Famine at birth: Long-term health effects of the 1974-75 Bangladesh famine *

Shaikh M.S.U. Eskander ♣ Edward B. Barbier

AAM version, Accepted at *Environment and Development Economics* on 24/08/2024

Abstract

We use childhood exposure to disasters as a natural experiment inducing variations in adulthood outcomes. Following the *fetal origin* hypothesis, we hypothesize that children from households with greater famine exposure will have poorer health outcomes. Employing a unique dataset from Bangladesh, we test this hypothesis for the 1974-75 famine that was largely caused by increased differences between price of coarse rice and agricultural wages, together with lack of entitlement to foodgrains for daily wage earners. People from northern regions of Bangladesh were unequally affected by this famine that spanned over several months in 1974 and 1975. We find that children surviving the 1974-75 famine have lower health outcomes during their adulthood. Due to the long-lasting effects of such adverse events and their apparent human capital and growth implications, it is

* **Eskander**: Department of Health Policy and Organization, School of Public Health, University of Alabama at Birmingham, AL, US, and Grantham Research Institute on Climate Change and the Environment (GRI) and Centre for Climate Change Economics and Policy (CCCEP), London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK (email: Eskander@uab.edu); **Barbier**: Department of Economics, Colorado State University, 1771 Campus Delivery, Fort Collins, CO 80523-1771 (Edward.Barbier@ColoState.Edu).
Eskander is also a research associate with the Centre for Applied Macroeconomic Analysis (CAMA) at Australian National University, and a non-resident Fellow with Centre for Development Economics and Sustainability (CDES) at Monash University.

♣ Corresponding author. *E-mail address: Eskander@uab.edu*.

important to enact and enforce public policies aimed at ameliorating the immediate harms of such events through helping the poor.

JEL: *Q54, O15, I31*

Keywords: Bangladesh, Fetal origin hypothesis, The 1974-75 Famine, Health, Long-term effects.

1. Introduction

Famines, defined as extreme scarcity of food, can be caused by multiple reasons including war, disasters, crop failures, population imbalance, widespread poverty, economic recession and government policies. According to the World Food Programme, there are currently more than 50 million people on the verge of famine and risk of starvation, up from 27 million in 2019 (WFP 2021). Earlier demographic and epidemiological studies have predominantly focused on the mortality effects of famine (Meng and Qian 2009), whereas more recent studies on their long-term effects are mostly focused on countries such as Netherlands, China and Greece where good quality datasets are available (e.g., Ampaabeng and Tan 2013; Scholte *et al.* 2015; Neelsen and Stratmann 2011). For developing countries with repeated occurrences of famine such as Bangladesh and Ethiopia, only a limited number of studies are available on their long-term effects (e.g., Razzaque *et al.* 1990; Arage *et al.* 2021). Moreover, previous studies have ambiguous results on the effect of in utero and early childhood famine exposure on adulthood health outcomes, therefore requiring case-specific further investigations rather than generalization of policies and remedial measures based on earlier findings. Since the mismatch between the growths in rice price and agricultural wages, which defines the local level entitlement failure and therefore causes the famine (Sen 1981; Sen 1980), is a local level phenomenon (e.g., Reardon 1997; Fink *et al.* 2020), identifying the long-term effects of famine requires a difference-in-difference setup which was absent in existing studies on famine in Bangladesh. Against this backdrop, we contribute to academic and policy literature by providing the first empirical research using a nationally representing survey data to investigate the long-term health effects of the 1974-75 Bangladesh famine.

Right after its independence in 1971, Bangladesh experienced a series of major natural and political events that adversely impacted the lives and livelihoods of its citizens. The worst post-independence event occurred in 1974, when the northern regions of Bangladesh were severely affected by the monsoon flood of June, triggering the now infamous the *1974-75 Great Bangladesh famine* which may have been responsible for 0.45-1.5 million deaths (Alamgir 1980)[1]. Although the causes and immediate consequences of the famine have been explored thoroughly (e.g., Sen 1981), the long-term impacts of the famine on the well-being of children who survived has received very little attention. We fill this gap by investigating the long-term health effects of the 1974-75 Bangladesh famine on those children born and raised during this event and its immediate aftermath.

This paper joins the growing literature investigating the "*fetal origin*" hypothesis that states that adverse environmental, political, or economic events in early childhood affect adulthood achievement including health outcomes (Almond and Currie, 2011; Almond *et al.* 2018). Affected households, especially from developing countries, often adopt coping strategies that are intended for immediate survival, such as reducing food intakes, sending children to paid work, early marriage of daughters, and selling of productive assets. Household expenditures on such coping strategies usually come at the expense of longer term investments, such as health care and education for children. Consequently, children from affected households are raised with less investment in their human capital development, resulting in a lower human capital endowment during their adulthood.

To explore this linkage between early-life adversity and later-life outcomes for the case of the 1974-75 Bangladesh famine, we hypothesize that children born and raised during the famine in

[1] Mortality figures vary across different sources from 27,000 to 1.5 million.

affected regions will have lower health outcomes than children born and raised during non-famine years in unafffected regions. We adopt a difference-in-difference framework, where historic data were used to classify famine treatment and control regions and cohorts. All outcome and socioeconomic data come from three waves of the Bangladesh Household Income and Expenditure (HIES) survey.

We make a number of novel contributions to the literature exploring the fetal origin hypothesis. First, to our knowledge, our analysis is the first to apply and test this hypothesis with respect to the 1974-75 Bangladesh famine through employing a natural experiment frameork. We use a nationally representative repeated cross-section data to identify the long-term effects of the 1974-75 famine. In earlier literature, Razzaque *et al.* (1990) used the Matlab DHS dataset to identify the adverse impacts of the famine on households. However, the Matlab DHS data cover only the Chandpur district of Bangladesh. Not only was this region largely outside the area most impacted by the famine, but also a single-region sttudy prohibits comparison with non-affected regions. In contrast, our analysis and approach are able to investigate the long-term effects of the 1974-75 famine using a difference-in-difference framework.

Second, understanding the long-term consequences of famine and similar adversities is important for formulating and implementing effective policy measures during such emergencies and their aftermath. Our results indicate that children exposed to famine have significantly lower health outcomes, and this human capital effect could have important implications for the long-term economic growth of the economy. Considering Bangladesh is undergoing significant rural transformation, whereby it is reducing its reliance on agricutlure and diversifying its economy, such a human capital impact could be substantial. Therefore, public policies aimed at ameliorating the harms of famine must also account for long-lasting health effects that are detrimental to human capital development, especially in rural areas.

The outline of the paper is as follows. Section 2 briefly reviews related literature. Section 3 provides background of the 1974-75 famine in Bangladesh. Section 4 develops the empirical strategy and describes the data and variables. Section 5 reports and analyzes main results. Section 6 provides additional results and robustness tests. Finally, Section 7 draws on policy implications and conclusion.

2. Literature review

Existing literature on *fetal origin* hypothesis in reference to famines provides evidence of different adversities that the affected people may face in their later life. Examples of such adversities include increased risk of diabetes (van Abeelen *et al.* 2012; Finer *et al.* 2016; Liu *et al.* 2020; Abate *et al.* 2022), obesity (Ravelli *et al.* 1976; Finer *et al.* 2016; Zhou *et al.* 2018), cardiometabolic non-communicable disease (Grey *et al.* 2021), dyslipidemia in female adults (Yao and Li 2019), chronic diseases (Hu *et al.* 2017), cardiovascular and metabolic diseases (Xu *et al.* 2016; Veenendaal *et al.* 2012), psychological disorders in adulthood (Neugebauer *et al.* 1999; Brown *et al.* 2000; Hulshoff Pol *et al.* 2000), and glucose intolerance (Ravelli *et al.* 1998). Adversities also vary by different attributes such as gender (Koenig and D'Souza 1986; Deng and Lindeboom 2021) and location (Li and Lumey 2017).

