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The Long-Term Health Effects of Mass Political Violence: Evidence from China's Cultural Revolution

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Abstract We examine the long-term health effects of mass political violence experienced in utero and in adolescence using China's Cultural Revolution as a natural experiment. We find that individuals who were in utero in the Cultural Revolution have reduced lung capacity later in life. We also find that individuals who were adolescents in the Cultural Revolution have higher blood pressure and reduced ability to engage in activities of daily living later in life. Females who were adolescents in the Cultural Revolution have reduced lung capacity later in life, while males who were adolescents in the Cultural Revolution have reduced cognitive function later in life. We find that these effects are channelled through childhood health and education as well as height, which itself is a marker of childhood health.

Keywords China · Asia · Health · Political shock · Old age

1 Introduction

There is growing concern about the increased prevalence of a range of adverse health outcomes in middle and old age, such as heightened blood pressure, decline in cognitive function and physical incapacitation. But, the aetiology of many diseases afflicting individuals later in life is not well understood. Factors in adult life that are known to influence blood pressure, such as body mass, alcohol consumption and intake of salt, account for only a small part of the differences in blood pressure between individual people and populations (Barker 1990). This is also true for other adverse health outcomes, such as cognitive decline (Plassman et al. 2010). Hence, in searching for new ways to tackle adverse health outcomes later in life, researchers have started to look beyond behavioural

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risk factors to examine the effect of shocks to health in utero and in childhood on health in old age. There is now widespread recognition that in addition to having a contemporary effect, the effects of certain types of shocks may be felt decades later. If events in utero and in childhood are found to affect the magnitude of adverse health outcomes in middle and old age, it is worthwhile to monitor those who were subject to such events at the beginning of their lives.

Existing studies in economics and epidemiology have focused on shocks to health in utero and in early childhood, primarily due to disease, famine, plague and war on health in middle and old-age. We extend this literature to examine the long-term health effects of violent political shocks. Specifically, we examine the long-term health effects from being exposed in utero or childhood to a pervasive atmosphere of fear and tension associated with mass social and political upheaval including widespread social and political violence.

To do so we examine the effects on long-term health of individuals who were either born or were children in China's Cultural Revolution. To do so, we use data from the China Health and Retirement Longitudinal Survey (CHARLS), which contains data on households in Zhejiang and Gansu, collected in 2008. Our identification strategy is to compare cohorts who were either born or adolescents during the Cultural Revolution with those who were either older during the Cultural Revolution or were born after the Cultural Revolution finished. We also exploit differences in the magnitude of the Cultural Revolution between rural and urban areas to test whether health effects reflect not only variance specific to the Cultural Revolution, but Cultural Revolution specific within cohort variance.

Our main findings are that individuals who were in utero in the Cultural Revolution have reduced lung capacity later in life and that individuals who were adolescents in the Cultural Revolution have higher blood pressure and reduced ability to engage in activities of daily living (ADL) later in life. We also find some gender differences in the effect of being an adolescent in the Cultural Revolution on health in later life. Specifically, we find that females who were adolescents in the Cultural Revolution have reduced lung capacity later in life and that males who were adolescents in the Cultural Revolution have reduced cognitive function later in life. We find these effects are channelled through childhood health and education.

The rest of the paper is set out as follows. The next section discusses the context of the Cultural Revolution as an episode of political violence. Section 3 reviews the existing literature. The conceptual arguments are presented in Sect. 4. Section 5 discusses the data. The empirical methodology is contained in Sect. 6 and the results are presented in Sect. 7. The final section concludes with a discussion of the study's main findings.

2 The Cultural Revolution as an Episode of Political Violence

The Cultural Revolution was initiated by Mao Zedong in May 1966 with the objective to purge "capitalist roaders" from the Chinese Communist Party and "counter-revolutionaries" from Chinese society. While the Cultural Revolution formally concluded with the arrest of the Gang of Four in 1976, the worst excesses and violence occurred between 1966 and 1968. As a consequence, some have argued that the Cultural Revolution concluded with the suppression of mass factions in the autumn of 1968 (Unger 2007).

