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ABSTRACT

The Inheritance of Historical Trauma: Intergenerational Effects of Early-Life Exposure to Famine on Mental Health*

Can the effects of early childhood trauma persist across generations, impacting the long-run outcomes of their children? To answer this question, we exploit the geographic variation in the intensity of the Great Famine in China and distinguish the effects of exposures during four stages of childhood cognitive development between ages 0 to 15 as defined in the child development theory of Jean Piaget. We find that exposure to famine in childhood, especially in ages 0—2 and 3—7, negatively impacts the adult mental health of the survivors' children. We also find negative effects on parent's mental health and parent-child interaction frequency, consistent with the role of childhood home environments as transmission channels. Our findings show that the determinants of mental health problems can be traced back across a generation and demonstrate the persistent damage of early childhood trauma on the survivors and their children.

JEL Classification: I14, I18, J13

Keywords: collective trauma, famine, mental health, intergenerational effects

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* This study is inspired by the conversation between Zhang and her grandmother who survived the Great Famine of China in her youth. It is hoped that this study will honor and commemorate those who endured the famine.

"Those who don't know history are doomed to repeat it." – Edmund Burke

1 Introduction

Mental health problems affect more than 10% of people globally, with a high rate of prevalence among both children and adults (GBD 2019 Mental Disorders Collaborators, 2022). Studies show that traumatic childhood experiences such as exposure to war, famine, and child abuse are among the predictors of mental health problems later in life (Oberg et al., 2022; Springer et al., 2007). Further, mental health problems of adults can shape parenting behaviors and parent-child interactions (van Ee et al., 2012; van Loon et al., 2014), which then affect children's mental health and their long-term outcomes (Almond et al., 2018; Currie, 2009; Heckman and Mosso, 2014). Following these links, the sources of mental health problems among adults may hypothetically be traced back to the childhood experiences of the earlier generation. It remains unknown, however, whether the traumatic experience of earlier generation affect the adult mental health in the next generation.

In this paper, we study whether parents' exposures to famine during childhood affect the mental health of the survivors' children in adulthood. We leverage China's Great Famine during 1959—1961, one of the most serious and nationwide food deprivation disaster in modern Chinese history. It affected more than 80% of the population in China, leading to tens of millions of excess deaths (Smil, 1999), but with considerable variation in the timing and magnitudes of famine severity across provinces (Chen and Zhou, 2007). The famine survivors are associated with significantly worse physical health, mental health, educational attainment, and labor market outcomes (Chen and Zhou, 2007; Cui et al., 2020; Li and Sunder, 2021; Meng and Qian 2009; Ren and Ye, 2022).

Our identification strategy uses information on the parents' duration of exposure to the famine in each of the cognitive developmental period in childhood, based on the seminal work of Jean Piaget that occupies an important place in developmental literature. Piaget proposed four stages of cognitive development of children, each in ages 0—2, 3—7, 8—11, and 12—15. We define exposure variables corresponding to the proportion of years exposed to the famine in each stage of development. This achieves more precise identification compared to the common practice of using dummy variables for exposures in childhood. We use data from Chinese Family Panel Studies (CFPS) combined with the famine intensity data from Lin and Yang (2000). Cohort difference-in-differences model is used.

We find that if the parents were exposed to the Great Famine, especially during the sensorimotor stage (ages 0—2) and the pre-operational stage (ages 3—7) when the brain development is highly sensitive to environmental shocks, their children are more likely to experience feelings of depression and loneliness in adulthood. The effects are observed regardless of the hukou status of the parents and the gender composition of the parent-child pairs. We also find negative effects on parents' mental health and the frequency of parent-child interaction which are consistent with the role of parenting and home environment in explaining the results. Exposures in later stages of development, when children develop skills for logical and abstract thinking, have small and insignificant effects.

We present the first causal evidence showing that traumatic experience in early life can have negative consequences on the long-term mental health of the second generation. By relying on an exogenous variation in traumatic shocks, we go beyond showing association in mental health across generations (Johnston et al., 2013; Propper et al., 2007). Further, we show that the determinants of mental health problems can be

traced as far back as the previous generation, whereas the current literature focuses on determinants within the lifespan of those experiencing mental health problems such as social media use, religiosity, in-utero stress, and socioeconomic inequality (Braghieri et al., 2022; Fruehwirth et al., 2019; Persson and Rossin-Slater, 2018; Reiss, 2013). In addition, our study adds a rare piece of evidence on the intergenerational persistence of early life shocks on the outcomes in the next generation. Literature shows that early childhood education and health programs improve skills, earnings, and health of the participants' children (Barr and Gibbs, 2023; East et al., 2023; García et al., 2023). Complementing these findings, ours show the harmful effects of negative shocks during parents' early childhood. Finally, we contribute to the literature on the intergenerational effects of the Great Famine on China, showing negative effects of parental exposures on children's height, years of schooling, income, and cognitive skills (Li and An, 2015; Kim et al., 2014; Tan et al., 2015; Xie and Zhu, 2022). We add to this literature by showing effects on the long-term mental health of the survivors' children.

Methodologically, our empirical model improves on the previous studies in this literature that typically use binary indicators for exposures to the famine during the in-utero or early childhood period interacted with regional famine intensity. Rather than limiting our attention to in-utero or early childhood period alone, we use the developmental framework from Piaget (1964, 1976) that encompasses the entire childhood. We further account for the different duration of exposure in each developmental period that is not captured by binary indicators. This strategy enables more precise identification of the effects of famine exposure on the outcomes of interest.

2 Background and conceptual framework

2.1 Historical background

The Great Famine of China from 1959 to 1961 lasted three years, claiming 30 million lives by some estimates and affecting almost everyone who were alive during that time in China (Smil, 1999). In May 1958, the Great Leap Forward Movement was initiated to facilitate the industrialization of China to be on par with the Western world. Food procurement projects were established to support steelmaking campaigns in the cities. To increase agricultural production, government implemented radical collectivization of agricultural production in rural areas by establishing "people's communes." Contrary to the expectations of central planners, however, grain harvested shrunk by 15% in 1959 and attained approximately 70% of the 1958 level in1960 and 1961. (Chen and Zhou, 2007).

The severity of the Great Famine was mostly determined by bad policy designs on agriculture production, bad management in the communes, and natural disasters (Li and Yang, 2005; Lin and Yang, 2000; Meng et al., 2015). First, the commune members lacked the incentive to meet the goals set up by central planners for food production, little of which was left for local consumption after being delivered to cities. Second, local officials did not take timely measures to address the large gap between food procurement targets and actual agricultural output to avoid political fallout. Third, serious drought struck two thirds of the country, which worsened agricultural production and accelerated the outbreak of the famine. The combination of these factors led to the outbreak of the famine in 31 provinces across China in 1959 (Clément, 2012; Lin and Yang, 2000; Meng et al., 2015;). Figure 1 shows that the famine period is associated with higher death rate and lower birth rate compared to other periods.