Most studies of the long-term impact of famine on survivors have focused on the 1944-45 Dutch famine and 1959-61 Chinese famine. Existing studies provide ambiguous results in terms of the directions and magnitudes of effects. On one hand, there are some evidences from epidemiological studies on the long-term adverse effects of the Dutch Famine. For example, Scholte *et al.* (2015) found that the people affected by the 1944-45 Dutch Hunger Winter during their first trimester of gestation experience negative labor market outcomes and higher hospitalization 53 or more years after birth. For China, Xu *et al.* (2018) found that prenatal and postnatal exposure to China's 1959–61 Great Leap Forward famine during prenatal and early postnatal life have significantly lower cognitive abilities.

Moreover, there are also increased risk of mental illness (Huang *et al.* 2013) and obesity and depression (Cui *et al.* 2020) due to exposure to the 1959-61 Chinese famine.

In contrast, as Xu *et al.* (2016) concluded, existing evidence does not establish an unambiguous relationship not only because of data limitations and modeling flaws but also for differences in the severity and extent of different famines, existing socioeconomic, financial, and political environment, and the appropriateness of emergency responses. Stanner *et al.* (1997) did not find any evidence of long-term adversity of the 1941-44 Leningrad siege, whereas Luo *et al.* (2006) found very little evidence adversities from exposure to the Chinese famine.

Most related literature on developing countries are focused on sub-Saharan Africa and South Asia. Ampaabeng and Tan (2013) found that the survivors of the 1983 famine in Ghana who were under two years of age during the famine had significantly lower intelligence scores. On the other hand, Arage *et al.* (2021) examine the impact of early life famine exposure on adulthood anthropometry among survivors of the 1983–85 Ethiopian great famine. Their results inform that decreased adult height and increased waist-to-height ratio were associated with early life exposure to famine, particularly prenatal and postnatal exposure.

Relevant literature on the 1974-75 great Bangladesh famine mainly focuses on the causes and immediate consequences with scarce focus on long-term effects. Alternative explanations behind the causes of the famine were portrayed in Sen (1981) and Muqtada (1981), among others. While Sen (1981) proposed the lack of entitlement as the key reason behind the famine, Muqtada (1981) critically assessed different sources and concluded that while the lack of entitlement is a more complete explanation, there can be multiple reasons behind the occurrence of the famine. Incomplete yet important explanations include damages to standing crops due to the June-1974 flood, lower per-capita food availability, unequal growths in food prices and agricultural wages, and increased competition for land between highly labor-intensive jute and less labor-intensive rice cultivation (Muqtada 1981).

Studies on the consquences of the 1974-75 famine almost always used different waves of the Matlab Health and Socioeconomic Survey (MHSS). For example, Hernández-Julián *et al.* (2014) used the 1996 MHSS whereas Razzaque *et al.* (1990) used the 1974-79 waves of the MHSS. Razzaque *et al.* (1990) investigated the sustained effects, including mortality and migration rates, of the 1974-75 famine using a two-stage approach where they adopted a bivariate analysis in the first stage to identify the crude effects of different factors such as articles owned, gender and mothers' age during pregnancy and birth, and then the second stage adopted a multivariate logistic regression model to identify their net effects of famine, controlling for other factors. Results identify significantly higher mortality among the famine-born than the non-famine born cohorts for overall sample and also for both males and females separately.

Hernández-Julián *et al.* (2014) used the 1996 MHSS and adopted different probit and OLS regression specifications for children born between 1970 and 1980 to estimate the effect of famine exposure on neonatal and postneonatal mortality. Their key findings include significantly higher mortality due to *in utero* exposure to the 1974-75 famine.

In related research, Razzaque (1989) used household-level socioeconomic information from the 1974 census and registration data on births, deaths, and migrations from the 1974-79 MHSS to identify that mortality rates that can be attributed to the 1974-75 famine are higher among the poorer than the richer households. Bairagi (1986) used the 1975-76 MHSS data and employed an OLS regression framework to identify that the famine had significant adverse effects on child nutrition and these adversities vary by gender, seasonality and different socioeconomic attributes. On the other hand, Finer *et al.* (2016) used the MHSS dataset to investigate effects of in utero famine exposure on increased risk of adulthood prevelances of type 2 diabetes and obesity. Using a cohort analysis, they found that the younger an adult was during exposure to the famine, the greater were the risks of diabetes and obesity during their adulthood.

However, despite providing a detailed longitudinal account of health and socioeconomic status of surveyed households, MHSS data only covers a certain region of Bangladesh which was not the primary or direct victims of the famine. Therefore, existing studies actually provide a measure of spillover effects of the famine on a less affected or unaffected region. Notable exceptions include Shabnam *et al.* (2022) who investigated the educational impacts of early life exposure to the 1974-75 famine. We differ by first investigating the long-term health adversities of the 1974-75 famine using a nationally representative survey data which allowed us to adopt the standard difference-in-difference estimation strategy.

3. The 1974-75 Bangladesh famine

Bangladesh has a long history of widepsread famines including the great famines of 1770, 1943, and 1974. In addition, there were several smaller famines in between these larger events. The 1770 famine (known as "*Chhiyattarer Manvantar*" or "The Great Famine of 1176 Bangla Year") was a consequence of severe drought in 1769 followed by excessive rainfall in 1770, resulting in damages to standing crops. The East India Company, revenue collector on behalf of the colonial British government, did not ease on revenue collection, thereby further adding to peoples' sufferings. Consequently, about 10 million people, or one-third of total Bengal population, died from starvation.

During the World War II, the Bengal was struck with the *Great Bengal Famine of 1943* which followed from a series of crop failures from 1938. Essential supplies of foodgrains from Myanmar was interrupted due to the war. Together with scarcity of food, influx of war refugees and rising food prices, British government's policy to reallocate foodgrains to meet the demand of the army was at least partly responsible for the extent and severity the 1943 famine. An estimated total of 3.5 million people died as a consequence.

Bangladesh experienced another famine in 1974-75 which was a consequence of, among others, internal and external political problems, a poor world food situation, and, most importantly, a devastating flood that damaged two successive rice crops (Bairagi 1986). Soon after independence in 1971, Bangladesh faced serious economic challenges, such as rising prices for essential commodities, and political conflicts related to its liberation war (Eskander and Barbier 2022). The situation worsened when a major famine struck the northern regions of Rangpur and Mymensingh, combined with severe monsoon flooding of the Brahmaputra River during June to September in 1974. There was significant crop damage, which led to a further escalation in rice prices, a spike in unemployment and reduced purchasing power for households (Alamgir 1980; Razzaque *et al.* 1990; Sen 1981). The severity of the situation forced the government to open around 5,825 *langarkhanas*[2] that fed about four million poor and famine affected people from September to December 1974 (Muqtada 1981).

However, direct causes include a combination of natural disasters, food availability decline and fluctuation in entitlements (Muqtada 1981). In this regard, Figure 1 explores the growth rates of monthly rice price and agricultural wages.

The famine spanned over almost two years: it began in March 1974 when the price of coarse rice (taka per maund[3]) started to increase (panel A in figure 1) at much faster rates than daily agricultural wages (panel B in figure 1) and reached its peak between July and October of that year (Alamgir and Salimullah 1977; Razzaque *et al.* 1990; Hernández-Julián *et al.* 2014). Sen (1981) also identified that the

[2] Locally known as *langarkhanas*, these were the gruel kitchens set up by the government of Bangladesh to feed severely famine affected people during the heights of the 1974-75 famine.

[3] Maund is a measurement of weight that was widely used in Indian subcontinent. In particular, 1 maund = 37.3242 kg.

