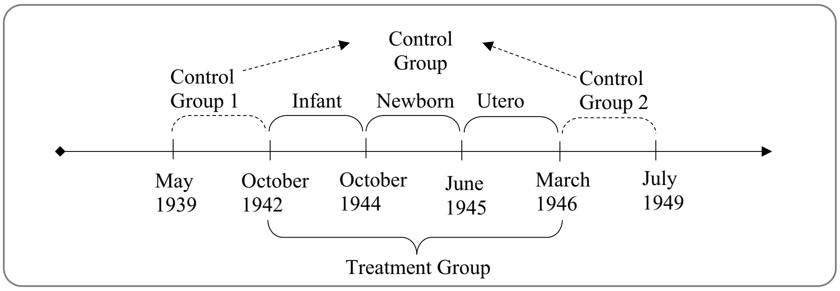

TABLE A1 Vietnamese famine effects on child survivors, 2009 census data

Outcome: Literacy Cohorts Born in→	(1) All Vietnam	(2) All Vietnam urban	(3) All Vietnam rural
Panel A: Using paddy per capita in 1944			
Treated cohort dummy × famine-affected area	0.214 (0.49)	2.206*** (3.01)	−0.289 (0.58)
Treated cohort dummy × famine-affected area × paddy per capita in 1944	0.171 (1.04)	−0.692** (2.42)	0.339** (2.02)
Panel B: Using excess paddy per capita in 1944			
Treated cohort dummy × famine-affected area	0.540* (1.91)	0.921** (2.27)	0.337 (1.01)
Treated cohort dummy × famine-affected area × excess paddy per capita in 1944	1.009*** (3.36)	0.120 (0.23)	1.109*** (3.47)

Note: OLS regressions, estimating Equation (2), where each outcome is a dummy variable that takes a value of either 100 or 0. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A2 Effects of malnutrition on survivors' literacy using cohort approach: Coefficient of treated cohort dummy

Census round 1989	(1)	(2)	(3)	(4)	(5)
Panel A: Estimations for people born in famine-affected areas					
	Full sample	Urban sample	Rural sample		
Treated cohort dummy	−1.119*** (3.27)				
		−0.323* (1.80)			
			−1.581*** (3.02)		
Panel B: Estimations for people born in famine-unaffected areas and people born abroad					
				Famine-unaffected area	Abroad
				−0.238 (0.62)	
					−1.126 (0.23)

Note: OLS regressions. The outcome is a dummy variable that takes a value of 100 if literate and 0 otherwise. Treated Cohort Dummy is equal to 1 if the individual was born between October 1942 and March 1946, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A3 Vietnamese famine and its early-life effects on infants, newborns and fetuses

Census round 1989 Cohorts Born in→ Coefficient on ↓	(1) All Vietnam	(2) All Vietnam Urban	(3) All Vietnam Rural
Panel A: Using paddy per capita in 1944			
1–2 Years old during famine × famine-affected area	−1.379** (2.10)	−0.529 (0.70)	−1.926** (2.37)
Born during famine × famine-affected area	−1.835 (0.95)	−0.976 (0.72)	−1.579 (0.57)
Born within 9 months after famine × famine-affected area	−2.457** (2.38)	−1.614 (1.35)	−3.286 (1.57)
1–2 Years old during famine × famine-affected area × paddy per capita in 1944	0.646** (2.66)	0.415* (1.83)	0.811** (2.56)
Born during famine × famine-affected area × paddy per capita in 1944	0.457 (0.59)	0.474 (1.40)	0.183 (0.15)
Born within 9 months after famine × famine-affected area × paddy per capita in 1944	0.934** (2.71)	0.279 (0.65)	1.759* (1.99)
Panel B: Using excess paddy per capita in 1944			
1–2 Years old during famine × famine-affected area	−0.476 (1.46)	−0.677 (1.59)	−0.279 (0.60)
Born during famine × famine-affected area	−0.609 (0.67)	0.162 (0.24)	−0.635 (0.50)
Born within 9 months after famine × famine-affected area	−0.766 (1.02)	−1.516** (2.31)	0.330 (0.33)
1–2 Years old during famine × famine-affected area × excess paddy per capita in 1944	0.440 (1.12)	0.0867 (0.22)	0.641 (1.16)
Born during famine × famine-affected area × excess paddy per capita in 1944	0.661 (0.77)	0.647 (1.13)	0.600 (0.47)
Born within 9 months after famine × famine-affected area × excess paddy per capita in 1944	1.241* (2.05)	−0.337 (0.50)	3.217*** (3.84)

