Economic Development and Population Mental Health: Evidence from the China Agricultural Reform in the Early 1980s

Cheng Huang, Chaoran Guo, Michael Phillips, and Xiaobo Zhang

INTRODUCTION

China launched agricultural reform in the early 1980s in a response to a severe deficiency in food supply and production that was considered to trigger another food crisis similar to the 1959-61 Great Leap Forward Famine. The reform was characterized by decollectivizing agriculture and adopting the "household-responsibility system" to replace the commune system implemented in rural China in the 1950s. By the end of 1984, approximately 98% of the land of the People's communes was divided into private plots, and farmers were able to keep their output after paying a share to the state. The reform rapidly and substantially stimulated agricultural production. For example, wheat output increased by 50% between 1981 and 1984, and vegetable and meat production also increased dramatically; consequently, food prices fell nearly 50% during the same period (J. Huang & Rozelle, 1998).

The reform and the consequent improvement in food production in rural China, following a prereform period when agricultural performance was extremely poor and food shortages were common, present a unique opportunity to study the long-term health consequences of nutrition during the critical first 1,000 days (conception to age 2).

In the absence of randomized trials of the effect of malnutrition on human beings because of ethical concerns, such a quasiexperiment design offers several advantages over the convenient research design usually linking the nutrition status of individuals born and raised in families with different socioeconomics status (SES) to their health conditions later in life, an approach likely to be subject to confounding such that family SES may affect both nutrition in early life and adult health. In contrast, the quasiexperiment approach, relying on nutritional improvement caused by exogenous forces such as the Chinese agricultural reform, makes it possible to isolate

causal effects of nutrition itself on adult health from the social, economic, and family confounders.

In the present study, we used unique data from the largest epidemiological survey on mental disorders among adult Chinese, conducted in four provinces in 2001–2005, to examine the potential mental health disparities among Chinese born between 1978 and 1987, roughly including pre-reform (1978–1980), during reform (1981–1984), and post-reform (1985–1987). The purposes of this study were twofold. First, we estimated the potential long-term effect of the reform on mental illness. Second, we tested a hypothesis that the effect of reform (nutrition) on mental disease is not sexneutral; that is, it is different between men and women.

BACKGROUND

It has been widely accepted that the quality of the prenatal and early postnatal period of life is crucial to brain development, including acquisition of functions such as vision, hearing, and speech as well as expression of higher cognitive functions (Grantham-McGregor et al., 2007; Thompson & Nelson, 2001). Disruptions in the normal course of development during this critical phase, including nutritional deficiencies during fetal life and infancy, will have profound long-term consequences (Grantham-McGregor et al., 2007; Thompson & Nelson, 2001).

More recently, increasing evidence also suggests that many human diseases or symptoms in adulthood, including coronary heart diseases, stroke, diabetes, and hypertension may be related to nutrition status and growth patterns during early life. The thrifty phenotype hypothesis proposes that an individual's metabolic profile is determined by environmental cues during the early periods of life. In poor nutrition conditions, a pregnant woman can modify the development of her unborn child in such a way that it will be prepared for survival in an environment in which

resources are short, resulting in a thrifty phenotype (Hales & Barker, 2013). Individuals with a thrifty phenotype are likely to have smaller body size, lower metabolic rate, and reduced levels of behavioral activity. When individuals with "thrifty phenotype" actually develop in an affluent environment, they are more prone to metabolic disorders, such as obesity and type II diabetes. Ethical concerns make testing these hypotheses directly in human beings difficult. Studies using quasiexperiments mainly including famines provide supporting evidence that malnutrition may have a causal effect on a series of adult outcomes, including chronic diseases, mental disorders, and behavioral problems (Lumey, Stein, & Susser, 2011). However, pitfalls of famine studies, mainly including selection bias such that famines usually cause substantial involuntary abortion and high infant mortality, may complicate the comparison between famine survivors, who are more robust genetically, and postfamine cohorts.