1974-75 famine was due to lack of entitlement of food especially for the agricultural wage workers, and not due to shortage of food production.

Moreover, relative lack of connectivity with Dhaka also added to the woe. In fact, before the completion of the construction of Bangabandhu Bridge in 1998, northern districts of Bangladesh were less connected to the capital city of Dhaka which is the principal destination of seasonal migrants. The bridge linked the east and west sides of river Jamuna, and in the process significantly reduced travel time and cost of transportation from northern districts to Dhaka (e.g., Jenkins and Shukla 1997).

Although the famine subsided later in 1974, farm wage earners continued to face soaring prices in comparison to their daily agricultural wage (panels C and D in figure 1). Khan (1984) and Palmer-Jones (1993) emphasize on the importance of real wages of agricultural workers, which have strong empirical links with rice prices (Palmer-Jones and Parikh 1998). In addition, Ravallion (1982) empirically established that there was a significant structural break in short-run response of agricultural wages to rice prices at the time of the 1974-75 famine. Consistently, panel C confirms that the percentage deviation from mean value was much higher for rice prices than agricultural wages up until September 1975, and then ultimately went back to pre-famine levels. Market failures and price speculation in food grains also played a substantial role in the famine (Ravallion 1982; Ravallion 1985). Altogether, the 1974-75 famine caused an estimated 0.45–1.5 million deaths through starvation and diseases such as cholera and diarrhea (Alamgir 1980).

4. Empirical strategy

4.1. Fetal origin hypothesis applied to the 1974-75 Bangladesh famine

The fetal origin hypothesis establishes the causal relationship between in utero exposure to adversities and adulthood health outcomes including diabetes, hypertension, and long-term disabilities (e.g., Barker 1990). Moreover, comprehensive reviews of medical evidence from selected developing countries by Walker *et al.* (2007) and Victoria *et al.* (2008) show that early childhood in addition to in utero exposure can result in later life health adversities. Together, the fetal origin hypothesis implies that exposure to in utero or early infancy adversities will result in adulthood health adversities or lower health outcomes.

Common sources of such adversities, as identified in public health, epidemiology, and economics literature, include disasters such as floods and storms, famine, war, and economic crises. The 1974-75 famine is an example of such adversities, especially for a newly independent country like Bangladesh with a huge population and population growth. Food scarcity affected a large population from northern regions of Bangladesh, especially pregnant women and children in their early infancy who are typically more vulnerable to food scarcity (e.g., Sparén *et al.* 2004), mostly due to their lower mobility and lack of income earning capabilities.

There are many undesirable consequences of famine. For example, using the 1996 Matlab Health and Socioeconomic Survey (MHSS), Hernández-Julián *et al.* (2014) identified that the 1974-75 famine resulted in greater infant mortality among the in utero children, lower birth of male children, and greater number of stillbirths. Moreover, Razzaque *et al.* (1990) found that infant mortality was higher among the in utero children and infants during the 1974-75 Bangladesh famine.

Against this backdrop, for our analysis of the effects of the 1974-75 Bangladesh famine, we hypothesize that children born and raised during the famine in affected regions will have lower health outcomes than children born and raised during non-famine years in unaffected regions.

4.2. Famine regions and cohorts

Based on literature (e.g., van Schendel 2009; Razzaque *et al.* 1990; Alamgir 1980) and newspaper reports, greater districts of Rangpur, Mymensingh, Bogra, and Pabna in northern Bangladesh are identified as the famine affected regions. Fifteen current administrative districts, that are parts of these four historical greater districts, form the famine regions. Of them, Rangpur is the primary famine affected region, and the neighboring regions of Mymensingh, Bogra, and Pabna are secondary famine affected districts. On the other hand, the rest of the country forms the unaffected regions that include 49 current administrative districts. Appendix Figure A1 shows the locations of famine regions.

However, four greater districts, CHT, Chittagong, Dhaka, and Sylhet, may require special attention. Of them, the mountainous region of CHT is population scarce and was mostly inhabited by various indigenous communities up until 1975. These distinct features make CHT incomparable to the rest of the country. On the other hand, unlike other regions, Dhaka and Chittagong regions are highly urban even in 1970s where alternative means of livelihoods are more available that can at least partially reduce some of the harms of famine. Moreover, Sylhet region is highly dependent on remittance receipts from *Sylheti diaspora* mainly in the UK, and is therefore relatively secured from domestic fluctuations in food prices. Therefore, we additionally consider regressions where we exclude these four regions from our estimating sample.

Next, we include newborns and early infants during the famine in the famine affected cohorts. This classification of famine affected cohorts directly follows from Figure 1. Panel C in Figure 1 shows that daily farm wage rates were keeping pace with increasing wholesale price of rice except for the famine months in 1974 and 1975. In particular, panels C and D confirm that the famine spanned from March 1974 (i.e., when the price level started to go up from its long-term level) to June 1975 (i.e., when the price level started to go back to pre-famine levels). Therefore, children born in the years 1973, 1974 and 1975 are directly affected by this famine either during their prenatal or neonatal, or both, periods. That is, they experienced the adversities caused by the famine that can have detrimental effects on their adulthood outcomes. Consistent with literature, we include newborns during 1973-75 in our famine affected cohorts.

Years preceding to the 1974-75 famine were flogged with a series of natural and political adversities including the 1970 cyclone and the 1971 liberation war of Bangladesh (see Eskander and Barbier

(2022) for a detailed account). Therefore, we do not include earlier years in the unaffected cohorts to avoid any overlapping effect of those earlier events. In addition, we also exclude years 1976 and 1977 to rule out the possibility of any remaining hardship the famine affected households were still experiencing. The unaffected cohorts are formed of newborns during 1978-81 who were not affected by the 1974-75 famine. Panel D in Figure 1 further confirms that the purchasing power of daily wages went back to pre-famine levels in those years.

Altogether, there are 1,235 and 1,489 respondents that are included in our unaffected and famine cohorts, respectively, whereas there are 2,019, 531, and 174 individuals from unaffected, other famine regions, and Rangpur region (Table A2). Moreover, there are a total of 374 individuals in our estimating sample who were born in famine-affected regions during 1973-75. Following the fetal origin hypothesis, we expect them to have lower health outcomes during their adulthood than the 904 individuals that were born in unaffected regions during 1978-81.

4.3. Identification strategy

We exploit the variations in timing and geography of the 1974-75 famine, as discussed above, in identifying variations in adulthood health outcomes. For this purpose, we use health outcomes that were included in the Bangladesh Household Income and Expenditure Survey (HIES). HIES contains data on the incidence and duration of chronic illness. Surveyed individuals self-report whether they suffer from any chronic illness in the previous year. Common examples of such illnesses include injuries, disabilities, chronic heart disease, breathing problem, chronic dysentery, ulcers, blood pressure, arthritis, rheumatism, eczema, diabetes, cancer, leprosy, paralysis, and hysteria. HIES also reports the duration of any such chronic illness over an individual's lifetime. We extract our first health outcome variable, *Healthy lifetime*, i.e., an individual's total life-years without any chronic illness, as the difference between current age and lifetime duration of illness. Our second measure of health outcome is the "*% of healthy lifetime*", i.e., percentage of lifetime without any chronic illness.

For the outcome variable y, the long-term impacts of the 1974-75 famine in Bangladesh is estimated by

$$y_i = \alpha_0 + \theta C + \vartheta R + \beta \times (R \times C) + x_i'\delta + \tau_{yob} + \Delta_{pob} + H_{yos} + \epsilon_i, \qquad (1)$$

for a household i. R and C denote the famine regions and cohorts, respectively. We expect famine exposure to result in lower long-term health outcomes, implying the long-term adverse effects of in utero or early childhood famine exposure. Therefore, we interact region and cohort dummies which yields the parameter of interest β. The vector of controls, x', includes household and regional level variables. In addition, τ_{yob}, Δ_{pob} and H_{yos} represent the vectors of birthyear, birthplace (i.e., subdivision) and survey year indicators, respectively.