Note: OLS regressions, estimating Equation (2), where each outcome is a dummy variable that takes a value of either 100 or 0. *1–2 Years Old During Famine* refers to survivors who were infants during the famine; *Born During Famine* refers to survivors who were born during the famine; and *Born Within 9 Months After Famine* refers to survivors who were fetuses during the famine. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A4 Vietnamese famine and its effects on gestational periods in utero

Census round 1989 Cohorts Born in→ Coefficient on ↓	(1) All Vietnam	(2) All Vietnam Urban	(3) All Vietnam Rural
Panel A: Using paddy per capita in 1944			
Born within 1–3 months after famine × famine-affected area	−1.290 (1.00)	−2.086 (0.99)	−1.535 (0.48)
Born within 4–6 months after famine × famine-affected area	0.140 (0.06)	0.954 (0.60)	0.285 (0.08)
Born within 7–9 months after famine × famine-affected area	−6.839*** (3.34)	−3.642** (2.22)	−10.17*** (2.79)
Born within 1–3 months after famine × famine-affected area × paddy per capita in 1944	0.864* (1.79)	0.653 (0.82)	1.592 (1.07)
Born within 4–6 months after famine × famine-affected area × paddy per capita in 1944	0.559 (0.65)	0.852* (1.84)	0.610 (0.51)
Born within 7–9 months after famine × famine-affected area × paddy per capita in 1944	2.699*** (4.01)	0.918* (1.86)	5.008*** (3.32)
Panel B: Using excess paddy per capita in 1944			
Born within 1–3 months after famine × famine-affected area	0.829 (0.88)	−0.738 (0.81)	2.397 (1.61)
Born within 4–6 months after famine × famine-affected area	−1.537 (1.07)	−2.323** (2.55)	−0.828 (0.41)
Born within 7–9 months after famine × famine-affected area	−2.047 (1.63)	−1.775 (1.27)	−1.005 (0.67)
Born within 1–3 months after famine × famine-affected area × excess paddy per capita in 1944	2.155*** (3.07)	−0.235 (0.23)	5.149*** (4.15)
Born within 4–6 months after famine × famine-affected area × excess paddy per capita in 1944	−0.0153 (0.01)	−0.910 (0.88)	0.692 (0.38)
Born within 7–9 months after famine × famine-affected area × excess paddy per capita in 1944	1.459 (1.41)	0.0874 (0.07)	3.928** (2.64)

Note: OLS regressions, estimating Equation (2), where each outcome is a dummy variable that takes a value of either 100 or 0. Robust standard errors are clustered at province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A5 Effects of famine on adult health and welfare using VHLSS 1993 and 1998: Controlling for own education