The 1981–1984 Chinese agricultural reform presents a new quasiexperiment for this research purpose. The reform substantially improved the food supply within a relatively short period without significant changes in either fertility or mortality. For example, grain output per capita increased by 20% from 1981 to 1984, and per capita meat and egg consumption also increased significantly. The consequent improvement in maternal and child nutrition presents a rare opportunity to test the long-term health effects of nutrition, but at the same time this quasiexperiment avoids bias caused by survival selection, a pitfall in famine study. More importantly, because famines usually represent the extremity of the shortage of food and malnutrition, the proposed study on reform will add new evidence on whether improvement in food supply and consequent nutritional status within the normal range has a long-term health impact. In particular, it contributes to a better understanding of whether the "nutritional mismatch" is responsible for the growing incidence of diabetes mellitus in countries such as

China and India, where many people were conceived during a shortage of nutrition but have developed in an affluent environment during the nutritional transition.

DATA & MEASUREMENT

The data derived from a series of epidemiological surveys on mental disorders conducted in four provinces in China, Zhejiang, Shandong, Qinghai, and Gansu, from 2001 to 2005 (Phillips et al., 2009). Multistage stratified random sampling methods were used to identify 96 urban and 267 rural primary sampling sites from 24 counties or districts in these four provinces; the sampling frame of 113 million individuals aged 18 years or older included 12% of the adult population in China. A total of 63,004 individuals, identified with simple random selection methods at the sampling sites, were screened with an expanded version of the General Health Questionnaire, and 16,577 were administered a Chinese version of the Structured Clinical Interview for Diagnostic and Statistical Manual (DSM)-IV axis I disorders by a psychiatrist (Phillips et al., 2009).

The screening interviews, which took a mean (SD) of 25 (9) minutes to complete, were done face to face in respondents' homes by 170 psychiatric nurses who had been trained for seven to 10 days before the main study commenced. The local institutional review board at each research site provided ethics approval for the study. Extensively pilot-tested at the research sites, the screening instrument was the 12-item General Health Questionnaire (GHQ-12). The 12-item General Health Questionnaire was developed to screen for nonspecific psychiatric morbidity and has been widely used and translated into many languages (Hankins, 2008). Its validity and reliability have been found to be acceptable as a screening instrument for psychiatric disorders in

various nonclinical settings (Goldberg & Williams, 1988; Hu, Stewart-Brown, Twigg, & Weich, 2007; Yang, Huang, & Wu, 2003).

The present study is based on all screened individuals 1) whose birth year lies in the window of 2-year prior to the reform and 5-year post reform; 2) who were aged 18 or above when they completed the survey; and 3) who were not from Qinghai or Zhejiang province. Qinghai was excluded because of its unique geographic altitude and climate. Most of Qinghai consists of mountains and pastoral areas that don't support crop production. Hence, the agricultural reform is expected to have little impact on the nutrition status of people born in Qinghai. We also excluded Zhejiang to avoid biased sampling, as all individuals in Zhejiang born in 1984 or later are below the age of 18 when surveyed. The final sample consists of 3,717 individuals (see Table 1).

ANALYTICAL STRATEGY

We measure early life nutritional status by the timing of birth and break all individuals into subgroups based on an individual's birth year and the first year Chinese agricultural reform took place in his/her county of residence. For example, for individuals born in 1982, their mothers' consumption of grain during pregnancy consists of three possible parts: 1) grain output of 1980 (if born in early 1982); 2) grain output of 1981; 3) grain output of 1982 (if born in fall or winter of 1982). Also, Douglas et al. showed that the first impacted grain output was one year after the first reform year, suggesting that individuals born in 1982 could benefit from the impacted harvests in the perinatal period if the reform was adopted in 1981 or earlier. The treatment group is therefore made up of individuals born at least one year after the first reform year. Given the nature of this market-oriented rural reform was to empower farmers to make decisions on their

own production and increase grain output, we expect that rural residents benefited more from the reforms while urban residents were expected to be less impacted. Therefore, difference-in-difference approach is used to examine the impact of early-life nutrition on mental disorder with a regression as follows:

$$GHQ_{irk} = Y_0 + \phi_r Province_r + \alpha\, Post + \gamma Rural + \beta\,(Post * Rural) + \delta\, D_i$$

Where GHQ_{irk} refers to the GHQ score of an individual i born in county r and year k (the reference group is made up of individuals born between 2 years prior to the reform and the reform year). ϕ_r is the region (province) fixed effect. Post is an indicator of whether the individual is in the treatment group, and Rural is a rural resident dummy variable. β captures the average effect of improved food supply in the post-reform period on the outcome variable. D_i are individuals' age and demographics. To further investigate the potential differential impacts of prenatal and postnatal nutrition status on mental disorders, we estimate the following regression model and allow the effect to vary across the period of fetal and early postnatal development.