Within the famine cohort, long-term effects of exposure to the 1974-75 famine should be common to all households and individuals born in the same locality (e.g., Almond *et al.* 2009; Maccini and Yang 2009). Therefore, variations in children's adulthood outcomes resulting from the variations in their time and place of birth should be absorbed by the full set of birthyear (τ_{yob}) and birthplace (Δ_{pob}) fixed effects. In particular, τ_{yob} controls for all other year-specific influences on children's adulthood outcomes, whereas Δ_{pob} controls for persistent effects of disaster exposure on the regions and households where the children are born. Finally, since data comes from three different survey years, we include a vector of survey year indicators, H_{yos}, to control for any variations in adulthood outcomes specific to survey year. These fixed effects control for unobserved time-varying factors that are common across the regions.

Parameter β allow for differential effects of regions on disaster cohorts and we hypothesize that $\hat{\beta} < 0$. We assume that

$$cov(\epsilon_i, R \times C | C, x', \Delta_{pob}, H_{yos}) = 0. \qquad (2)$$

That is, our identifying assumption is the independence between the disturbances and the measure of exposure to a disaster, conditional on permanent differences between the districts of birth and other control variables. However, $\epsilon_i = \eta_{id} + u_i$, where u_i is the white noise error term, but η_{id} may be correlated across i within d. We cluster the standard errors at the district level to overcome this problem, allowing for correlation in the error terms of observations within the same thana (i.e., subdivision).

The HIES dataset does not report birthplaces. Therefore, we assume that the respondents were born in their respective location of current residence. To explicitly account for this issue, we additionally investigate by excluding four qualitatively different regions of Bangladesh from our estimating sample to reduce the potential discrepancy between birthplace and current residence: densely populated and highly urban greater districts of Dhaka and Chittagong, remittance-heavy Sylhet, and the population-scarce and mountainous Chittagong Hill Tracts (CHT).

Finally, migration is a natural response to famine. The 1974-75 famine was a rural phenomenon, and many affected people migrated either temporarily or permanently to different urban centers across the country. Although Razzaque *et al.* (1990) and Razzaque (1989) did not find any statistically significant migration response to famine exposure, their analyses were based on only a single region, and they did not adopt a difference-in-difference framework to draw on causal inference. Instead, consistent with Sen (1981), we postulate that those who are primarily non-farmers and have lower landholding maybe more vulnerable to the harms of famine due to their lack of entitlement to food. If this is true, then the estimated adverse effects of famine should be higher among the non-farmers. We, therefore, additionally employ specification (1) on the sample of non-agricultural households.

4.4. Data and variables

Health outcome and household-level control variables come from three waves of the HIES dataset, which is the principal source of household-level socio-economic data in Bangladesh. We extract an estimating sample of 2,724 observations using the HIES datasets from the survey years 2000, 2005, and 2010.

x' is a vector of controls for current household characteristics, and labor market conditions during the birthyear to control for selection into fertility (Almond *et al.* 2009). Measures of household and individual characteristics include location and education. We control for "*location*" defined as 1 if the household lives in a rural area and 0 if otherwise, and "*Education*" measured as years of schooling. In addition, we use "*ALF*" (i.e., percentage of labor force employed in agriculture during the birth year) as a measure of regional labor market conditions and its dependency on agriculture during the birth year. We also control for "*landholding*" which is a measure of entitlement in this context. We use inverse hyperbolic sine (IHS) transformation for both *ALF* and *landholding* variables to reduce potential skewness in their respective distribution. Data on *ALF* comes from the Statistical Yearbook of Bangladesh (BBS various years) and the Population and Housing Census of Bangladesh (BBS 2011). All other control variables come from the HIES datasets.

5. Main results

We start with investigating the parallel trends assumption that is necessary for validating a difference-in-difference specification. For this purpose, we employ the regression $y_i = \alpha_0 + \vartheta R + \epsilon_i$ for the unaffected cohorts, where R denotes famine regions. Results in appendix Table A3 confirm that other famine regions have similar health outcomes, whereas Rangpur region had significantly better health outcomes, in comparison to unaffected regions when unaffected (i.e., over the years 1978-1981). Therefore, statistically significant negative values for out coefficients of interest will necessarily portray causal relationships.

Appendix Table A4 reports the balancing properties: whether important explanatory and other variables vary across famine regions and cohorts. There is mixed evidence, for example, some variables that we control for in regressions according to equation (1) such as ALF has statistically significant variations, whereas location is similar, across famine regions and cohorts. Overall, these results justify the inclusion of these control variables in our regression models.

Table 2 reports the results on the long-term health adversities of the 1974-75 famine. For both the outcome variables "*Healthy lifetime*" and "*% of Healthy lifetime*", we report our results using the entire sample of 2,685 respondents and a sample of 1,852 respondents from non-agricultural households, as specified in column headings. Control variables are reported, but we confine our discussion only to the parameters of interest, $\hat{\beta}$, given by the coefficients of "*Famine Cohort* × *Famine Region*". Famine regions and cohorts follow the definitions in section 4.2, whereas all regressions include the indicator variables for year of birth, subdivision/thana of birth, and survey year.

In all cases, results confirm $\hat{\beta} < 0$ for both the health outcome variables. However, estimated coefficients are statistically significant only for the severely affected Rangpur region. Therefore, we identify significant long-term health adversities for the 1973-75 cohorts from Rangpur region. Estimated effects are similar with and without the control variables but we will focus only on our main results where we include the controls. When compared to the 1978-81 cohorts from the unaffected regions, 1973-75 cohorts from Rangpur region have 1.8 less years of good health, which is equivalent to 6.3% of their entire lifetime.

Table 2 also reports the regression results for the non-agricultural sample, which serves as a robustness check. Overall, results are consistent with our main specification, but estimated impacts are greater for respondents from non-agricultural households. We find that for the selected non-agricultural sample, 1973-75 cohorts from famine regions have 3.3 less years of good health which is equivalent to 11.42% of their entire lifetime.

The related literature supports our evidence from the 1974-75 famine in Bangladesh. For example, both the 1959-61 Chinese famine and 1941-42 Greek famine affect the younger children more adversely. Chen and Zhou (2007) found significant long-term negative effects of China's 1959–1961 famine on the health and economic status of the survivors, especially for those in early childhood during the famine. Neelsen and Stratmann (2011) identified significant long-term education and labor market effects of early-life exposure to the 1941-42 Greek famine. In addition, Razzaque *et al.* (1990) found higher infant mortality among the in utero children and infants during the 1974-75 famine in Bangladesh.[4]

Our results hold despite concerted efforts to mitigate the immediate harms of the famine. The government of Bangladesh provided food supports to the victims of the famine, hence lowering the severity of famine exposure in the severely affected regions, which may have mitigated some of the long-term adversities. Such food supports were extended to some neighboring districts, where many famine-affected people from Rangpur district took refuge. As Sen (1981) pointed out, most of the recipients of public food supports from the Dinajpur district were originally from Rangpur, indicating a large out-migration of famine affected people. Although related literature (e.g., Razzaque *et al.* 1990; Razzaque 1989) do not identify any significant sustained or permanent out-migration of people from the famine affected regions, larger magnitudes of our estimated coefficients from the non-agricultural sample implies that our results are underestimated if not corrected for selection into migration, and therefore, we cannot rule out the possibility that permanent migration was a response to exposure to the 1974-75 famine.

[4] However, Razzaque *et al.* (1990) used the Matlab Demographic Surveillance System dataset, whose geographic coverage falls outside the definition of famine regions in this paper.