The Cultural Revolution represents an extreme episode of political trauma in the history of mankind, in which Mao Zedong's instructions were that there could be "no construction without destruction" and "to put destruction first" (Joseph et al. 1991). The Cultural

Revolution has been characterized as "an unprecedented wave of state-instigated persecution, torture, gang warfare and mindless violence" (Walder 1991, p. 42) and as "the terrorisation of society" (Chang and Holliday 2005, p. 534). Its survivors have likened the trauma caused by the Cultural Revolution to the Holocaust (Dittmer 1991). Early assessments of the Cultural Revolution depicted it primarily being concentrated in urban centres with little impact on rural areas. More recent accounts, though, acknowledge that the Cultural Revolution had an extensive impact in the villages and the rural countryside (Walder and Su 2003). Su (2006) suggests that the majority of victims of mass killings in the Cultural Revolution were rural residents and that this reflects the fact that mass killings occurred in the lower reaches of the government hierarchy where state control was the weakest. Walder and Su (2003) estimate that in rural China alone 36 million people were persecuted; of whom, between 750,000 and 1.5 million were killed, with roughly the same number permanently injured. Chang and Holliday (2005) claim that as many as three million people died in the Cultural Revolution.

Clearly not everybody who lived through the Cultural Revolution was directly subject to violence. However, it is important to note that one does not have to be directly subjected to violence to suffer trauma from a mass event such as the Cultural Revolution (Wright and Steinbach 2001). It is sufficient if one lives in an environment in which mass social and political upheaval, including violence or fear of violence, is taking place. One may be exposed to violence either directly or indirectly through the media or knowing someone who has been exposed to terror. Over and above those who were killed or tortured, political scientists have documented that the Cultural Revolution generated political and social destructiveness that caused "mass anxiety" among the populace (White 1991, p. 102). Chang and Holiday (2005, p. 545) state: "Leisure disappeared. Instead, there were endless, mind-numbing - but nerve-wracking – meetings to read and reread Mao's works …. People were herded into numerous violent denunciation rallies against 'capitalist roaders' and other appointed enemies. Public brutality became an inescapable part of daily life". As Barnouin and Yu (1993, p. vii), put it: "The cataclysm it created had traumatic effects on the majority of the Chinese people that permeated both their personal and professional lives".

3 Existing Literature

Our contribution is related to several strands of literature. The first is epidemiological studies of the effects of intrauterine growth retardation on physical health in old age (see e.g. Barker 1990). The second are economic studies of the effects of in utero health and childhood health on health and socioeconomic outcomes later in life (see e.g. Case et al. 2005). A third related strand of literature are economic and epidemiological studies of the effects of specific shocks to health in utero and in early childhood on cognitive and physical health later in life. This literature has focused on shocks due to disease (Almond 2006), famine (Neelsen and Stratmann 2011), civil war (Akresh et al. 2012a), World War II (Kesternich et al. 2014) and economic downturn (Cutler et al. 2007). A fourth related set of studies is a health literature on the effects of social and political upheaval, including political and social violence, on health outcomes. This literature includes studies of the effect of socio-political violence on risk of pregnancy outcomes (Zapata et al. 1992) and in triggering a range of adverse health outcomes such as asthma (Wright and Steinbach 2001). A fifth related set of studies are those on the effects of armed conflict and civil war on child

health (Bundervoet et al. 2009; Akresh et al. 2012b). A sixth set of studies are those on the long-run effects of violent conflict on labour market and other socioeconomic outcomes other than health later in life, including studies of the long-run labour market effects of World War II (see e.g. Jurges 2012).[1]

Finally, this study contributes to a literature on the long-run outcomes of events in the Mao era in China. Several studies have examined the long-run economic and health effects of the Chinese Great Famine in 1959–1961 (see e.g. Almond et al. 2010). Several studies have focused on the effect on subsequent earnings of individuals who encountered education interruptions in the Cultural Revolution (see e.g. Zhang et al. 2007). None of these studies investigate the long-run impacts of the Cultural Revolution on the well being of the next generation. The only study to so do is Chen (2010), who examines the effect of interruptions in maternal education caused by disruption to the school system in the Cultural Revolution on children's health. Chen (2010) finds that the loss in mother's education due to the Cultural Revolution led to over 0.3 standard deviations' decrease in child height, which is similar to being exposed to malnutrition in early childhood in the Chinese Great Famine.