During the famine period, daily caloric intake was often limited to only 1500 in

1960, much smaller than average human energy requirements 2100 calories (Ashton et al., 1984). Anecdotal evidence describes people eating bark and sand out of starvation, further damaging their health. The famine claimed tens of millions of deaths, and had long-term consequences on the survivors' health, educational attainment, and income (Cheng et al., 2021; Li and Sunder, 2021; Meng and Qian, 2009; Ren and Ye, 2022; Smil, 1999).

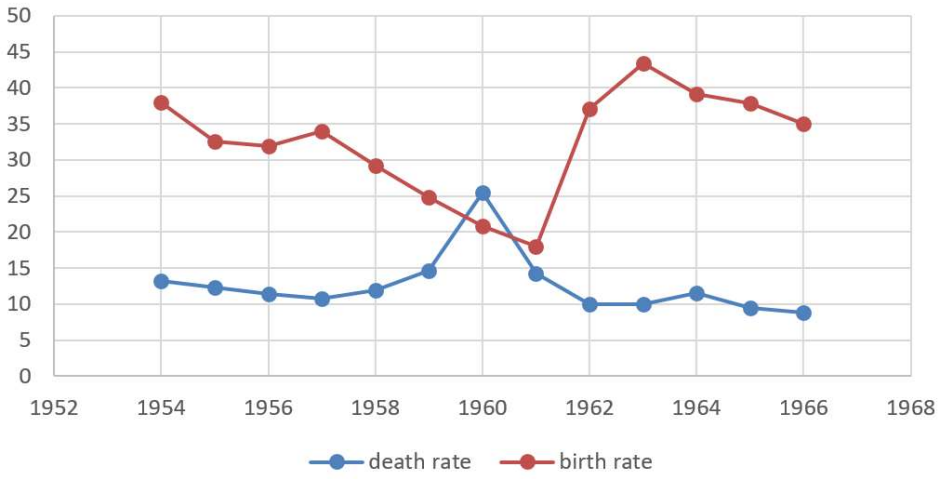

Figure 1 Birth rate and death rate in China, 1954—1966.

Notes: This figure presents the change of birth rate and death rate in China during 1954-1966. The unit of the y-axis is 0.1%.

2.2 Conceptual framework

We refer to the first (exposed) generation as the parents or the G1, and the second generation as their children or the G2.

How does parental exposure to famine in the childhood of G1 affects mental health of the G2? The importance of childhood in shaping life outcomes is well-known in economics literature—shocks *in-utero* or before age 5 (the "critical period") can have disproportionate effects on life outcomes (Almond and Currie, 2011; Almond et al., 2018) and early-life investments can complement later-life investments (Heckman and Mosso, 2014).

In psychology, a seminal work by Jean Piaget (1964; 1976) provided the

framework to analyze the cognitive development of children throughout childhood that inspired much of subsequent research in developmental psychology. He proposed that cognitive development takes place as children build schemas, the mental structures used to interpret experiences, as outcomes of both brain development and the children interacting with their physical and social environments. This process takes place in stages: sensorimotor stage (ages 0—2), in which children experience rapid cognitive growth by exploring their environment and using trial and error; pre-operational stage (ages 3—7), in which children develop language abilities and concepts of past and future; concrete operational stage (ages 8—11), in which children acquire skills to think logically ("operation") and understand others' point of view; and finally formal operational stage (ages 12—15), in which children develop skills for abstract thinking.[1][2]

The Great Famine limited nutrition intake of children and adults alike, and disrupted G1's childhood home environment as the parents of G1 struggled to provide for food and suffered emotional trauma as death toll increased around them (Ashton et al., 1992). G1's neural development and the learning through interactions both likely have been disrupted by these shocks. Such shocks would have different effects on cognitive development, and by extension, human capital development of G1, depending on the stage of development of the child.

The skills of G1 allow them to provide home environments that shape the long-term outcomes of G2 such as mental health. G1's exposures to Great Famine may affect G2's mental health by affecting G1's ability to provide good parenting, for example by undermining G1's language abilities (developed in pre-operational stage). Parenting

[1] Beyond the age of 15, Piaget believed that cognitive development is gradual and incremental.

[2] See Table A1 in the Appendix for more information on Piaget's model of childhood cognitive development.

and parent-child interactions, which are important components of home environment, critically depend on parents' skills to understand and communicate effectively with their children (Kim et al., 2018; Sylvia et al., 2021). Evidence shows that parenting and parent-child interaction are important determinants of children's mental health (McLeod et al., 1993; Ryan et al., 2017).

Alternatively, disruptions of Great Famine may undermine G1's mental and physical health which then affect child's mental health. Studies suggest that parent-child interaction is an important channel. Parents' health shapes the quality of parenting and parent-child interactions which in turn determines children's mental health (Smith, 2004). Baranov et al. (2020) provides experimental evidence showing that parents' mental health determines the quality of their involvement with children.

In addition, G1 affected by the famine may attain low household income, undermining G2's mental health. G1 with low household income would not be able to provide sufficient materials such as books and toys, which are important elements of material home environment. Studies show that aggregate economy is a determinant of child mental health (Golberstein et al., 2019), although evidence is weaker on the role of household income (Duncan et al., 2010; Propper et al., 2007).

3 Data

3.1 Regional variation in mortality rate during the Great Famine

We use excess death rate (EDR) at the province level to measure the variation of famine severity during the Great Famine, which is widely used in the related literature (Chen and Zhou, 2007; Li and Sunder, 2021; Lin and Yang, 2000). Following Lin and Yang (2000), we calculate EDR as the difference between death rate in 1960 and average death rate during 1956—1958 for each province. Data on 28 Chinese province death rate is derived from Chinese Statistical Yearbook published by the State Statistical

Bureau of China in 1990. The insight behind this measure is that the severity of the Great Famine in a province can be measured by the surge of death rate during the peak famine year (1960; see Figure 1) compared to its level in the pre-famine period (1956—1958). Mean EDR across provinces in our analysis sample is 1.42%, or 14.2 extra deaths per thousand because of the famine (Table 1). In our robustness analysis, we consider an alternative measure of famine intensity called cohort size shrinkage index (CSSI; see Section 8).

Figure 2 presents the spatial distribution of famine severity across provinces as measured by EDR. The variation of EDR across provinces is large, ranging from 0.56 per thousand to 56 per thousand. Among these, Shanghai, Heilongjiang, Inner Mongolia and Beijing were least affected by the Great Famine; Anhui, Sichuan, Guizhou and Qinghai were most affected by the famine, with more than 20 deaths per thousand for some provinces. The sources of variation in famine severity across provinces include the variation in food procurement target, agricultural production, local officials' efficiency, and severity of natural disasters, as discussed in Section 2.