6. Additional results and robustness check

6.1. Selective mortality and fertility

As has been found by Razzaque *et al.* (1990), infant mortality was higher among the in utero children and infants during the 1974-75 Bangladesh famine. Therefore, it is possible that those who have survived the famine might have stronger immune systems and, therefore, may not exhibit long-term health adversities. In addition, Xu *et al.* (2016) cautioned about the choice of method and health measures to identify the long-term effects of famine especially due to the presence of mortality selection among the survivors. This can be true if there is a systematic pattern in health outcomes by percentile groups. That is, such selective mortality may result in the surviving 1973-75 cohorts from famine regions to belong to higher health percentiles. To check for this possibility, we run quantile regressions on 20^{th} and 70^{th} percentiles for "*healthy lifetime*". Results in Table 3 confirm that there is no such selection into mortality – estimated coefficients for all the regressions are statistically insignificant. This is consistent with Kannisto *et al.* (1997) who did not find any significant difference between moratlity among the affected and unaffected cohorts for the 1866-68 famine in Finland.

Similarly, women may select their fertility and decide not to give birth during the famine. If this is the case, there will be significantly lower incidences of birth for the famine cohorts. To check this possibility, we collapse data to the district-birthyear level and count the total number of children born in a particular year in each locality. We then use these locality-birthyear panels to regress total number of children born in that year on exposure to famine. Results in Table 3 confirm that neither of the exposure coefficients are significant, offering no evidence of selective fertility or selective child mortality. While this finding is in stark contrast to Razzaque *et al.* (1990) and Razzaque (1989), those earlier studies did not implement a difference-in-difference framework to retrieve any causal inference.

6.2. Placebo falsification test

We perform a falsification test by repeating the analysis using the individuals born during 1960-69, who were never been exposed to the 1974-75 famine during their respective childhood. We backdate the actual event by 13 years so that the placebo cohorts become: 1960-62 for famine and 1965-69 for unaffected cohorts.

We then rematch the actual famine regions to generate our placebo variable. Results in Table 4 show that placebo famine groups do not experience any significant long-term health adversities. Therefore, this falsification test confirms that our main results are not driven by unobserved time-persistent regional heterogeneity connected with exposure to the 1974-75 famine. While this is the case, our main specification in equation (1) includes thana, birthyear, and survey year fixed effects to account for any unobserved time-persistent regional heterogeneity that are not already absorbed by the control variables in x'.

6.3. Effects of per-capita income

Finally, our estimated effects might vary by income levels. If so, then our main results in Table 2 will be biased. To investigate whether per-capita income further exacerbates or mitigates the long-term adverse health effects of the 1974-75 famine, we estimate the following equation for the outcome variable y

$$(3) \qquad y_i = \alpha_0 + \theta_1 C + \vartheta_1 R + \beta_1 \times (R \times C) + \gamma Y + \theta_2 \times (C \times Y) + \vartheta_2 \times (R \times Y) + \beta_2 \times (R \times C \times Y) + x_i' \delta + \tau_{yob} + \Delta_{pob} + H_{yos} + \epsilon_i,$$

for a household i. R and C denote the famine regions and cohorts, respectively, whereas Y denotes per-capita income of the household. All other variables are as defined in equation (1) and Table 1.

Results in Table 5 confirm that per-capita expenditure, a measure of economic solvency, does not affect the estimated health adversities induced by exposure to the 1974-75 famine since all the estimated coefficients are statistically insignificant.

7. Conclusion

Following the *fetal origin* hypothesis framework, we empirically estimate the long-term health effect of the 1974-75 famine in Bangladesh using a difference-in-difference specification. Our results inform that the relative scarcity of essential foods, measured by the difference between growths in rice price and agricultural wages, during their pre-natal and neonatal periods saw the famine cohorts from famine regions in Bangladesh achieve significantly lower health outcomes during their adulthood. First such investigation for Bangladesh, our findings are consistent with similar studies on Netherlands and China, among others, where in utero and early childhood famine exposures have resulted in significant health adversities including chronic diseases (e.g., Hu *et al.* 2017).

Immediate effects of the 1974-75 famine including deaths, hunger, and malnutrition were reduced but not completely eliminated by the concerted efforts of the government to help the famine affected people to overcome the food scarcity. Consequently, as our results have informed, relatively malnourished survivors with in utero or early childhood exposure to the famine have significantly lower healthy lifetime. In fact, this research reinforces the need for keeping prices of rice and other essential commodities within the reach of rural poor especially during mass hardships like famine and ongoing covid-19 pandemic and Ukraine war. In related literature, Ahmed (1988) reviews the rationale of rice price stabilization for Bangladesh for the period of 1960-84, and suggests that a combination of public procurement, import, rationing and open market operations will be necessary to keep rice prices within desired level. Importantly, our findings and policy suggestions can be generalized for other developing countries and events. Due to their sustained effects, public service facilitations during and after a similar emergency event should aim at prioritizing consumption of vulnerable groups.[5]

Drawing on the lack of entitlement to foodgrains for daily wage laborers (Sen 1981), Muqtada (1981) argued that the 1974-75 famine must be seen as an extension of poverty. In particular, the government needs to give special attention to reducing the gap between food price and wages, which was the primary reason behind the 1974 Bangladesh famine. Poor and vulnerable people who now have fewer means to maintain their sustenance will need public support to ensure better health outcomes, and better adulthood productivity as a consequence, for their children. Relevant examples include the food assistance programs in the US especially the Supplemental Nutrition Assistance Program (SNAP, or food stamps) which has successfully reduced food insecurity among low-income children, reduced poverty, improved birth outcomes and children's health generally, and increase survival among low-weight infants (Gundersen 2015). By reducing childhood hunger, the SNAP program has also reduced obesity (Ludwig *et al.* 2012). In addition, other OECD countries have even better food security and health for children due to their higher investments in children (Fernald and Gosliner 2019). For developing countries, Glewwe and Miguel (2007) have found that nutrition and child health are positively related to educational outcomes. Consistently, Jomaa *et al.* (2011) have found that school feeding programs in developing countries have positive effects on children's health and educational outcomes, whereas Fang and Zhu (2022) have identified that early exposure to the school meal program significantly improved children's long-term cognitive and health outcomes, especially among the low-income children. Therefore, it is essential that the public policies aim at ensuring food security especially during the time of food scarcity for the long-term welfare of the future generation.

[5] In addition, the newly opened manpower market in Saudi Arabia and other middle eastern countries in 1976 helped ease the remaining harms of the 1974-75 Bangladesh. However, confounding effects, if any, of these external events may be the subject of future research.

For an agricultural country like Bangladesh which is going through economic transformation, such public supports can have long-lasting human capital and growth benefits.

Despite its unique contributions, our paper has some limitations which might open up avenues for future research. First, we resort to a small sample size due to unavailability of panel data from Bangladesh covering such historical events that took place long ago. Next, similar to Eskander and Barbier (2022), we made a restrictive assumption that people were born where they currently live due to unavailability of data. Although we adopted some measures to reduce the possibility of mismatch between birthplace and residence, future research can benefit from using a better dataset with information on birthplace. Finally, it is possible that in addition to famine-induced food shortages, some of the coping strategies that the affected households adopted may have also contributed to the adulthood health adversities of their children. Common such coping strategies include, but not limited to, reducing food intake, borrowing from family and friends, and dietary changes. While the estimated total effects might be a combination of both direct exposure to the famine and consequent coping strategies, we could not decouple these effects due to data limitations.

Competing interests:

The authors declare none.

References

Abate KH, Arage G, Hassen H, Abafita J, and Belachew T (2022) Impact of prenatal famine exposure on adulthood fasting blood glucose level. *Scientific reports* 12(1), 1-6.

Ahmed RU (1988) Rice price stabilization and food security in Bangladesh. *World Development* 16(9), 1035-1050.