$$GHQ_{irk} = Y_0 + \phi_r Province_r + \alpha_k PostYear_k + \gamma Rural + \beta_k (PostYear_k * Rural) + \delta\, D_i$$

Where $PostYear_k$ is an indicator of the difference in years between an individual's birth year and the first year of reform in his/her county of residence. The reference group is the same as the reference group used for the first model, that is those whose $ostYear \in [-2,0]$. Among all individuals in the treatment group, the $\text{PostYear} = 1$ birth cohort was exposed to improved nutrition during the postnatal period, but with little or no prenatal exposure; the $PostYear \in [2,5]$ birth cohorts were exposed in utero as well as during postnatal period. β_k capture the differential impact on GHQ scores and varied magnitude of $\beta_k$would suggest differential prenatal/postnatal impact on adult mental health. Standard errors (confidence intervals) were adjusted for clustering at community level in both models and analyses were conducted using

Stata 13. In all the analysis above, men and women were analyzed separately to explore whether the impact differs by sex.

RESULTS

The characteristics of our study sample are presented by gender and place of residence in Table 1. Both women and men reported relatively low GHQ scores (i.e., good mental health status) across birth cohorts. Overall, we don't observe any statistically significant gender differences or rural-urban differences in GHQ scores. GHQ scores range from 0.244 to 0.575 among women and from 0.323 to 0.654 among men. About 17.3% of women and 19.8% of men scored zero on the GHQ-12 questionnaire.

Estimates of average impact on GHQ scores are shown in Table 2. Exposure to improved levels of nutrition in the post-reform period was associated with an average decrease of 0.743 points (improved mental health status) among women. The corresponding effect size is 0.60 (0.743 divided by 1.23, the standard deviation of GHQ scores among women in post-reform cohorts), which represents a medium to large effect (Cohen, 1988). In contrast, no similar impact was observed among men.

To differentiate the prenatal and postnatal impact, we further broke all individuals born in the post-reform period into subgroups based on the difference in years between an individual's year of birth and the first year of reform in his/her county of residence. The results are shown in Table 3. There was no significant impact on women born in the first year after reforms. However, from the second year after reforms and onward, nutritional exposure was associated with substantial lower GHQ-12 scores among women, with the exception of women in the 4th year post reform cohort. The effect retains the same sign but lose some magnitude and precision in that year

(PostHRS = 4). In contrast, similar exposure among men wasn't associated with any change in GHQ-12 scores, as none of the coefficients of the interaction terms were significant.

Discussion

We investigated relationships between early-life exposure to China's agricultural reform and the risk of mental disorders in adulthood (~25 yr). We chose urban residents as a control group as urban food supply was guaranteed in the 1980s by the urban food distribution and rationing system. In contrast, rural food consumption was more closely tied to local productions (Food and Agriculture Organization of the United Nations, 1998). We tested the hypothesis that such exposure has differential effects among rural men and women. We found evidence for strong associations between early-life exposure to agricultural reforms and lower risk of mental illness later in life, but only among rural women.

In the past several years, significant links have been established between maternal and early life nutrition and later mental health outcomes. Most past work was based on early life nutritional hardship, a majority of which examined this link under relatively extreme circumstances such as famine (Brown, Susser, Lin, Neugebauer, & Gorman, 1995; Galler, Waber, Harrison, & Ramsey, 2005; C. Huang et al., 2013; Lumey et al., 2011; Susser & Lin, 1992). However, famines are normally accompanied by survival selection, which may bias the result. There are also concerns over the validity of extrapolating results from famine studies to a generally healthy population. The present study, therefore, provides an important addition to the literature and shows evidence of long-term health impact of moderate improvement in food supply and consequent nutritional status.

We found differential effects of reform exposure by gender, supported by the larger magnitude of the point estimates and the greater statistical significance among women. One possible explanation is the son preference tradition in China. Son preference has historically been strong, particularly among rural couples (Graham, Larsen, & Xu, 1998). Such son preference is partially expressed through gender bias favoring males in food allocation within household (Luo, Zhai, Jin, & Ge, 2001). Therefore when there is a shortage of food (i.e. pre-reform period), male children may have priority treatment over female children. In other word, malnutrition may be less severe among boys in pre-reform period. The following significant growth of agricultural production and decline of rural poverty population during the reform era made it possible for families to allocate more resources to daughters. Thus, female children are likely to benefit more from reforms, and enjoyed greater improvement in nutrition status and better mental health outcomes in adult life.