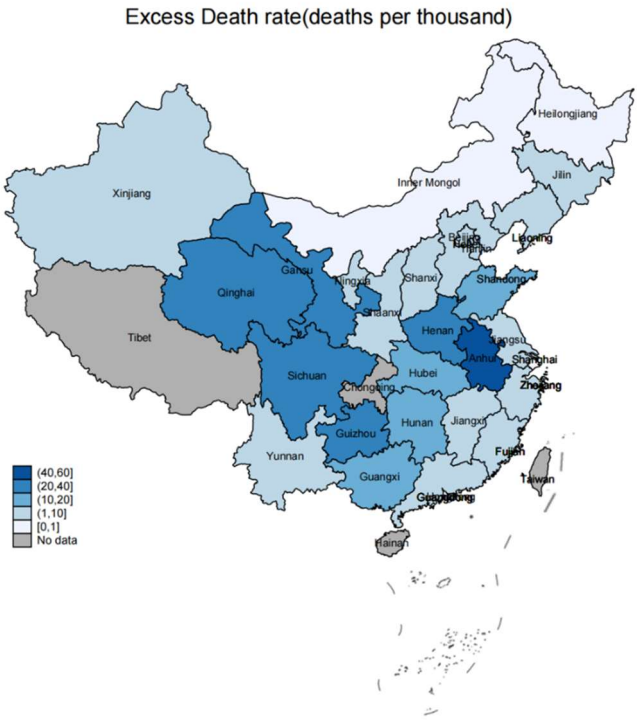

Figure 2 Famine intensity across provinces.

Note: This figure plots the spatial distribution of famine intensity across provinces in China.

Table 1 Summary Statistics

	Mean	SD	Min	Max	N
Excess death rate (EDR)	14.20	12.80	0.567	56.70	3485
Cohort size shrinkage index (CSSI)	0.389	0.108	0.190	0.630	3485
Irrigated area per capita	0.454	0.245	0.0300	4.351	1335
CES-D20	-0.002	0.986	-1.470	5.392	3485
CES-D8	-0.002	0.986	-1.447	5.079	3480
G2's birth year	1980	6.805	1963	2003	3485
G2's gender (=1, male)	0.805	0.397	0	1	3485
G2 is first child	0.615	0.487	0	1	2345
G2 is only child	0.363	0.481	0	1	2345
G2 has rural hukou	0.642	0.480	0	1	3473
G1's birth year	1952	5.771	1923	1960	3485
G1's gender (=1, male)	0.485	0.500	0	1	3485
G1 has rural hukou when 3 years old	0.860	0.347	0	1	3485
G1's age at first childbirth	25.95	4.493	13	49	2343
Whether G1 lives with G2	0.994	0.0790	0	1	3485
The number of G1's children	2.057	1.066	1	7	3485

Notes: Sample is restricted to CFPS respondents (G2) aged more than 15 by 2018. *Excess death rate* is the difference between death rate in 1960 and average death rate during 1956--1958 for each

province, which is used in the baseline regression. The unit of *Excess death rate i*s 0.1%, or the number of deaths among one thousand people. *CSSI* is the provincial cohort size shrinkage index provided by Huang et al. (2013). *Irrigated area per capita* is the province-year irrigated area per capita (1000 hectares) based on the data from Meng et al. (2015). *CES-D20* is the synthetic depression scores of G2 calculated by CFPS. *CES-D8* is the sum score of eight items. All CES-D indices are standardized to have mean zero and standard deviation one in the sample. A higher value corresponds to more mental health problems.

3.2 China Family Panel Studies

To examine how parental exposure to famine during childhood affects second generation's mental health, we use data from the CFPS.[3] The CFPS is a nationally representative social tracking survey project of Chinese families administrated by Institute of Social Science Survey of Peking University. It has been widely used in empirical research because of its nationwide coverage, richness of longitudinal information, and low refusal rate. The initial CFPS survey was carried out in 2010, covering 14,960 households and 42,590 individuals across 25 provinces, autonomous regions, and municipalities in mainland China, representing the majority of the Chinese population (Li, 2021).[4] CFPS tracks the status of family members and their children who have been involved in the baseline survey since 2010 every two years, and has provided its survey data in 2010, 2012, 2014, 2016, 2018 and 2020 to the public. We choose CFPS dataset because it includes abundant information on respondents' personal characteristics, parental and sibling information, marriage information, and health status, and has more detailed measures of mental status compared to other datasets in China.

Our main empirical analysis is based on a panel sample drawn from 2018 and 2020 waves of CFPS Adult Dataset. We focus on these two waves because they contain

[3] CFPS data is publicly available at https://www.isss.pku.edu.cn/cfps/en/data/public.

[4] The CFPS survey does not cover the following provinces: Hainan, Inner Mongolia, Ningxia, Qinghai, Tibet and Xinjiang.

accurate measurements of mental health and a larger sample of the children (G2, the second generation) that are over 15 years old at the time of the survey compared to the earlier waves of CFPS. The additional sample restrictions for the parent-child pairs include: (1) the G2 (the children) were born between 1963[5] and 2003 so that they were not directly exposed to the Great Famine and were over 15 years old when included in the CFPS survey in 2018; and (2) the G1 (the parents) were born before 1962, because we do not have observations of parent-child pairs for parents born in 1962 or later. Our analysis sample contains 3485 parent-child pairs.

As our measure of mental health, we focus on the Center for the Epidemiological Studies of Depression scale (CES-D), an authoritative instrument for measuring depression symptoms with good sensitivity and high internal consistency across different age ranges and ethnic groups (Lewisohn et al., 1997). The CES-D index is comprised of 8 questions as shown in Table A2. Individuals answer the frequency of the mental statuses in the past week using Likert scale ranging from 1 (never or less than one day) to 4 (most of the time or 5—7 days).

The dependent variable of interest for the main analysis is the CES-D20, the composite score of eight CES-D items constructed by equipercentile equating method. As a robustness check, we also use CES-D8 index, constructed as a sum score of the 8 items. These indices are standardized to be mean zero and standard deviation one within the sample. Higher scores indicate higher levels of depression and worse mental status.

Table 1 presents the summary statistics of the analysis sample and the outcome and control variables used in the analysis. Most of the children in CFPS Adult Dataset are living with their parents when involved in the CFPS survey. The proportion of male children is 80.5%, likely because most of Chinese parents live with their male

[5] Some authors argue that the Great Famine persisted until 1962 (Chen and Zhou, 2007).

adult children (Ting and Chiu, 2002). CSSI, irrigated area per capita, and CES-D8 are discussed in the robustness analysis in Section 8.

4 Empirical Strategy

4.1 Identification Strategy

Our construction of treatment variables allows precise identification of the effects of exposures in each developmental stage. Based on Piaget's theory of child development, we create four variables representing the individuals' exposure to the famine in each of the four cognitive development stages: ages 0—2, ages 3—7, ages 8—11, and ages 12—15. Table 2 presents proportion of exposure to the famine by age for the four developmental periods.[6] Due to lack of birth month data, we calculate the exposure starting from the beginning of the birth year. For example, as shown in Table 2, individuals born in 1959 is considered three years old at the end of the Great Famine. They experience the Great Famine during the entire first stage period, so the variable for the exposure during the first stage is assigned the value of 1. And the variable for the exposure during the second stage is assigned the value of 1/5 because they are exposed to the famine for only one year during the five-year-long period. The 1927—1944 birth cohorts are included in the sample as a "control group" because they were not exposed to the famine during the developmental period. Piaget (1964, 1976) suggests that children complete important brain development by age 16 and that subsequent cognitive development is gradual and incremental.