To summarize, there are studies of the effects of episodes or shocks in utero or in early childhood on long-run health outcomes, but there are no systematic studies of the effect of shocks due to political violence/mass upheaval in utero and early childhood on long-run health outcomes. Moreover, within the extant literature, few studies use a range of health measures—an exception is Cutler et al. (2007)—nor attempt to differentiate between variance in shocks to the initial health endowment and investment in childhood health on different health outcomes (cognitive and physical) in old age. This study addresses this gap by examining the effects of a shock in utero and early childhood due to mass social and political upheaval on long-run health outcomes using a range of health measures and distinguishing between cognitive and physical health outcomes in middle and old age.

4 Conceptual Arguments

4.1 Shock to Initial Health Endowment on Health Outcomes in Old Age

Living in an uncontrollable or unpredictable environment accompanied by violence predisposes individuals to psychological stress, which can result in biological changes that generate in utero stressors. The fetal programming hypothesis states that in utero stressors give rise to chronic health conditions later in life (Barker 1990). Among chronic health problems traced to the womb, shocks in utero are correlated with high blood pressure in old age (Barker 1990). Prenatal maternal stress in response to external conditions such as violence has been shown to result in earlier delivery and lower birth weight (Lobel et al. 1992). Adults born prematurely have been shown to have lower lung capacity later in life, reflected in more bronchial obstruction and lower diffusion capacity than non-pre-terms (Vrijlandt et al. 2006). The two major pregnancy determinants of lung development are fetal growth and duration of gestation and both are impaired in pre-terms. While Vrijlandt et al. (2006) study young adults, they note (at. p. 895) that lung function abnormalities "may have impact at later phases in life, since it has been shown that young adults with

[1] Almond and Currie (2011a, b) review much of this literature and draw out the cross over between the epidemiology literature and the economics literature following Barker (1990) and Almond (2006).

submaximal lung function will reach the danger zone of impaired lung function in elderly age more quickly".

The cognitive reserve hypothesis posits that maternal stress in crucial phases of fetal development would have a major impact on the development of essential structural elements of the brain and affect the timing or quality of neural development and/or alter neuronal membrane function. The resulting lower capacity would lead to lower brain reserve capacity and hence to lower cognitive performance, especially when the physiological processing of the brain is compromised, such as at older ages (de Groot et al. 2011). Hence, one expects that a shock to health in utero will lead to a decline in word count recall in old age.

The cognitive reserve and fetal programming hypotheses together predict that a shock to health in utero will result in a decline in cognitive function and physical health in old age more generally. Shocks in utero are correlated with health problems later in life including cardiovascular disease (Barker 1990), non-insulin dependent diabetes (Barker 1990), osteoporosis (Barker 1990) and obesity (Higgins et al. 2011). The combination of declining cognitive function and physical health is likely to result in lower self-reported health, more difficulties in performing ADL and feeling lethargic in middle and old age.

4.2 Shock to Childhood Health on Health Outcomes in Old Age

Children exposed to traumatic events can suffer long-term stress effects through lasting physiologic responses maintained through recurrent unwanted or intrusive thoughts about past events (Kaitz et al. 2009). Traumatic events can be conceptualised as a psychosocial environmental exposure that "get into the body" and contribute to poor cognitive outcomes by triggering exacerbations through neuroimmunological mechanisms, which often only become apparent decades later (Wright and Steinbach 2001). Traumatic events impacting on cognitive development in childhood also impair educational attainment in childhood. Those with lower educational attainment have been found to experience accelerated rates of memory loss and higher prevalence of dementia later in life (Schmand et al. 1997).

Exposure to violence has been shown to be correlated with reduced lung capacity and respiratory problems later in life (Wright and Steinbach 2001). Intense or prolonged stress experiences increases smooth muscle tone in the lung which is associated with lung conditions such as emotionally induced bronchoconstriction and inflammatory diseases such as asthma. Exposure to community violence may also operate through effects on impulse control, risk taking behaviour and the adoption of coping behaviours such as smoking which reduces lung capacity in old age (Wright and Steinbach 2001).