It is noteworthy to point out that almost all rural men born in the post-reform period had lower GHQ scores with the exception of one cohort. The pattern was somewhat similar to what we observed among rural women. But because of smaller effect size and sample size, we failed to reach conventional levels of statistical significance. Additional work is needed to fully understand the long-term reform impact among men.

Findings in this study also highlight the importance of adequate nutrition during gestation. Better mental health outcomes among rural women were observed in all but one cohort – those born one year after the first year of reform. These individuals were not exposed to improved nutrition in utero, given the one-year lag between the time of reform and increased grain yields. This is consistent with previous famine studies that emphasized the relationship between maternal undernutrition during gestation, particularly early gestation stage, and mental health in later life

(Hoek et al., 1996; Neugebauer, Hoek, & Susser, 1999). Given the lack of a clear starting point of the reforms in each county, the measure of exposure in our study was less precise thus prevent us from drawing more specific conclusion for different stages of pregnancy. The above mentioned studies together with the findings in this paper, however, suggest that preconception and prenatal periods offer important opportunities for avoiding fetal exposures which exert deleterious effects leading to increased risk of mental diseases in adulthood.

Conclusion

We found long-term effects of improved nutrition on mental illness. Rural women born in the post-reform period showed better mental health status compared to their counterparts born prior to reforms. The effect is gender specific and no similar effects were observed among men.

Table 1. GHQ scores by gender and place of residence

Post Reform	Female (N=1846)					
	Rural			Urban		
	N	mean	sd	N	mean	sd
-2	242	0.450	1.311	98	0.286	0.995
-1	206	0.573	1.394	72	0.458	1.635
0	167	0.575	1.681	77	0.364	1.202
1	169	0.467	1.145	94	0.340	0.934
2	147	0.374	1.099	84	0.488	1.103
3	119	0.286	0.825	71	0.521	1.566
4	109	0.440	1.228	61	0.361	0.753
5	82	0.244	0.950	48	0.458	1.368
Post Reform	Male (N=1871)					
	Rural			Urban		
	N	mean	sd	N	mean	sd
-2	238	0.538	1.383	96	0.406	1.389
-1	188	0.532	1.221	121	0.455	1.335
0	187	0.433	1.187	96	0.531	1.297
1	151	0.603	1.633	85	0.553	1.323
2	153	0.595	1.844	62	0.323	0.937
3	112	0.339	1.143	64	0.484	1.168
4	112	0.438	1.387	52	0.654	1.413
5	103	0.350	1.073	51	0.471	1.286