Alamgir M and Salimullah (1977) *Famine, 1974: Political economy of mass starvation in Bangladesh: A statistical annexe*. Bangladesh Institute of Development Studies, Dhaka, Bangladesh.

Alamgir M (1980) *Famine in South Asia. Political economy of mass starvation,* Oelgeschlager, Gunn & Hain, Publishers, Inc.

Almond D and Currie J (2011) Killing me softly: The fetal origins hypothesis. *The Journal of Economic Perspectives* 153-172.

Almond D, Currie J and Duque V (2018) Childhood circumstances and adult outcomes: Act II. *Journal of Economic Literature* 56(4), 1360-1446.

Almond D, Edlund L, and Palme M (2009) Chernobyl's Subclinical Legacy: Prenatal Exposure to Radioactive Fallout and School Outcomes in Sweden. *The Quarterly Journal of Economics* 124(4), 1729-1772.

Ampaabeng SK and Tan CM (2013) The long-term cognitive consequences of early childhood malnutrition: the case of famine in Ghana. *Journal of health economics* 32(6), 1013-1027.

Arage G, Belachew T, Hajmahmud K, Abera M, Abdulhay F, Abdulahi M and Abate KH (2021) Impact of early life famine exposure on adulthood anthropometry among survivors of the 1983–1985 Ethiopian Great famine: a historical cohort study. *BMC Public Health* 21(1), 1-16.

Bairagi R (1986) Food crisis, nutrition, and female children in rural Bangladesh. *Population and Development Review* 307-315.

BBS (2011) *Population and Housing Census 2011: Socio-economic and Demographic Report, National Series, Volume-4*. Bangladesh Bureau of Statistics, Dhaka: Ministry of Planning, Government of Bangladesh.

BBS (various years) *Statistical Yearbook of Bangladesh.* Bangladesh Bureau of Statistics. Dhaka: Ministry of Planning, Government of Bangladesh.

Barker DJP (1990) The fetal and infant origins of adult disease. *BMJ: British Medical Journal* 301(6761), 1111.

Brown AS, van Os J, Driessens C, Hoek HW and Susser ES (2000) Further evidence of relation between prenatal famine and major affective disorder. *American Journal of Psychiatry* 157(2), 190-195.

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

Cui H, Smith JP and Zhao Y (2020) Early-life deprivation and health outcomes in adulthood: Evidence from childhood hunger episodes of middle-aged and elderly Chinese. *Journal of development economics* 143, 102417.

Deng Z and Lindeboom M (2021) Early-life famine exposure, hunger recall, and later-life health. *Journal of Applied Econometrics.*

Eskander S and Barbier EB (2022) Long-term impacts of the 1970 cyclone in Bangladesh. *World Development* 152, 105793.

Fang G and Zhu Y (2022) Long-term impacts of school nutrition: Evidence from China's school meal reform. *World Development* 153, 105854.

Fernald LCH and Gosliner W (2019) Alternatives to SNAP: global approaches to addressing childhood poverty and food insecurity. *American Journal of Public Health* 109(12), 1668-1677.

Finer S, Iqbal MS, Lowe R, Ogunkolade BW, Pervin S, Mathews C, Smart M, Alam DS, and Hitman GA (2016) Is famine exposure during developmental life in rural Bangladesh associated with a metabolic and epigenetic signature in young adulthood? A historical cohort study. *BMJ open* 6 (11), e011768.

Fink G, Jack BK and Masiye F (2020) Seasonal liquidity, rural labor markets, and agricultural production. *American Economic Review* 110(11), 3351-92.

Glewwe P and Miguel EA (2007) The impact of child health and nutrition on education in less developed countries. *Handbook of development economics* 4, 3561-3606.

Grey K, Gonzales GB, Abera M, Lelijveld N, Thompson D, Berhane M, Abdissa A, Girma T and Kerac M (2021) Severe malnutrition or famine exposure in childhood and cardiometabolic non-communicable disease later in life: a systematic review. *BMJ global health* 6(3), e003161.

Gundersen G (2015) Food assistance programs and child health. *The Future of Children* 91-109.

Hernández-Julián R, Mansour H and Peters C (2014) The effects of intrauterine malnutrition on birth and fertility outcomes: evidence from the 1974 Bangladesh famine. *Demography* 51(5), 1775-1796.

Hu XF, Liu GG and Fan M (2017) Long-Term Effects of Famine on Chronic Diseases: Evidence from China's Great Leap Forward Famine. *Health Economics* 26(7), 922-936.

Huang C, Phillips MR, Zhang Y, Zhang J, Shi Q, Song Z, Ding Z, Pang S and Martorell R (2013) Malnutrition in early life and adult mental health: evidence from a natural experiment. *Social science & medicine* 97, 259-266.

Hulshoff Pol HE, Hoek HW, Susser E, Brown AS, Dingemans A, Schnack HG, van Haren NEM, Ramos LMP, Gispen-de Wied CC and Kahn RS (2000) Prenatal exposure to famine and brain morphology in schizophrenia." *American Journal of Psychiatry* 157(7), 1170-1172.

Jenkins GP and Shukla GP (1997) Linking east and west Bangladesh: the jamuna bridge project. *The Canadian Journal of Program Evaluation* 12, 121.

Jomaa LH, McDonnell E and Probart C (2011) School feeding programs in developing countries: impacts on children's health and educational outcomes. *Nutrition reviews* 69(2), 83-98.

Kannisto V, Christensen K and Vaupel JW (1997) No Increased Mortality in Later Life for Cohorts Born during Famine. *American Journal of Epidemiology* 145, 987–94.

Khan AR (1984) Real wages of agricultural workers in Bangladesh. *Economic and Political Weekly* PE40-PE48.

Koenig MA and D'Souza S (1986) Sex differences in childhood mortality in rural Bangladesh. *Social Science & Medicine* 22(1), 15-22.

Li C and Lumey LH (2017) Exposure to the Chinese famine of 1959–61 in early life and long-term health conditions: a systematic review and meta-analysis. *International journal of epidemiology* 46(4), 1157-1170.

Liu H, Chen X, Shi T, Qu G, Zhao T, Xuan K and Sun Y (2020) Association of famine exposure with the risk of type 2 diabetes: A meta-analysis. *Clinical Nutrition* 39(6), 1717-1723.

Ludwig DS, Blumenthal SJ and Willett WC (2012) Opportunities to reduce childhood hunger and obesity: restructuring the Supplemental Nutrition Assistance Program (the Food Stamp Program). *Jama* 308(24), 2567-2568.

Luo Z, Mu R and Zhang X (2006) The long term health impact of the Chinese Great Famine. *Mich State Univ Work Paper*.

Maccini S and Yang D (2009) Under the weather: Health, schooling, and economic consequences of early-life rainfall. *The American Economic Review* 1006-1026.

Meng X and Qian N (2009) *The long term consequences of famine on survivors: evidence from a unique natural experiment using China's great famine*. No. w14917. National Bureau of Economic Research.

Muqtada M (1981) Poverty and famines in Bangladesh." *The Bangladesh Development Studies* 1-34.

Neelsen S and Stratmann T (2011) Effects of prenatal and early life malnutrition: Evidence from the Greek famine. *Journal of Health Economics* 30(3), 479-488.

Neugebauer R, Hoek HW and Susser E (1999) Prenatal exposure to wartime famine and development of antisocial personality disorder in early adulthood. *Jama* 282(5), 455-462.

Palmer-Jones RW (1993) Agricultural wages in Bangladesh: What the figures really show?." *The Journal of Development Studies* 29(2), 277-300.

Palmer-Jones RW and Parikh A (1998) The determination of agricultural wage rates in Bangladesh." *Journal of agricultural economics* 49(1), 111-133.