Events in childhood might influence the onset of conditions later in life, such as high blood pressure/hypertension and chronic diseases associated with such conditions, such as cardiovascular disease (Godfrey 1998). In terms of a link between the effect of mass upheaval in childhood on physical health in old age, there is considerable evidence that emotional and psychological disorders associated with traumas may translate into physical health decline (Case and Paxson 2008). Several studies suggest a link between cognitive decline and decline in physical health in old age (Case and Paxson 2008). Studies have shown that blood pressure is associated with individual differences in cognitive function (Anstey and Christensen 2000) and that experiencing a stroke in old age is correlated with cognitive decline (Van den Berg et al. 2010). Mental and physical decline in old age, in turn, is likely to be reflected in difficulties performing ADL, lack of energy and feelings of lethargy.

5 Data and Descriptive Statistics

We use pilot data from CHARLS, which contains data from 1563 households, selected using Probability Proportional to Size (PPS) from two provinces, Zhejiang and Gansu, in 2008 (see Zhao et al. 2009). Between 25 and 36 households in each community containing at least one individual aged 45 or above was selected and either one or two individuals in each household were interviewed depending on marital status in the household, giving information on 2951 individuals. Events in both provinces in the late 1960s were typical of the Cultural Revolution. Forster (1991, p. 113) states: "Zhejiang experienced a period of great political and economic turbulence" in the Cultural Revolution with Red Guards and rebel workers emphasising the slogans 'it is right to rebel' and 'going against the tide' to underpin widespread unrest and violence. Gansu was one of the rural provinces in which there was extensive violence. Walder and Su (2003) suggest that there were 58 deaths per county in Gansu throughout the Cultural Revolution, which is typical of other rural provinces.

We use six alternative measures of health, spanning cognitive function and physical health; namely, ADL difficulty, health status, blood pressure, lung capacity, word count and feeling lethargic. Self-reported health is the response to the question: "how is your health at present?' Survey respondents are asked to rate their current health status on the Likert scale where 1 = excellent health, 2 = very good health, 3 = good health, 4 = fair health and 5 = poor health. ADL difficulty is a composite index of the level of difficulty that the respondent has in performing a number of fairly normal and routine day-to-day activities or tasks. Specifically, we considered the degree of difficulty experienced by the respondent in performing the following 20 tasks: dressing, bathing, eating, getting in or out of bed, walking 100 m, walking one kilometre, sitting for 2 h, getting up from a chair, climbing several flights of stairs, stopping, kneeling or crouching, lifting 10 *jin* (equivalent to a heavy bag of groceries), extending one's arm, pushing or pulling large objects, urinating, doing household chores, preparing hot meals, shopping for groceries, managing money, making phone calls and taking medicine. Respondents' answers were coded: 1 = 'I do not have any difficulty in performing the task'; 2 = 'I can perform the task, but only with difficulty', 3 = 'I cannot perform the task'. Our measure of ADL is the sum of responses on all 20 tasks. Responses were normalized so that the maximum value of the composite ADL variable is 1 and the minimum value is zero.

To measure word count, respondents read a list of ten simple words and were then asked to repeat as many of these words as they could in any order. On average, respondents recalled 2.2 out of the ten words in immediate recall with one-third of the sample being able to recall between 4 and 9 words. About a quarter of the sample could not recall any words. To measure feeling lethargic, respondents were asked: Have you felt lethargic in the last week? Respondents answered on a scale where 1 = rarely or none of the time, 2 = some of the time, 3 = a moderate amount of time and 4 = most or all of the time. Lung capacity was measured by a peak flow meter in terms of centilitres. The lung capacity was measured using three deep breaths, and we consider here the average. The average lung capacity is about 3 l/min. To measure blood pressure, the blood pressure of the individual was taken three times and we take the average of these blood pressure measures to determine whether an individual has high or normal blood pressure. We convert the blood pressure variable into a binary variable, which is equal to 1 if a person has high blood pressure (above 140/80) and zero otherwise.