Regional variation in the famine intensity is captured by the EDR variable. As reviewed in Section 2.1 and 3.1, regional intensity of the famine is determined by

[6] Table A3 in the Appendix part presents the age distribution of the first generation during the famine period 1959--1961 and the corresponding proportion of exposure to the famine calculated.

political and bureaucratic incentives and natural disasters that are plausibly exogenous to other environmental factors that determine life outcomes of those affected by the famine.

Table 2 Proportions of exposure to the Great Famine for each developmental period of G1

	Exposures to the Great Famine (1959—1961)			
G1 birth year	Ages 0-2	Ages 3-7	Ages 8-11	Ages 12-15
1960	1	0	0	0
1959	1	1/5	0	0
1958	1/2	2/5	0	0
1957	0	3/5	0	0
1956	0	3/5	0	0
1955	0	2/5	1/4	0
1954	0	1/5	2/4	0
1953	0	0	3/4	0
1952	0	0	3/4	0
1951	0	0	2/4	1/4
1950	0	0	1/4	2/4
1949	0	0	0	3/4
1948	0	0	0	3/4
1947	0	0	0	2/4
1946	0	0	0	1/4
1945	0	0	0	0
1944	0	0	0	0

Notes: This table shows, for individuals (G1) with different birth years, the proportion of years exposed to the Great Famine within each stage of development.

4.2 The Empirical Model

We use a cohort difference-in-difference (DID) identification strategy that builds on two sources of variation. First, provinces were exposed to different levels of famine intensity during the famine period. Second, in each province, individuals in different cohorts were exposed to the famine at different stages of cognitive development. Following Chen et al. (2020), we estimate the following equation:

$$Mental_{ip} = \alpha + \sum_{c=1}^{4} \beta_c Famine_{ic} + \sum_{c=1}^{4} \delta_c Famine_{ic} \times EDR_{ip} + \lambda \mathbf{X_i} + \epsilon_{ipc}, \quad (1)$$

where $Mental_{ip}$ is the adult mental outcome of an individual i, the G2 respondent, whose parent (the G1) was exposed to the Great Famine in province p. $Famine_{ic}$ is

a variable measuring the proportion of time the G1 was exposed to the famine during developmental stage c (see Table 2). The famine severity variable EDR_{ip} is the excess death rate of the Great Famine in province p. $\mathbf{X_i}$ is a vector of control variables, including G2's birth year, gender, first child and only child status, rural hukou status, G1's birth year, gender, rural hukou status, age at first childbirth, whether G1 lives with G2, the number of G1's children, wave fixed effects, and G2's birth province fixed effects. Given that the birth provinces of G1 and G2 are the same in most cases, we do not control for the birth province of G1. ε_{ipc} is an idiosyncratic error term, clustered at the level of G2's province of residence. $\delta_c, c = 1, \dots, 4$ are the coefficients of interest.

We estimate this equation using the overall analysis sample, and the rural and urban subsamples defined by the G1's hukou status at age 3. Migration was strictly restricted by the central government until the late 20th century, so the hukou status of G1 at age 3 is likely to be the same as their residential status (Fan, 2007; Zhao, 2005).

5 Results

5.1 Main results

Table 3 Impact of the Great Famine on second generation mental health

	All sample	Rural sample	Urban sample
	(1)	(2)	(3)
Famine at 0-2×EDR	0.013**	0.013*	0.030
	(0.006)	(0.007)	(0.020)
Famine at 3-7×EDR	0.015*	0.014*	0.015
	(0.008)	(0.008)	(0.014)
Famine at 8-11×EDR	0.009	0.011	0.013
	(0.007)	(0.007)	(0.022)
Famine at 12-15×EDR	0.004	0.007	-0.005
	(0.009)	(0.007)	(0.027)
Observations	3485	2997	488

Notes: The sample consists of G2 who were more than 15 years old by 2018 across 25 provinces in China. Column (1) is based on the overall analysis sample. Results in Columns (2) and (3) are based on subsamples divided by the hukou status of G1 at age 3. The dependent variable is CES-D20, the synthetic depression scores of G2 calculated by CFPS, standardized to have mean zero and standard deviation one. A higher value indicates more mental health problems. Control variables are as explained in Section 4.2. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3 shows the impact of childhood exposure to the Great Famine on the mental health realized in the next generation based on equation (1). It shows that if the parents are exposed to the famine during the first two developmental stages (sensorimotor and pre-operational stages, ages 0—2 and 3—7 respectively), their children are more likely to experience symptoms of depression in adulthood. Effects of exposure during the third and fourth developmental stages (age 8 and after) are consistent in sign but close to zero and insignificant. The magnitude of effects is comparable for the rural and urban subsamples. The estimates for the urban subsample are insignificant, possibly because of small sample size.

The coefficient of 0.013 in the first row and first column implies that a unit increase in EDR (0.1 percent point or 1 in 1,000) in the province while the G1 is in the first stage, between ages 0—2, increases the marginal effect of being exposed to the Great Famine by 0.013 in standard deviation unit for G2. Alternatively, it implies that an increase in the proportion of time exposed to the famine from 0.5 to 1 during the first stage increases the marginal effect of EDR in ages 0—2 by approximately 0.007. The coefficients for the exposures in the second (pre-operational) stage, between ages 3—7, are comparable in magnitude to those in the earlier period. Given that the second stage is longer than the first stage, the estimates imply that a year of exposure during the first stage has more negative impact than during the second stage, consistent with the vulnerability of early childhood reported in the literature (Almond et al., 2018; Heckman and Mosso, 2014).

Table 4 estimates equation (1) for each item of the CES-D. The effects of famine exposure during the first two stages are consistent across the items and often significant, reflecting the findings in Table 3. Among them, the magnitude and significance of estimates are larger for the fifth item ("I feel lonely"), potentially driving the main

results. The effects are small and insignificant for the second item ("I find it difficult to do anything").

The exposure to famine has intergenerational mental health consequences only if it affects the parents during the first two stages of cognitive development. Exposures during the third and fourth stages, during which children develop skills for logical and abstract thinking, do not have intergenerational impacts. One explanation for these results is that parenting and parent-child interactions that predict future mental health of children are governed not by abstract and logical thinking, but by skills developed in earlier stages. For example, language skills are developed in the second (pre-operational) stage and would be relevant for parent-child communications and interactions.

The first two stages of cognitive development (ages 0—2 and 3—7) overlap with the "critical period" of child development that are predictive of future outcomes, during which children are highly sensitive to external shocks. In Section 7, we present evidence that the direct impacts on parents' mental health is not limited to exposures during the critical period, implying that the concept of critical period do not entirely explain the intergenerational effects.