Ravallion M (1982) Agricultural Wages in Bangladesh before and after the 1974 Famine. *The Bangladesh Development Studies* 75-89.

Ravallion M (1985) The performance of rice markets in Bangladesh during the 1974 famine. *The Economic Journal* 15-29.

Ravelli ACJ, van der Meulen JHP, Michels RPJ, Osmond C, Barker DJP, Hales CN and Bleker OP (1998) Glucose tolerance in adults after prenatal exposure to famine. *The Lancet* 351(9097), 173-177.

Ravelli G, Stein ZA and Susser MW (1976) Obesity in young men after famine exposure in utero and early infancy. *New England Journal of Medicine* 295(7), 349-353.

Razzaque A, Alam N, Wai L and Foster A (1990) Sustained effects of the 1974–5 famine on infant and child mortality in a rural area of Bangladesh. *Population Studies* 44(1), 145-154.

Razzaque A (1989) Sociodemographic differentials in mortality during the 1974–75 famine in a rural area of Bangladesh. *Journal of Biosocial Science* 21(1), 13-22.

Reardon T (1997) Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World development* 25(5), 735-747.

Scholte RS, van Den Berg GJ and Lindeboom M (2015) Long-run effects of gestation during the Dutch Hunger Winter famine on labor market and hospitalization outcomes. *Journal of health economics* 39, 17-30.

Sen A (1980) Famines. *World development* 8(9), 613-621.

Sen A (1981) Ingredients of famine analysis: availability and entitlements. *The Quarterly Journal of Economics* 433-464.

Shabnam N, Ulubaşoğlu MA and Guven C (2022) Food Affordability and Double Catastrophe in Early Life: Lessons from the 1974–75 Bangladesh Famine. *Economic Record* 98, 24-51.

Sparén P, Vågerö D, Shestov DB, Plavinskaja S, Parfenova N, Hoptiar V, Paturot D and Galanti MR (2004) Long term mortality after severe starvation during the siege of Leningrad: prospective cohort study. *British Medical Journal* 328(7430), 11.

Stanner SA, Bulmer K, Andres C, Lantseva OE, Borodina V, Poteen VV and Yudkin JS (1997) Does malnutrition in utero determine diabetes and coronary heart disease in adulthood? Results from the Leningrad siege study, a cross sectional study. *Bmj* 315(7119), 1342-1348.

van Abeelen AFM, Elias SG, Bossuyt PMM, Grobbee DE, van der Schouw YT, Roseboom TJ and Uiterwaal CSPM (2012) Famine exposure in the young and the risk of type 2 diabetes in adulthood." *Diabetes* 61(9), 2255-2260.

van Schendel W (2009) *A history of Bangladesh*. Cambridge: Cambridge University Press.

Veenendaal MV, Costello PM, Lillycrop KA, de Rooij SR, van Der Post JA, Bossuyt PM, Hanson MA, Painter RC and Roseboom TJ (2012) Prenatal famine exposure, health in later life and promoter methylation of four candidate genes." *Journal of developmental origins of health and disease* 3(6), 450-457.

WFP (2021). "Fighting famine". *wfp.org*. World Food Programme. Retrieved 4 November 2022.

Xu H, Li L, Zhang Z and Liu J (2016) Is natural experiment a cure? Re-examining the long-term health effects of China's 1959–1961 famine. *Social Science & Medicine* 148, 110-122.

Xu H, Zhang Z, Li L and Liu J (2018) Early life exposure to China's 1959–61 famine and midlife cognition. *International Journal of Epidemiology* 47(1), 109-120.

Yao H and Li L (2019) Famine exposure during the fetal period increased the risk of dyslipidemia in female adults. *Lipids* 54(5), 301-309.

Zhou J, Zhang L, Xuan P, Fan Y, Yang L, Hu C, Bo Q, Wang G, Sheng J and Wang S (2018) The relationship between famine exposure during early life and body mass index in adulthood: a systematic review and meta-analysis. *PloS one* 13(2), e0192212.

Tables

Table 1. Variable description and summary statistics.

Variables	Description	Mean	S.D.	Min.	Max.
Famine regions	2 if severely affected Rangpur region, 1 if moderately affected other famine regions, and 0 if unaffected regions	0.32	0.59	0	2
Famine cohorts	1 if affected cohorts and 0 if unaffected cohorts	0.55	0.50	0	1
Healthy lifetime	Total lifetime without major illness, in completed years	25.89	11.51	0	36
% of healthy lifetime	Percentage of lifetime without major illness (%)	84.73	35.98	0	100
Location	1 if rural household and 0 if otherwise	0.63	0.48	0	1
ALF	Birth-year agricultural labor force (% of total labor force)	71.03	14.42	34.41	88.65
Education	Years of schooling	4.06	4.70	0	16
Agriculture	1 if agricultural household and 0 if otherwise	0.29	0.45	0	1
Landholding	Ownership of agricultural lands, decimals	26.92	68.25	0	500
No. of Obs.		2,724			

Notes: Summary statistics consider birth cohorts 1973-75 and 1978-81 and exclude Chittagong, CHT, Dhaka and Sylhet regions, so that the number of valid observations is 2,028. Landholding is expressed in decimals where 1 acre = 100 decimals.

Table 2. Health adversities of the 1974-75 famine.

Variables	No controls		With controls		Non-agricultural sample	
	Healthy lifetime	% of healthy lifetime	Healthy lifetime	% of healthy lifetime	Healthy lifetime	% of healthy lifetime
Famine Cohort × Other Famine Regions	-0.859	-2.141	-1.215	-3.221	-1.034	-2.828
	(1.075)	(3.238)	(1.073)	(3.301)	(1.600)	(4.973)
Famine Cohort × Rangpur Region	-1.232*	-4.550*	-1.832**	-6.343**	-3.257***	-11.417***
	(0.733)	(2.640)	(0.846)	(3.013)	(1.202)	(3.780)
Location			-0.959	-3.142	-0.833	-2.855
			(0.788)	(2.569)	(0.971)	(3.153)
Education			0.047	0.158	-0.016	-0.053
			(0.066)	(0.209)	(0.070)	(0.216)
IHS(ALF)			-14.200*	-42.780*	-12.708	-43.795
			(7.448)	(24.265)	(9.446)	(30.948)
IHS(Landholding)			-0.050	-0.192	-0.092	-0.301
			(0.145)	(0.473)	(0.185)	(0.608)
Constant	26.031***	85.068***	96.595**	297.795**	89.195*	302.554*
	(0.124)	(0.380)	(36.793)	(119.936)	(46.260)	(151.623)
No. of Obs.	2,685	2,685	2,685	2,685	1,852	1,852
R-squared	0.226	0.193	0.228	0.195	0.241	0.209
Year FE	YES	YES	YES	YES	YES	YES
Thana FE	YES	YES	YES	YES	YES	YES
HIES FE	YES	YES	YES	YES	YES	YES

Notes: Standard errors clustered at the district level are shown in parentheses. ***, ** and * represent statistical significance at 1, 5 and 10 percent levels, respectively. The table presents estimates from regressions of whether exposure to the 1974-75 famine induces long-term health adversities, according to the empirical specification (1). All the variables follow their respective definitions in Table 1. All regressions include the indicator variables for year of birth, subdivision/thana of birth, and survey year. Parameter of interest, $\hat{\beta}$, is given by the coefficients of "*Famine Cohort × Famine Region*". Famine regions and cohorts follow the definitions in section 4.2.

Table 3. Selection into mortality and fertility.