Table 1 Descriptive statistics

	Obs.	Mean	SD
ADL difficulty	1946	0.069	0.099
Health status	1860	3.803	1.019
Blood pressure	1944	0.349	0.477
Lung capacity	987	307.366	108.135
Word count	1946	2.207	2.160
Feel lethargic	1637	1.737	0.946
CR 0–2 years	1946	0.038	0.190
CR 10–11 years, female	1946	0.196	0.397
CR 12–13 years, male	1946	0.181	0.385
Born rural	1946	0.936	0.244
Height in cm	1946	158.270	8.502
Education	1945	3.202	3.529
Child health	1865	0.673	0.469
Ln(Wealth)	1731	2.710	2.000
Ln(Expenditure)	1943	8.417	1.070
Smoking	1865	0.379	0.485
Age	1946	58.645	10.038
Female	1946	0.522	0.500
Rural	1946	0.835	0.372
Gansu	1946	0.462	0.499
GF 0–2 years	1946	0.179	0.384
GF 10–11 years, female	1946	0.076	0.265
GF 12–13 years, male	1946	0.075	0.264

CR Cultural Revolution, *GF* Great Famine

Table 1 summarizes descriptive statistics for all health variables, variables of interest, and other controls. It shows that 3.8 % of respondents were aged two or under in the Cultural Revolution and 37.7 % were in the adolescent growth spurt (10–11 for females and 12–13 for males) during the Cultural Revolution. Overall, the respondents had 3.2 years of education, with about 40 % not attending school at all. The average age in our sample is about 59 years, 52 % are female, 93.6 % live in a rural area and 46.2 % are from Gansu province with the rest being from Zhejiang province.

6 Empirical Methodology

Our objective is to estimate the effects of the Cultural Revolution on health status of those who were either born in, or in infancy in, the Cultural Revolution or were in the adolescent growth spurt during the Cultural Revolution. We utilize an empirical strategy which is based on the principle of treatment–control groups. We compare cohorts who were either born or were in the adolescent growth spurt during the Cultural Revolution (treatment group) with those who were either older during the Cultural Revolution or were born after the Cultural Revolution finished (control group). We estimate the following health equation:

$$HEALTH = \beta_0 + \beta_1 CR + \beta_2 X + \upsilon \quad (1)$$

Here *HEALTH* is the health status of the respondent. We consider the six health status variables as defined above. X is a vector of control variables that measure the respondent's characteristics. Most of the control variables that we employ are standard in the literature examining determinants of health status (see e.g. Case et al. 2005). The specific respondents' characteristics for which we control are age, education, gender, health status during childhood, height, whether the respondent has ever smoked in his/her live, whether he/she lives in a rural or urban area and a province fixed effect. We also control for household expenditure and wealth, which proxy living standards. We use self-reported health during childhood, which potentially controls for standard of living at that age. It also takes into account if health or living conditions during childhood is correlated with health status later in life. Since both height and health status during childhood might be affected by Cultural Revolution, we consider estimates with and without controlling for these variables separately.

In Eq. (1), CR is a set of dummy variables denoting if the respondent was aged 0–2, 10–11 if female and 12–13 if male during the Cultural Revolution. These ages are selected because they are the key ages predicting ultimate adult height and associated cognitive ability and physical health outcomes later in life. Specifically, the most important factors influencing health are shocks to health in utero and in infancy (aged 0–2) and in the adolescent growth spurt (Beard and Blaser 2002). Epidemiological studies suggest that the adolescent growth spurt in China is 10–11 for girls and 12–13 for boys (Ji et al. 1995; Leung et al. 1996). Age 0–2 is used to test the fetal programming and cognitive reserve hypotheses (or shock to the initial health endowment). While these hypotheses strictly refer to what happens in utero, they are typically taken to refer to in utero plus the first couple of years of life (Cutler et al. 2007). Age 10–11 for girls and 12–13 for boys are used to test for shocks to childhood health.

We used an ordered probit model when the dependent variable was self-reported health and feeling lethargic and a probit model when the dependent variable was blood pressure. When the dependent variable was lung capacity we used a Tobit model to account for the zeros. When the dependent variable was ADL difficulty, which we normalized between 0 and 1, we used ordinary least squares (OLS). We used negative binomial regression when the dependent variable was word count as word count is an integer describing count. We report marginal effects for all the coefficients. It is to be noted that, our results do not differ much when we use alternative estimation techniques, such as OLS, in all cases.