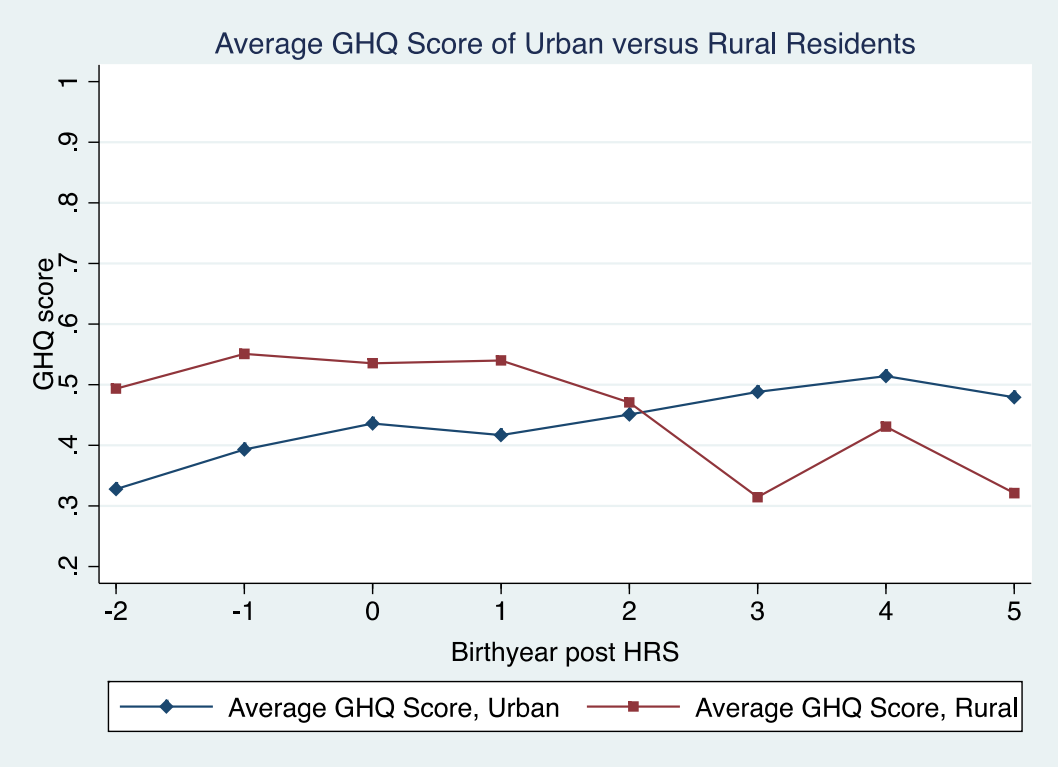
Table 2. Average effect on scores of GHQ-12, based on negative binomial regression with difference-in-difference estimator		
	Female	Male
Post Reform	0.312	0.0996
	(0.313)	(0.350)
Rural	0.872*	0.316
	(0.421)	(0.356)
Post Reform x Rural	-0.743*	-0.156
	(0.311)	(0.414)
Age	0.163	0.414*
	(0.317)	(0.197)
Age squared	-0.00240	-0.00724*
	(0.00602)	(0.00353)
Married	-0.575**	-0.677***
	(0.217)	(0.203)
Schooling	0.0282	0.0331
	(0.0242)	(0.0254)
Province Fixed Effects	Y	Y

Standard errors in parentheses, clustered at the county level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