Table 4 Impact of the Great Famine on second generation mental health for each CES-D item

	I am in a low spirit	I find it difficult to do anything	I cannot sleep well	I feel happy	I feel lonely	I have a happy life	I feel sad	I feel that I cannot continue with my life
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. All sample								
Hunger at 0-2×EDR	0.004	0.008	0.002	-0.009**	0.015***	-0.002	0.015**	0.019**
	(0.008)	(0.007)	(0.007)	(0.004)	(0.005)	(0.006)	(0.006)	(0.009)
Hunger at 3-7×EDR	0.007	-0.001	0.011*	-0.008	0.018***	-0.014*	0.009	0.005
	(0.007)	(0.006)	(0.006)	(0.008)	(0.005)	(0.008)	(0.006)	(0.009)
Hunger at 8-11×EDR	0.002	0.000	0.006	-0.003	0.005	-0.009	0.009	0.010
	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)
Hunger at 12-15×EDR	-0.002	0.001	0.006	0.007	0.000	-0.007	0.007	0.011*
	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)	(0.006)	(0.006)
Observations	3485	3482	3485	3485	3484	3484	3485	3485
B. Rural sample								
Hunger at 0-2×EDR	0.002	0.006	0.003	-0.009	0.016***	-0.001	0.014**	0.021**
	(0.007)	(0.007)	(0.007)	(0.005)	(0.006)	(0.008)	(0.005)	(0.010)
Hunger at 3-7×EDR	0.006	-0.003	0.009	-0.007	0.022***	-0.015*	0.007	0.004
	(0.007)	(0.006)	(0.006)	(0.008)	(0.005)	(0.009)	(0.006)	(0.009)
Hunger at 8-11×EDR	0.003	0.001	0.008	-0.004	0.009	-0.008	0.010	0.012
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.008)
Hunger at 12-15×EDR	-0.003	-0.001	0.006	0.001	0.006	-0.0120	0.009	0.013*
	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.008)	(0.005)	(0.007)
Observations	2994	2996	2997	2997	2996	2996	2997	2997
C. Urban sample								
Hunger at 0-2×EDR	0.013	0.028**	0.014	-0.021	0.008	-0.010	0.042	0.016
	(0.014)	(0.012)	(0.013)	(0.022)	(0.013)	(0.018)	(0.026)	(0.014)
Hunger at 3-7×EDR	-0.001	0.008	0.019	-0.018	0.004	-0.001	0.015	0.017
	(0.015)	(0.017)	(0.015)	(0.016)	(0.012)	(0.017)	(0.019)	(0.021)
Hunger at 8-11×EDR	-0.025	-0.001	-0.005	-0.021	0.010	-0.050***	0.011	-0.010
	(0.026)	(0.027)	(0.023)	(0.021)	(0.025)	(0.017)	(0.024)	(0.025)

Hunger at 12-15×EDR	0.012	0.015	0.018	0.017	-0.035**	0.0120	-0.004	0.005
	(0.025)	(0.038)	(0.024)	(0.015)	(0.015)	(0.014)	(0.028)	(0.014)
Observations	488	488	488	488	488	488	488	488

Notes: The sample consists of G2 who were born between 1963 and 2003 across 25 provinces in China. Panel A uses the overall analysis sample. Panel B is based on the subsample in which G1 has rural hukou at age 3. Panel C is based on the subsample in which G1 has urban hukou at age 3. The dependent variables are standardized to have mean zero and standard deviation one. Higher value indicates greater frequency of the corresponding mental state. Control variables are as explained in Section 4.2. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

Table 5 Heterogeneity by the gender of the parent and child

	Father	Mother	Father-son	Mother-daughter	Son	Daughter
	(1)	(2)	(3)	(4)	（5）	（6）
Hunger at 0-2×EDR	0.014**	0.015	0.017**	0.036	0.013*	0.010
	(0.007)	(0.009)	(0.008)	(0.033)	(0.007)	(0.016)
Hunger at 3-7×EDR	0.013	0.018**	0.006	0.028**	0.010	0.020**
	(0.011)	(0.008)	(0.010)	(0.012)	(0.008)	(0.010)
Hunger at 8-11×EDR	0.011	0.007	0.011	-0.008	0.007	0.004
	(0.010)	(0.005)	(0.011)	(0.010)	(0.007)	(0.014)
Hunger at 12-15×EDR	0.000	0.010	-0.004	0.025	0.001	0.011
	(0.013)	(0.009)	(0.012)	(0.021)	(0.008)	(0.018)
Observations	1690	1795	1369	360	2804	681

Notes: The sample consists of G2 who were born between 1963 and 2003 across 25 provinces in China. The dependent variable is CES-D20, the synthetic depression scores of G2 calculated by CFPS, standardized to have mean zero and standard deviation one. Control variables are as explained in Section 4.2. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

Table 6 Heterogeneity by sibling structure

	G2 is the first child	G2 is not the first child	G2 is the only child	G2 is not the only child	G1 has sons	G1 doesn't have sons
	(1)	(2)	(3)	(4)	（5）	（6）
Hunger at 0-2×EDR	0.008	0.005	0.003	0.004	0.012	0.010
	(0.009)	(0.008)	(0.012)	(0.007)	(0.011)	(0.009)
Hunger at 3-7×EDR	0.004	0.020	-0.018**	0.020**	0.006	0.018*
	(0.012)	(0.014)	(0.009)	(0.010)	(0.014)	(0.010)
Hunger at 8-11×EDR	-0.006	0.014	-0.016	0.007	0.019	-0.015
	(0.012)	(0.015)	(0.011)	(0.010)	(0.018)	(0.010)
Hunger at 12-15×EDR	-0.022	0.017	-0.047***	0.003	-0.016	0.003
	(0.014)	(0.011)	(0.015)	(0.009)	(0.021)	(0.012)
Observations	1443	902	852	1493	759	817

Notes: The sample consists of G2 who were born between 1963 and 2003 across 25 provinces in China. The dependent variable is CES-D20, the synthetic depression scores of G2 calculated by CFPS, standardized to have mean zero and standard deviation one. Control variables are as explained in Section 4.2. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

5.2 Heterogeneous results

Studies show that mothers and fathers play different roles in child development (Del Boca et al., 2014) and that parent-child interactions may depend on the gender composition of the parent-child pair (Russell and Saebel, 1997). Gender of the child may also affect the interactions, in part because of son preference in China (Murphy et al., 2011). Intergenerational transmission may therefore depend on the gender of the parent and the child. Table 5 shows evidence of limited heterogeneity by the gender of the parent or child, however, as the coefficients are similar in magnitude across different dimensions of heterogeneity. An interesting pattern is that the negative effects from exposures during the second stage (aged 3—7) are greater in magnitude for the subsamples consisting of mothers, daughters or mother-daughter pairs compared to the corresponding subsamples consisting of fathers and sons, although the differences are likely to be marginally significant. The negative effects from exposures during the first stage, before age 2, are similar across the genders of G1 and G2.