7 Results

Table 2 presents the baseline results using only the set of Cultural Revolution dummies. Obtaining a positive coefficient on the Cultural Revolution dummies when the dependent variables are ADL difficulty, health status, blood pressure and feeling lethargic and a negative coefficient on the Cultural Revolution dummies when the dependent variables are lung capacity and word count would be consistent with the hypotheses that a violent political will have adverse health effects later in life. We find that those who were in utero or infancy during the Cultural Revolution have reduced lung capacity in old age. There is some weak support that children in in utero have higher difficulty engaging in ADL in older age (at the 15 % level). This should be noted considering our small sample size. We further find that males who were in the adolescent growth spurt in the Cultural Revolution

Table 2 The effects of the Cultural Revolution during childhood growth periods—baseline results

	ADL difficulty[a]	Health status[b]	Blood pressure[c]	Lung capacity[d]	Word count[e]	Feel lethargic[b]
Cultural Revolution	0.012	−0.153	0.027	−41.470***	−0.150	0.173
0–2 years	(0.009)	(0.141)	(0.185)	(11.601)	(0.103)	(0.157)
Cultural Revolution	0.008	−0.110	0.169	−24.831***	−0.097	−0.061
10–11 years, female	(0.007)	(0.094)	(0.113)	(8.980)	(0.079)	(0.102)
Cultural Revolution	0.013*	−0.108	0.302**	8.991	−0.175**	−0.031
12–13 years, male	(0.007)	(0.094)	(0.119)	(11.579)	(0.078)	(0.106)
R^2	0.289					
Pseudo R^2		0.058	0.037	0.058		0.047
N	1865	1860	1864	954	1865	1636

Robust standard errors (in parentheses)

Control variables are age, sex, smoking, Gansu and rural. Cultural Revolution treated as the period 1966–1976

***, **, * Significance at the 1, 5 and 10 % level, respectively

[a] OLS, [b] Ordered probit, [c] Probit, [d] Tobit, [e] Negative binomial

have higher blood pressure and more difficulties with ADL in old age. Males who were in the adolescent growth spurt in the Cultural Revolution recalled fewer words, while females who were in the adolescent growth spurt in the Cultural Revolution exhibited reduced lung capacity in old age.

In Table 3, we include additional variables controlling for education, height and self-reported health during childhood as well as household expenditure, wealth, age, gender and dummies for whether the respondent lives in a rural area and is from Gansu province. Inclusion of additional controls effect the economic significance of the coefficient estimates, but all the variables that were significant in Table 2 continue to be so and other variables also become significant. The coefficient on males aged 12–13 in the Cultural Revolution in the ADL regression is significant at 5 %, instead of 10 % as in Table 2, and the coefficient on females aged 10–11 in the Cultural Revolution in the blood pressure and ADL difficulty regressions become weakly significant at 10 % with the expected sign.

Overall, these results indicate that there are some adverse effects on health in old age due to the Cultural Revolution and that for all health measures, except blood pressure, these effects are also channelled through one or more of self-reported child health, education, height, household expenditure or household wealth. Note that a negative coefficient on these variables for difficulty in performing ADL, self-reported health status, blood pressure, and feeling lethargic, and a positive coefficient on these variables for lung capacity and word count indicate favourable effects on health. We find that being better educated, being taller and having better health during childhood contributes to less difficulty with ADL, improved lung capacity and better word count recall. We find that being better educated and better childhood health contributes to better self-reported health and feeling less lethargic. Finally, we find higher household wealth is associated with improved word count recall and lung capacity, while those with higher household expenditure have less ADL difficulty, better self-reported health and better word recall, suggesting living standards are associated with health.