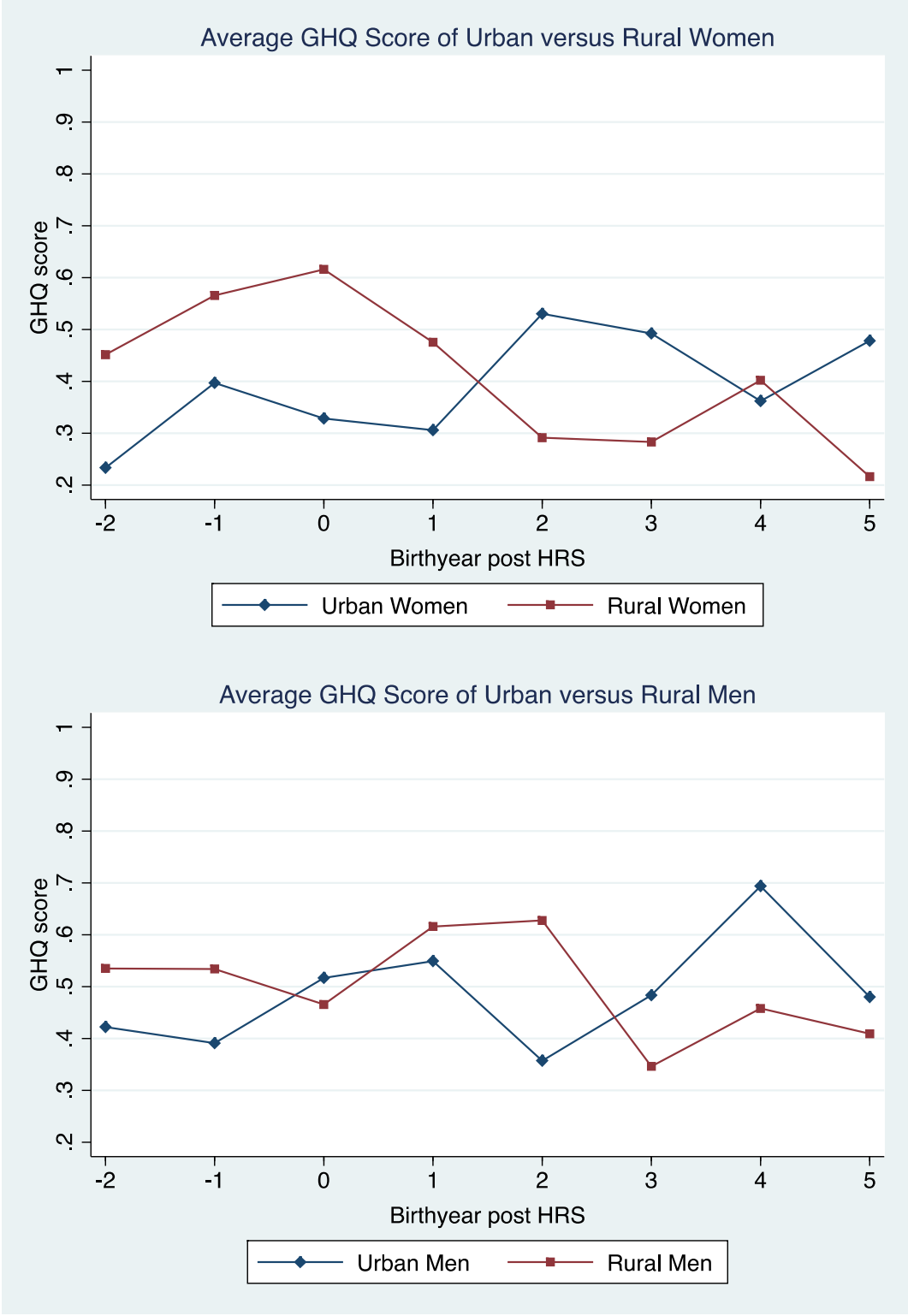
Table 3. Differential effects on scores of GHQ-12 by birth year, based on negative binomial regression with difference-in-difference estimator		
	Female	Male
Born in the 1st year post Reform	-0.149	0.120
	(0.346)	(0.380)
Born in the 2nd year post Reform	0.536	-0.180
	(0.357)	(0.437)
Born in the 3rd year post Reform	0.184	0.0596
	(0.506)	(0.451)
Born in the 4th year post Reform	0.167	0.462
	(0.496)	(0.435)
Born in the 5th year post Reform	0.150	0.230
	(0.618)	(0.627)
Rural	0.879*	0.324
	(0.426)	(0.353)
Rural x Born in the 1st year post Reform	-0.0846	-0.0771
	(0.375)	(0.475)
Rural x Born in the 2nd year post Reform	-1.340**	0.216
	(0.432)	(0.524)
Rural x Born in the 3rd year post Reform	-0.975*	-0.534
	(0.480)	(0.551)
Rural x Born in the 4th year post Reform	-0.537	-0.349
	(0.433)	(0.605)
Rural x Born in the 5th year post Reform	-1.252*	-0.133
	(0.619)	(0.708)
Age	0.147	0.472*
	(0.331)	(0.221)
Age squared	-0.00259	-0.00815*
	(0.00609)	(0.00370)

Married	-0.637**	-0.702***
	(0.203)	(0.206)
Schooling	0.0276	0.0346
	(0.0243)	(0.0256)
Province Fixed Effects	Y	Y

Standard errors in parentheses, clustered at the county level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$


Average GHQ Score of Urban versus Rural Residents
GHQ score
.2
.3
.4
.5
.6
.7
.8
.9
1
-2
-1
0
1
2
3
4
5
Birthyear post HRS
Average GHQ Score, Urban
Average GHQ Score, Rural


Average GHQ Score of Rural Residents
GHQ score
.2
.3
.4
.5
.6
.7
.8
.9
1
-2
-1
0
1
2
3
4
5
Birthyear post HRS
Women
Men
Average GHQ Score of Urban Residents
GHQ score
.2
.3
.4
.5
.6
.7
.8
.9
1
-2
-1
0
1
2
3
4
5
Birthyear post HRS
Women
Men


Average GHQ Score of Urban versus Rural Women
GHQ score
.2
.3
.4
.5
.6
.7
.8
.9
1
-2
-1
0
1
2
3
4
5
Birthyear post HRS
Urban Women
Rural Women
Average GHQ Score of Urban versus Rural Men
GHQ score
.2
.3
.4
.5
.6
.7
.8
.9
1
-2
-1
0
1
2
3
4
5
Birthyear post HRS
Urban Men
Rural Men

Brown, A. S., Susser, E. S., Lin, S. P., Neugebauer, R., & Gorman, J. M. (1995). Increased risk of affective disorders in males after second trimester prenatal exposure to the Dutch hunger winter of 1944-45. *Br J Psychiatry, 166*(5), 601-606.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N.J.: L. Erlbaum Associates.