Table 6 presents heterogeneity results by the birth order and the number of siblings. Literature suggests that birth order, presence of siblings, and the presence of male siblings can impact children's outcomes because of birth order effect and son preference (Cameron et al., 2013; Kim and Wang, 2023). We would detect heterogeneity in intergenerational effects if birth order or son preference mediate the intergenerational transmission. The results show evidence of limited heterogeneity by the first-born status, but shows that the negative effects are concentrated on households in which the G1 had multiple children and the G1 had daughters but not sons. One possible explanation is that parents' effort to compensate for the negative effects of own exposure to the Great Famine was strengthened by son preference and the preferential care provided to the only child.

Table A4 in the Appendix presents results by the waves of survey and the intensity of the survey. We find that the estimates in the 2020 wave are smaller than those of the 2018 wave, suggesting fade out over time. We do not find evidence of heterogeneity along other dimensions.

6 Threats to identification

Survivors of the famine may be selected in characteristics that make them more resilient to external shocks. Such mortality selection may introduce bias to the estimates. In an extreme case, mortality selection may lead to "positive" effects of exposure to negative shocks, as in the case of Wilde et al. (2017). Our study shows negative effects of famine exposure. Suppose survivors have resilient characteristics that increase their chance of survival. If these characteristics also help parents shield their parents from the negative effects of parental famine exposure, mortality selection would bias our estimates upward. In this case, our negative estimates should be considered conservative estimates.

Another source of bias is the impact of being exposed to the famine on marriage and fertility decisions. This selection on fertility may bias our estimates upward if those less affected by the famine are more likely to get married and have children.[7] We test for this possibility directly using a sample of G1 exposed to the Great Famine and use equation (1) to estimate the effects of famine exposure on their number of children, whether they have at least one son, and the number of marriages they had. Results shown in Table 7 show that famine exposures are not associated with these outcomes, reducing the concerns about bias from selective fertility.

We conduct placebo test to ensure that the results are not driven by pre-famine

[7] Exposure to the famine may have made individuals more reckless and have unplanned pregnancies. We do not consider this possibility, however, because extramarital fertility is extremely rare in China and fertility restriction policies such as One Child Policy impose heavy costs on having children beyond the first one.

characteristics, using indicator variables to represent two birth cohorts: those born in 1944—1946 and in 1937—1942. Those born in 1923—1942 form the reference group. Table A5 in the Appendix shows that EDR does not affect the outcomes of interest for these birth cohorts.

Table 7 The effects of the Great Famine on G1's marital and fertility choices.

	Number of children	Whether has a son	The number of marriages
	(1)	(2)	(3)
Hunger at 0-2×EDR	-0.010	0.004	0.001
	(0.007)	(0.004)	(0.003)
Hunger at 3-7×EDR	-0.010	0.006	-0.002
	(0.016)	(0.005)	(0.006)
Hunger at 8-11×EDR	0.005	0.006*	-0.001
	(0.017)	(0.003)	(0.005)
Hunger at 12-15×EDR	-0.004	0.005	-0.005
	(0.017)	(0.005)	(0.004)
Observations	2669	1666	3167

Notes: The sample consists of individuals born before 1960 across 25 provinces in China. The dependent variable *Number of children* is the number of G1's children. *Whether has a son* is a dummy variable which is equal to 1 if G1 has at least one son. *The number of marriages* is the number of marriages that G1 has had. Control variables are as explained in Section 4.2. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

7 Discussion of mechanisms

What are the potential mechanisms underlying the intergenerational effects we find? In Section 2.2 on conceptual framework, we emphasized that home environments are likely channels between parents' exposure to the famine and their children's adult outcomes. In this section, we show that G1's exposures to the Great Famine affect parental characteristics such as parents' mental health and income that determine the quality of home environment for children. We further show the effects of famine exposures on parent-child interactions, an important component of home environment. These findings are consistent with the parents and the home environment playing important roles in transmitting parental disadvantages to children's long-run mental

health.[8]

Table 8 shows that childhood exposures to the Great Famine undermine the mental health of the survivors, consistent with the positive association between parents' mental health and children's mental health reported in the literature (Johnston et al., 2013; Loon et al., 2014). The evidence is stronger for the father than for the mother, whereas the intergenerational effects were observed regardless of the gender of the parents in Section 5. It is interesting to note that exposures to the famine during the first stage (ages 0—2) do not impact mother's mental health or their daughter's (Table 5).

Columns (3) and (4) of Table 8 show somewhat puzzling results, indicating that those exposed to the Great Famine in ages 0—2 tend to have higher earnings.[9] They show that G1's income is unlikely to be a channel explaining the effects. One possible explanation for this finding is that the exposures to the famine shaped the preferences of survivors to prioritize income over other goals (Ding et al., 2022; Xu et al., 2023).

Table 9 further supports the channel through home environment as an explanation for the intergenerational effects. Studies show that there are close relationships among the well-being of elderly parents and the adult children, intergenerational support, and adult parent-child relationships (Merz et al., 2009). Even as the Great Famine exposures have positive impacts on G1's income, the frequency of interactions between the adult children (G2) and their parents are reduced by the famine. The reductions in interactions are observed for exposures not just for the first two stages but throughout the four stages of development, implying that there are unexplored channels in play.

[8] We emphasize that these results are suggestive, however, because our measures of G1's mental health, income, and interactions with their children are all collected after their children are fully grown. These results are therefore not free of reverse causality concerns. G2's childhood measures are not available because of the design of the CFPS.

[9] To calculate G1's total income, we add the annual after-tax wage income and annual after-tax retirement pension.

Table 8 Effects of the Great Famine exposures on G1's outcomes

	Father's mental health	Mother's mental health	Father's ln(income)	Mother's ln(income)
	(1)	(2)	(3)	(4)
Famine at 0-2×EDR	0.012**	-0.001	0.032**	0.019*
	(0.004)	(0.010)	(0.012)	(0.011)
Famine at 3-7×EDR	0.017***	0.0170	0.014	0.020
	(0.004)	(0.014)	(0.011)	(0.019)
Famine at 8-11×EDR	0.009	0.005	0.016	0.004
	(0.007)	(0.010)	(0.010)	(0.016)
Famine at 12-15×EDR	0.010*	0.020	0.001	-0.011
	(0.005)	(0.013)	(0.012)	(0.013)
Observations	2106	2160	1731	1646

Notes: The sample consists of individuals born before 1960 across 25 provinces in China. The dependent variables include CES-D20 standardized to have mean zero and standard deviation one and the log of annual income as a sum of labor and pension earnings. Control variables include G1's gender, G1's rural hukou at age 3, G1's nationality, G1's province of birth fixed effects, and wave fixed effects. Standard errors are in parenthesis, clustered at the level of G1's current province of residence. *p < 0.10, ** p < 0.05, *** p < 0.01.