Table 3 The effects of the Cultural Revolution during childhood growth periods—additional controls

	ADL difficulty[a]	Health status[b]	Blood pressure[c]	Lung capacity[d]	Word count[e]	Feel lethargic[b]
Cultural Revolution	0.005	−0.166	0.057	−35.244***	−0.058	0.105
0–2 years	(0.009)	(0.150)	(0.190)	(11.406)	(0.106)	(0.165)
Cultural Revolution	0.013*	−0.039	0.202*	−33.085***	−0.128	−0.054
10–11 years, female	(0.007)	(0.100)	(0.122)	(9.334)	(0.084)	(0.110)
Cultural Revolution	0.014**	−0.111	0.360***	−1.775	−0.160**	−0.040
12–13 years, male	(0.007)	(0.101)	(0.127)	(11.917)	(0.082)	(0.114)
Height in cm	−0.001**	0.001	−0.002	1.904***	0.015***	−0.003
	(0.000)	(0.004)	(0.005)	(0.476)	(0.004)	(0.005)
Education	−0.002***	−0.020**	0.005	2.971***	0.064***	−0.018*
	(0.001)	(0.009)	(0.011)	(0.994)	(0.007)	(0.010)
Child health	−0.008*	−0.381***	0.052	11.942*	0.093*	−0.116*
	(0.004)	(0.055)	(0.070)	(6.276)	(0.049)	(0.065)
Ln(Wealth)	−0.001	−0.029	−0.007	5.337***	0.046***	−0.007
	(0.001)	(0.018)	(0.021)	(1.855)	(0.016)	(0.020)
Ln(Expenditure)	−0.005*	−0.061*	0.018	−0.006	0.099***	−0.056
	(0.003)	(0.032)	(0.037)	(3.391)	(0.034)	(0.034)
R^2	0.283					
Pseudo R^2		0.046	0.041	0.056		0.043
N	1656	1651	1656	867	1656	1464

Notes as per Table 2

The results indicate that some of the effects of the Cultural Revolution on health in later in life are transmitted through education, household expenditure and wealth, child health and height. These findings are similar to the result in Case and Paxson (2008) that the effect of height on several health indicators in old age is transmitted through own education. The exact mechanisms at work here are unclear. One possibility is that education and health human capital have a causal role in assisting individuals to maintain cognitive ability and physical health over time. This explanation is consistent with the view that education is protective of wellbeing at old ages. A second possibility is that higher educational attainment and health human capital in childhood persists into old age (Case et al. 2005; Case and Paxson 2008).

In Table 4, we consider the potential effect of the famine during 1958–1961 on health. Since a large number of people in our sample were either born before, or during, the Chinese great famine, it is important to control for the potential effects of the famine on health later in life (Almond et al. 2010). In Table 4 we include separate dummies for famine just as we do for the Cultural Revolution. In particular, we consider age 0–2 for the shock to the initial health endowment due to famine. We also consider age 10–11 for girls and 12–13 for boys to test for shocks to childhood health due to famine. Summary statistics for these variables are reported in Table 1. Our results indicate insignificant or no effect of the famine on our sample of people in all but blood pressure and lung capacity for males who were 12–13 years old during famine. Importantly, the effects of the Cultural Revolution on health in later life remains robust after controlling for the effect of the famine on health in later life. Males and females who were adolescents in the Cultural Revolution

Table 4 Robustness test 1: Include effects of the Great Famine

	ADL difficulty[a]	Health status[b]	Blood pressure[c]	Lung capacity[d]	Word count[e]	Feel lethargic[b]
Cultural Revolution	0.009	−0.158	0.031	−36.209***	−0.103	0.153
0–2 years	(0.009)	(0.144)	(0.192)	(11.384)	(0.102)	(0.162)
Cultural Revolution	0.015**	0.009	0.324**	−24.550**	−0.071	−0.086
10–11 years, female	(0.008)	(0.109)	(0.138)	(10.551)	(0.091)	(0.122)
Cultural Revolution	0.017**	−0.053	0.374***	7.107	−0.180**	−0.027
12–13 years, male	(0.007)	(0.103)	(0.132)	(12.059)	(0.083)	(0.117)
Great Famine (1958–1961)	−0.004	−0.061	−0.077	−4.070	−0.058	−0.001
0–2 years	(0.004)	(0.078)	(0.105)	(9.224)	(0.059)	(0.094)
Great Famine (1958–1961)	0.003	0.034	0.119	−12.633	0.024	0.018
10–11 years, female	(0.009)	(0.121)	(0.137)	(10.643)	(0.107)	(0.122)
Great Famine (1958–1961)	0.009	0.173	0.234*	22.162**	0.051	−0.147
12–13 years, male	(0.010)	(0.121)	(0.135)	(11.091)	(0.103)	(0.125)
Other controls[f]	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.297					
Pseudo R^2		0.038	0.055	0.036		0.041
N	1864	1859	1863	954	1864	1636