Food and Agriculture Organization of the United Nations. (1998). Annex 3: Agricultural policy and food security in China *Poverty Alleviation and Food Security in Asia: Lessons and Challenges*.

Galler, J. R., Waber, D., Harrison, R., & Ramsey, F. (2005). Behavioral effects of childhood malnutrition. *Am J Psychiatry, 162*(9), 1760-1761; author reply 1761. doi: 10.1176/appi.ajp.162.9.1760-b

Goldberg, D. P., & Williams, P. (1988). A user's guide to the General Health Questionnaire. *Berkshire: NFER, Nelson*.

Graham, M. J., Larsen, U., & Xu, X. P. (1998). Son preference in Anhui Province, China. *International Family Planning Perspectives, 24*(2), 72-77. doi: Doi 10.2307/2991929

Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., Strupp, B., & International Child Development Steering, G. (2007). Developmental potential in the first 5 years for children in developing countries. *Lancet, 369*(9555), 60-70. doi: 10.1016/S0140-6736(07)60032-4

Hales, C. N., & Barker, D. J. P. (2013). Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis (Reprinted from Diabetalogia, vol 35, pg 595-601, 1992). *International Journal of Epidemiology, 42*(5), 1215-1222. doi: Doi 10.1093/Ije/Dyt133

Hankins, M. (2008). The reliability of the twelve-item general health questionnaire (GHQ-12) under realistic assumptions. *BMC Public Health, 8*, 355. doi: 10.1186/1471-2458-8-355

Hoek, H. W., Susser, E., Buck, K. A., Lumey, L. H., Lin, S. P., & Gorman, J. M. (1996). Schizoid personality disorder after prenatal exposure to famine. *Am J Psychiatry, 153*(12), 1637-1639.

Hu, Y. J., Stewart-Brown, S., Twigg, L., & Weich, S. (2007). Can the 12-item General Health Questionnaire be used to measure positive mental health? *Psychological Medicine, 37*(7), 1005-1013. doi: Doi 10.1017/S0033291707009993

Huang, C., Phillips, M. R., Zhang, Y., Zhang, J., Shi, Q., Song, Z., . . . Martorell, R. (2013). Malnutrition in early life and adult mental health: evidence from a natural experiment. *Soc Sci Med, 97*, 259-266. doi: 10.1016/j.socscimed.2012.09.051

Huang, J., & Rozelle, S. (1998). Market development and food demand in rural China. *China Economic Review, 9*(1), 25-45. doi: Doi 10.1016/S1043-951x(99)80002-9

Lumey, L. H., Stein, A. D., & Susser, E. (2011). Prenatal famine and adult health. *Annu Rev Public Health, 32*, 237-262. doi: 10.1146/annurev-publhealth-031210-101230

Luo, W., Zhai, F., Jin, S., & Ge, K. (2001). Intrahousehold food distribution: a case study of eight provinces in China. *Asia Pac J Clin Nutr, 10 Suppl*, S19-28.

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

Phillips, M. R., Zhang, J., Shi, Q., Song, Z., Ding, Z., Pang, S., . . . Wang, Z. (2009). Prevalence, treatment, and associated disability of mental disorders in four provinces in China during 2001-05: an epidemiological survey. *Lancet, 373*(9680), 2041-2053. doi: 10.1016/S0140-6736(09)60660-7

Susser, E. S., & Lin, S. P. (1992). Schizophrenia after prenatal exposure to the Dutch Hunger Winter of 1944-1945. *Arch Gen Psychiatry, 49*(12), 983-988.

Thompson, R. A., & Nelson, C. A. (2001). Developmental science and the media. Early brain development. *Am Psychol, 56*(1), 5-15.

Yang, T. Z., Huang, L., & Wu, Z. Y. (2003). [The application of Chinese health questionnaire for mental disorder screening in community settings in mainland China]. *Zhonghua Liu Xing Bing Xue Za Zhi, 24*(9), 769-773.