	Selection into mortality				Selection into fertility		
Variables	20%	40%	60%	80%	Thana level	District level	Region level
Famine Cohort × Other Famine Region	-23.759***	2.000***	0.518	0.000	-0.091	0.159	-0.427
	(8.070)	(0.688)	(0.445)	(0.000)	(0.178)	(1.201)	(6.559)
Famine Cohort × Rangpur Region	-0.079	0.000	-0.507	-0.000	-0.234	-0.693	-1.622
	(4.138)	(1.264)	(1.347)	(0.000)	(0.284)	(1.806)	(10.627)
No. of Obs.	2,724	2,724	2,724	2,724	1,503	432	119
Pseudo R-squared	0.0126	0.0360	0.0820	0.211			
No. of regions							17
No. of districts						64	
No. of thanas					425		
Controls	YES	YES	YES	YES	NO	NO	NO
Year FE	NO	NO	NO	NO	NO	NO	NO
Thana FE	NO	NO	NO	NO	NO	NO	NO
HIES FE	NO	NO	NO	NO	NO	NO	NO

Notes: Robust standard errors are shown in parentheses. ***, ** and * represent statistical significance at 1, 5 and 10 percent levels, respectively. Regressions for selection into mortality are estimated using quantile regressions at 20, 40, 60, and 80 percentile levels, where the dependent variable is "*healthy lifetime*". We do not include the fixed effects in quantile regressions. Regressions for selection into fertility are estimated using the specification $f_i = \alpha_0 + \theta C + \vartheta R + \beta \times (R \times C) + \epsilon_i$, where the outcome variable f_i denotes *fertility*. Famine regions and cohorts follow the definitions in section 4.2.

Table 4. Health adversities of the 1974 famine - Placebo test.

Variables	No controls		With controls		Non-agricultural sample	
	Healthy lifetime	% of healthy lifetime	Healthy lifetime	% of healthy lifetime	Healthy lifetime	% of healthy lifetime
Famine Cohort × Other Famine Region	-1.399	-2.819	-2.026	-4.400	-1.179	-2.022
	(1.489)	(3.367)	(1.569)	(3.624)	(1.941)	(4.414)
Famine Cohort × Rangpur Region	1.549	2.822	-0.372	-1.453	2.408*	6.224*
	(2.631)	(6.290)	(2.881)	(6.702)	(1.398)	(3.205)
No. of Obs.	3,860	3,860	3,487	3,487	2,359	2,359
R-squared	0.161	0.147	0.166	0.150	0.202	0.184
Controls	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Thana FE	YES	YES	YES	YES	YES	YES
HIES FE	YES	YES	YES	YES	YES	YES

Notes: Standard errors clustered at the district level are shown in parentheses. ***, ** and * represent statistical significance at 1, 5 and 10 percent levels, respectively. Placebo regressions follow the empirical specification (1). Outcome variables, as identified in headers, and control variables follow their respective definitions in Table 1. Famine regions and placebo cohorts follow the definitions in section 6.2.

Table 5. Effects of per-capita expenditure.

Variables	Healthy lifetime	% of healthy lifetime
Famine Cohort × Other Famine Region × Per-capita expenditures	-0.001	-0.001
	(0.001)	(0.003)
Famine Cohort × Rangpur Region × Per-capita expenditures	0.002	0.004
	(0.002)	(0.005)
No. of Obs.	2,685	2,685
R-squared	0.230	0.196
Controls	YES	YES
Year FE	YES	YES
Thana FE	YES	YES
HIES FE	YES	YES

Notes: Standard errors clustered at the district level are shown in parentheses. ***, ** and * represent statistical significance at 1, 5 and 10 percent levels, respectively. The table presents estimates of whether the long-term health adversities induced by exposure to the 1974-75 famine are further accentuated or mitigated by per-capita income, according to the empirical specification (3). All the variables follow their respective definitions in Table 1. All regressions include the indicator variables for year of birth, subdivision/thana of birth, and survey year. Parameter of interest is given by the coefficients of "*Famine Cohort* × *Famine Region* × *Per-capita expenditure*". Famine regions and cohorts follow the definitions in section 4.2.

Figures

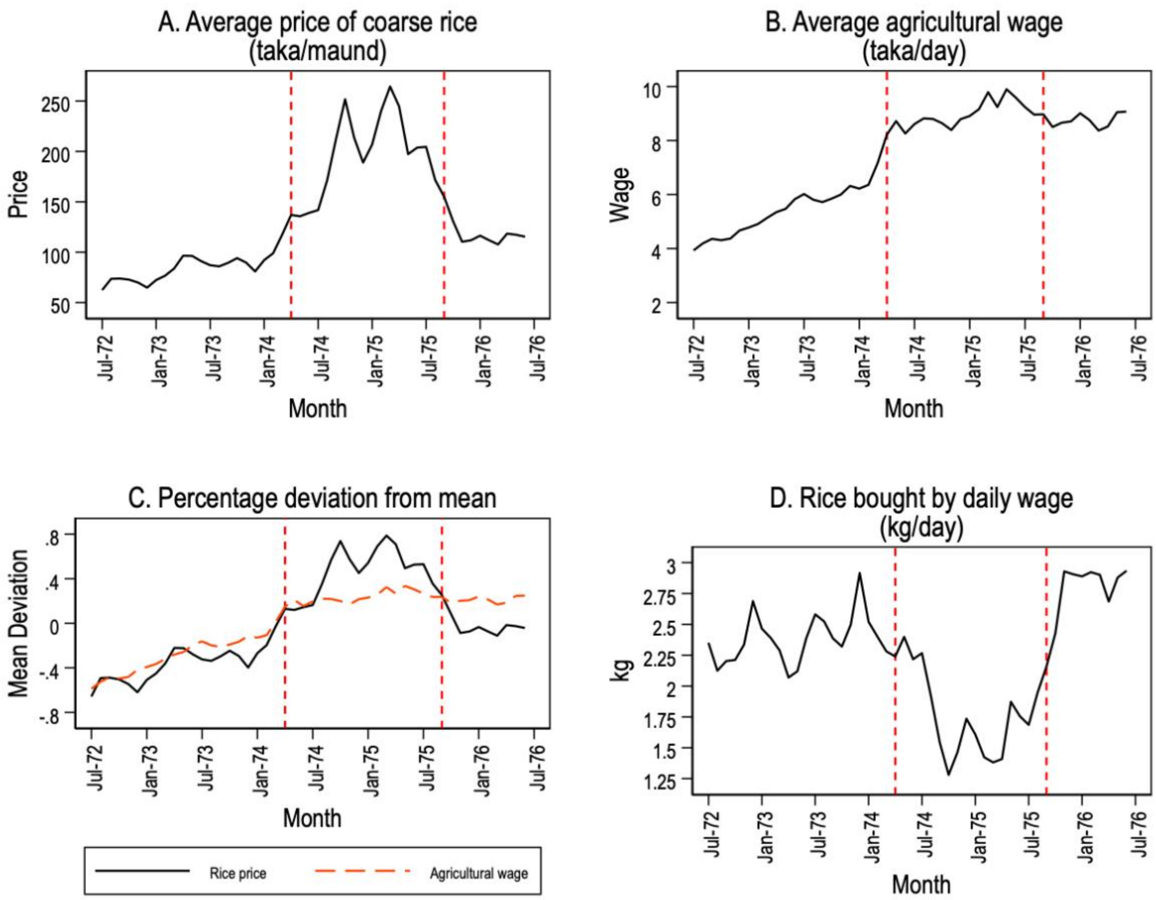

Figure 1. Price of rice and farm wage rate, 1972-76.

Notes: Data on price of coarse rice and agricultural wages come from Alamgir and Salimullah (1977), where the latest data are available for July 1976. Panel A plots monthly average price of coarse rice expressed in taka per maund (where 1 maund = 37.3242 kilograms). Panel B plots monthly average agricultural wages in taka per day. Following Ravallion (1982), Panel C plots percentage deviation from respective mean values for price of coarse rice per maund and daily agricultural wages. Finally, Panel D plots kilograms of rice that can be bought by daily wage.