Table 9 The effects of the Great Famine on the frequency of parent-child interactions

	Never	Three to four times a week	Everyday
	(1)	(2)	(3)
Famine at 0-2×EDR	0.007*	-0.004*	-0.004
	(0.004)	(0.002)	(0.006)
Famine at 3-7×EDR	0.009***	0.002	-0.013**
	(0.003)	(0.002)	(0.005)
Famine at 8-11×EDR	0.007*	0.001	-0.011***
	(0.004)	(0.001)	(0.004)
Famine at 12-15×EDR	0.008***	0.000	-0.012**
	(0.002)	(0.002)	(0.005)
Observations	3163	3163	3163

Notes: The sample consists of G2 who were born between 1963 and 2003 across 25 provinces in China. The dummy variables *Never, Three to four times a week* and *Everyday* are responses to the question "How often do you meet your son/daughter in the past six months?" Control variables are as explained in Section 4.2. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

8 Robustness Test

In this section, we examine the robustness of main results to different model specifications. For the results in Panel A of Table 10, we use the famine exposure variables used for the main results. In Panel B, we use four birth cohort dummy

variables (birth years 1959—1961 for Cohort 1; 1955—1958 for Cohort 2; 1951—1954 for Cohort 3; 1947—1950 for Cohort 4; 1937—1946 for the "control group") instead and interact them with the famine intensity variables. In column (2), we use an alternative outcome measure CES-D8, a sum score of 8 item measures, standardized to be mean 0 and standard deviation 1. In column (3), we use an alternative measure of famine intensity based on the work by Huang et al., (2013) called cohort size shrinkage index (CSSI).[10] The measure is based on the idea that smaller cohort size reflects higher severity of the famine because of higher mortality and lower fertility. In column (4), we exclude cohorts whose parents were born before 1977 because they may have been exposed to the Cultural Revolution in their childhood, potentially confounding the interpretation of the results. In column (5), we control for G1's birth province fixed effects in addition to other control variables in equation (1). We do this because for 10% of the parent-child pairs in the sample, the province of residence of the adult children is different from the province of birth of their parents. For the last column (6), we control for the irrigated area per capita for each province, an important determinant of food production, using data from Meng et al. (2015).[11] Our results are robust throughout these specifications—exposures to the famine in the first two stages of development are found to affect adult mental health of the second generation.

[10] This variable is constructed by comparing the mean size of the cohorts affected by the famine (N_{famine}; born during 1959—1961) relative to the mean size of the surrounding cohorts not affected by the famine (N_{nonfam}; born during 1956—1958 and 1962—1964), using the 1% sample of China's 1990 population census. $CSSI = (N_{nonfam} - N_{famine})/N_{nonfam}$.

[11] We construct *irrigated area per capita* variable using data from Meng et al., (2015). We construct the variable as: $irrigated\ area\ per\ capita_{p,t} = \frac{irrigated\ area_{p,t-1}}{total\ population_{p,t}}$, where p is the birth province of the first generation and t is the birth year of the first generation. The unit of irrigated area is 1,000 hectares. We use lagged variables for the irrigated area because of time delay in agricultural production.

Table 10 Robustness to different specifications and controls

	Baseline	Outcome measure: CES-D8	Famine Intensity (FI) measure: CSSI	Excluded cohorts exposed to CR	Added control: G1's province of birth	Added control: irrigated area per capita
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
Famine at 0—2×FI	0.013**	0.013**	1.098	0.014**	0.011*	0.016**
	(0.006)	(0.006)	(0.781)	(0.006)	(0.006)	(0.007)
Famine at 3—7×FI	0.015*	0.0150*	1.547*	0.013	0.011	0.010
	(0.008)	(0.009)	(0.781)	(0.008)	(0.007)	(0.007)
Famine at 8—11×FI	0.009	0.008	0.550	0.013*	0.004	-0.002
	(0.007)	(0.007)	(0.660)	(0.007)	(0.007)	(0.004)
Famine at 12—15×FI	0.004	0.003	-0.004	0.002	-0.001	0.000
	(0.009)	(0.009)	(1.198)	(0.014)	(0.007)	(0.069)
Irrigated area per capita						0.031
						(0.111)
Observations	3485	3480	3485	2395	3485	1335
Panel B						
Cohort 1×FI	0.016***	0.015**	1.329	0.015**	0.013**	0.016***
	(0.006)	(0.006)	(0.885)	(0.006)	(0.006)	(0.005)
Cohort 2×FI	0.008**	0.009*	0.912*	0.009*	0.007*	0.006
	(0.004)	(0.005)	(0.476)	(0.005)	(0.004)	(0.006)
Cohort 3×FI	0.006	0.007	0.617	0.009	0.005	0.002
	(0.004)	(0.005)	(0.463)	(0.005)	(0.005)	(0.003)
Cohort 4×FI	0.005	0.006	0.327	0.008	0.003	-0.001
	(0.006)	(0.006)	(0.806)	(0.010)	(0.005)	(0.018)
Irrigated area per capita						0.031
						(0.109)
Observations	3495	3480	3555	2395	3485	1335

Note: The sample consists of G2 who were more than 15 years old by 2018 across 25 provinces in China. Cohort 1 is an indicator for those born 1959—1961; cohort 2, 1955—1958; cohort 3, 1951—1954; cohort 4, 1947—1950. Those born 1937—1946 are included as the "control group." The dependent variable is CES-D20 unless otherwise indicated. FI is EDR unless otherwise indicated. A higher value indicates more mental health problems. Control variables are as explained in Section 4.2 unless otherwise indicated. Standard errors are in parenthesis, clustered at the province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

10 Conclusion

In this study, we investigate the intergenerational effects of exposure to famine in early childhood on the mental health of famine survivors' children in adulthood. For identification, we exploit the regional variation in the intensity of the Great Famine in China and the proportion of exposure in each cognitive developmental stage as defined by Jean Piaget. We find significant negative intergenerational effects for the exposures in ages 0—2 and 3—7, which correspond to the sensorimotor and pre-operational stages of development in which children experience rapid cognitive growth and acquire language skills. Exposures to the famine in older ages that are associated with the development of logical and abstract thinking do not significant affect the mental health of their children.

Exploring potential mechanisms, we find that exposures to the famine reduce G1's mental health and the interaction frequencies of G1 and G2, all measured when the G2 is fully grown. Although suggestive, these results are consistent with the importance of home environments and the parents' ability to provide for them in explaining the intergenerational effects. Interestingly, we find positive effects of famine exposure on G1's income, suggesting that reduced income is unlikely to be an important channel. Further, our results robust to selection into marriage and fertility and a set of robustness tests. Mortality selection implies that our results may be underestimates of true effects.

Generational persistence in the impacts of early-life environments we find suggests that historical differences in childhood growth conditions in earlier generations can lead to health inequalities today. Poor childhood environment and experience can lead to very long-term consequences that spills over into the lives of the next generation. Programs that target parents' mental health (Baranov et al., 2020), parenting skills, and

home environment of children have been shown to improve the lives of the participants and their children (Barr and Gibbs, 2023; East et al., 2023; Garcia et al., 2023). Our findings reinforce the importance of addressing childhood disadvantages through such program.