Sample→	(1) Full	(2) Urban	(3) Rural	(4) Father agriculture sector	(5) Father not agriculture sector	(6) Mother agriculture sector	(7) Mother not agriculture sector	(8) Both parents agriculture	(9) Neither parents agriculture
BMI									
	0.471**	−0.532	0.704***	0.572**	−0.399	0.286	0.0386	0.396	−0.337
	(2.34)	(0.81)	(2.76)	(2.06)	(0.63)	(1.26)	(0.03)	(1.55)	(0.32)
Observations	4215	1183	3032	3131	978	3136	763	2840	589
Arm length (in cm)									
	0.570***	0.275	0.703**	0.674***	−0.196	0.386	0.182	0.539**	0.0469
	(2.98)	(0.41)	(2.48)	(2.66)	(0.28)	(1.49)	(0.14)	(2.18)	(0.04)
Observations	4215	1183	3032	3131	978	3136	763	2840	589
Weight (in kg)									
	1.665**	−1.925	2.939***	2.301**	−2.438	1.702**	−2.612	1.847**	−4.941
	(2.56)	(0.78)	(3.32)	(2.54)	(1.29)	(2.11)	(0.69)	(2.07)	(1.16)
Observations	4215	1183	3032	3131	978	3136	763	2840	589
Height (in cm)									
	0.968	−1.328	2.100**	1.580*	−2.465**	1.771**	−4.035*	1.615*	−6.701**
	(1.33)	(0.62)	(2.42)	(1.71)	(2.23)	(1.97)	(1.66)	(1.67)	(2.41)
Observations	4215	1183	3032	3131	978	3136	763	2840	589
HH income									
	0.569***	−0.138	0.739***	0.545***	0.718*	0.513***	0.606	0.422***	0.0341
	(3.63)	(0.57)	(5.56)	(3.86)	(1.66)	(3.65)	(1.57)	(2.79)	(0.07)
Observations	4320	1211	3109	3211	999	3213	775	2911	599
ln non-food HH expenditures									
	0.312**	0.320	0.259**	0.259**	0.417	0.387***	−0.649	0.255**	−1.342
	(2.35)	(0.84)	(2.23)	(2.42)	(0.77)	(3.59)	(0.93)	(2.24)	(1.15)
Observations	1970	437	1533	1513	398	1527	238	1384	186
ln non-food HH expenditures per person									
	0.389***	0.352	0.367***	0.353***	0.390	0.439***	−0.320	0.307**	−0.993
	(4.19)	(0.83)	(3.81)	(2.97)	(0.83)	(3.86)	(0.50)	(2.17)	(0.27)
Observations	1970	437	1533	1513	398	1527	238	1384	186

Note: OLS regressions, estimating Equation (2). The controls include parental characteristics for all parents and an internal-migration dummy. Own education is controlled for in the regressions. Robust standard errors are clustered at the birth-province and person levels. Absolute *t*-statistics are given in parentheses.

Abbreviation: VHLSS, Vietnam Household Living Standards Survey.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A6 Intergenerational effects of famine on school attendance through fathers

Outcome: Being at school dummy 0–100 (mean = 68.59%) **Census 1989 cohorts born in→** **All ever born children alive and in the household→** **Age restriction→**	**(1)** **All Vietnam** **No** **Aged 7–17**	**(2)** **All Vietnam** **No** **Aged 7–18**	**(3)** **All Vietnam** **Yes** **Aged 7–17**	**(4)** **All Vietnam** **Yes** **Aged 7–18**
Panel A: Using paddy per capita in 1944				
Father treated cohort dummy × famine-affected area	1.272 (1.10)	1.642 (1.37)	1.297 (1.13)	1.666 (1.41)
Father treated cohort dummy × paddy per capita in 1944 × famine-affected area	−0.112 (0.31)	−0.218 (0.59)	−0.123 (0.35)	−0.229 (0.63)
Panel B: Using excess paddy per capita in 1944				
Father treated cohort dummy × famine-affected area	1.182 (1.63)	1.272* (1.82)	1.179 (1.62)	1.271* (1.81)
Father treated cohort dummy × excess paddy per capita in 1944 × famine-affected area	0.588 (0.83)	0.419 (0.59)	0.584 (0.83)	0.416 (0.59)

Note: OLS regressions. The regression sample includes all cohorts born in Vietnam. Father Treated Cohort Dummy is equal to 1 if the individual's father was born between October 1942 and March 1946, and 0 otherwise. Famine-Affected Area is equal to 1 if the individual's father lives in a region which is located to the north of the 17th parallel, namely Red River Delta, Northeast, Northwest or North Central Coast, and 0 otherwise. Robust standard errors are clustered at the province level. Absolute *t*-statistics are given in parentheses.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.