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Appendix

Table A1 Piaget's cognitive development stages of children.

Age Period	**Child development stages**	**Characteristics**	**The corresponding stage of brain development**
0-2 years old	Sensorimotor	● Children receive passively various social impacts such as material goods, emotional warmth, entertainment, and comfort during distress from adults. ● The people and objects surrounding them bring emotional and affective fluctuations. ● At this stage, there is no significant impacts on their intellectual structure.	Large motor system and visual system
3-7 years old	Pre-operational	● In the preoperational stage, children start to acquire language and social interaction. ● The child's thinking remains egocentric, meaning they have difficulty understanding other people's perspectives. They are unable to distinguish well between their own and others' relationships, and easily accept the suggestions and coercion of people around them, without hesitation to conform to the outside world. ● Children at this stage highly assimilate the behavioral patterns, opinions, and external examples of others into their own views.	Language acquisition
8-11 years old	Concrete operations	● Children in this stage can reason logically and understand the concept of reversibility, yet their thinking is still tied to physical objects they can manipulate. They overcome egocentrism and become more adept at classification tasks, and are able to grasp previously unfamiliar concepts such as conservation and seriation. ● The issue of the interaction between social and individual structures in cognitive development has become prominent. Through coordinating, reasoning, and striving for free individual thinking activities that do not distort the thoughts of others or the objective facts, individuals integrate with the surrounding environment. ● They overcome egocentrism and become more adept at classification tasks and are able to grasp previously unfamiliar concepts such as conservation and seriation.	Manipulate thoughts and ideas
12-15 year old	Formal operations	● During the formal operational stage, children acquire the ability to think abstractly and reason logically in their mind, which allows them to solve complex problems and plan for the future. ● Children in the formal operational stage demonstrate greater cognitive flexibility and metacognitive abilities, enabling them to reflect on their own thinking and adjust their strategies .	Higher-order thinking

Table A2 CES-D items and the distribution of responses

	Frequency in days last week			
Mental status	< 1 day	1—2 days	3—4 days	5—7 days
I am in a low spirit	40.0%	50.6%	6.6%	2.7%
I find it difficult to do anything	46.5%	44.2%	6.2%	3.0%
I cannot sleep well	50.0%	34.0%	10.8%	5.2%
I feel happy	6.0%	28.1%	36.5%	29.4%
I feel lonely	63.1%	29.8%	4.8%	2.2%
I have a happy life	5.2%	24.0%	37.4%	33.4%
I feel sad	58.2%	37.0%	3.7%	1.1%
I feel that I cannot continue with my life	86.4%	11.0%	1.5%	1.2%

Note: The question is: "Here are some descriptions of people's mental statuses. Please select according to your statuses in the past week." Responses are 1 (never, less than one day), 2 (sometimes, 1—2 days), 3 (often, 3—4 days), and 4 (most of the time, 5—7 days). Frequencies of responses to different mental status in the last week are shown. The sample size is 3485.

Table A3 G1's birth year, age, and the proportion of exposure to the Great Famine during each developmental stage

	Year	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	Proportion of Exposure			
Birth year																	**The Great Famine**			Stage 1 (0--2)	Stage t2 (3--7)	Stage 3 (8--11)	Stage 4 (12--15)
1960																		1	2	1	0	0	0
1959																	1	2	3	1	0.2	0	0
1958																1	2	3	4	0.5	0.4	0	0
1957															1	2	3	4	5	0	0.6	0	0
1956														1	2	3	4	5	6	0	0.6	0	0
1955													1	2	3	4	5	6	7	0	0.6	0	0
1954												1	2	3	4	5	6	7	8	0	0.4	0.25	0
1953											1	2	3	4	5	6	7	8	9	0	0.2	0.5	0
1952										1	2	3	4	5	6	7	8	9	10	0	0	0.75	0
1951									1	2	3	4	5	6	7	8	9	10	11	0	0	0.75	0
1950								1	2	3	4	5	6	7	8	9	10	11	12	0	0	0.5	0.25
1949							1	2	3	4	5	6	7	8	9	10	11	12	13	0	0	0.25	0.5
1948						1	2	3	4	5	6	7	8	9	10	11	12	13	14	0	0	0	0.75
1947					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	0	0	0	0.75
1946				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	0	0	0	0.5
1945			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	0	0	0	0.25
1944		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	0	0	0	0

Table A2 describes the relationship between the birth year of variables and the exposure to the Great Famine. For example, G1 born in 1959 would be three years old at the end of the Great Famine. This person is exposed to Great Famine during their entire first stage of development. Also, this person is exposed to the famine for 1/5 time of the second stage of development.

Table A4 Heterogeneity by the waves of survey and famine intensity

	2018 wave	2020 wave	High-intensity area	Low-intensity area
	(1)	(2)	(3)	(4)
Hunger at 0-2×EDR	0.016	0.012*	0.014	-0.014
	(0.011)	(0.007)	(0.021)	(0.027)
Hunger at 3-7×EDR	0.020**	0.010	0.008	0.032
	(0.009)	(0.010)	(0.018)	(0.030)
Hunger at 8-11×EDR	0.018***	-0.001	0.024*	-0.006
	(0.006)	(0.010)	(0.013)	(0.017)
Hunger at 12-15×EDR	0.015	-0.006	0.028	-0.031
	(0.009)	(0.012)	(0.019)	(0.043)
Observations	1443	902	852	1493

Notes: The sample consists of G2 who were born between 1963 and 2003 across 25 provinces in China. The dependent variable CES-D20, the synthetic depression scores of G2 calculated by CFPS, standardized to have mean zero and standard deviation one. Control variables are as explained in Section 4.2. Standard errors are in the parentheses and are clustered at province level. *p < 0.10, ** p < 0.05, *** p < 0.01.

Table A5 Impact of the Great Famine on second generation mental health (placebo test)

	Depression	Feel lonely	Feel happy	Feel sad	Feel bored
	(1)	(2)	(3)	(4)	(5)
Hunger at 16-18×EDR	0.008	0.009	0.005	0.001	-0.025
	(0.028)	(0.028)	(0.011)	(0.018)	(0.025)
Hunger at 19-25×EDR	0.005	0.005	0.025	-0.001	-0.019
	(0.026)	(0.026)	(0.016)	(0.020)	(0.031)
G2 controls	√	√	√	√	√
G1 controls	√	√	√	√	√
Family controls	√	√	√	√	√
G1 birth cohort FE	√	√	√	√	√
G2 birth year FE	√	√	√	√	√
Province FE	√	√	√	√	√
Observations	244	244	244	244	244
R^2	0.297	0.297	0.345	0.333	0.343

Notes: The sample consists of G2 who were born between 1963 and 2003 from 25 provinces in China. The dependent variable CES-D20, the synthetic depression scores of G2 calculated by CFPS, standardized to have mean zero and standard deviation one. Control variables are as explained in Section 4.2. Standard errors are in the parentheses and are clustered at province level. *p < 0.10, ** p < 0.05, *** p < 0.01.