Notes as per Table 2; (f) other controls are as per Table 3

experience more difficulties with ADL and have higher blood pressure later in life. Individuals who were in utero or infancy in the Cultural Revolution, and females who were adolescents in the Cultural Revolution, experience reduced lung capacity later in life. Finally, males who were adolescents in the Cultural Revolution have lower cognitive ability in later life, proxied by word count recall.

In Table 5, we examine whether the Cultural Revolution has a differential effect on health in later life depending on whether people were born in a rural area during that period. Consistent with previous studies, our identification strategy relies on a comparison between birth cohorts (e.g. Case et al. 2005; Case and Paxson 2008). However, it is possible to distinguish the effect within the exposed cohort by the magnitude of the effect of the Cultural Revolution. As discussed above, there is evidence that the majority of killings during the Cultural Revolution occurred in rural areas and the level of political violence was more pervasive in the countryside (see e.g. Su 2006). Hence, one might expect that the adverse health effects in later life of the Cultural Revolution would be stronger for those who were born, and who lived as children, in the rural areas. We exploit this within difference exposure to the Cultural Revolution to test whether health effects are not only driven by Cultural Revolution specific between variance but also Cultural Revolution specific within cohort variance.

The findings are mixed. We find that being in utero in the Cultural Revolution has significant adverse effects on ADL difficulties, but, contrary to expectations, those who were in utero in a rural area actually have less difficulties with ADL later in life than their equivalents from urban areas. The coefficient on the interaction term, though, is only weakly significant. Our results show that respondents who were in utero during the Cultural Revolution in a rural area have higher blood pressure later in life. However, males who were adolescents in the Cultural Revolution in rural areas have lower blood pressure

Table 5 Robustness test 2: Effects of being born rural

	ADL difficulty[a]	Health status[b]	Blood pressure[c]	Lung capacity[d]	Word count[e]	Feel lethargic[b]
Cultural Revolution	0.050**	−0.433	−3.793***	−70.335**	−0.368	0.338
0–2 years	(0.024)	(0.582)	(0.305)	(29.115)	(0.267)	(0.440)
Cultural Revolution	−0.043*	0.295	3.860***	36.928	0.300	−0.188
0–2 years × born rural	(0.025)	(0.595)	(0.353)	(30.424)	(0.282)	(0.465)
Cultural Revolution	−0.001	0.046	0.213	−67.419**	0.005	0.303
10–11 years, female	(0.013)	(0.241)	(0.346)	(31.739)	(0.154)	(0.301)
Cultural Revolution	0.012	−0.135	−0.049	43.002	−0.135	−0.381
10–11 years, female × born rural	(0.013)	(0.243)	(0.348)	(31.751)	(0.155)	(0.301)
Cultural Revolution	0.029**	−0.199	0.772**	−3.340	−0.324**	0.423
12–13 years, male	(0.013)	(0.234)	(0.307)	(26.918)	(0.161)	(0.298)
Cultural Revolution	−0.017	0.110	−0.510*	9.342	0.123	−0.478
12–13 years, male × born rural	(0.012)	(0.231)	(0.307)	(27.433)	(0.159)	(0.300)
Born rural	0.002	0.008	0.218	−10.692	0.018	0.196
	(0.009)	(0.119)	(0.184)	(14.170)	(0.110)	(0.183)
Other controls[f]	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.297					
Pseudo R^2		0.050	0.061	0.041		0.044
N	1864	1859	1858	954	1864	1636

Notes as per Table 2

later in life than their equivalents in urban areas, although, again, the coefficient is only weakly significant.

As discussed above, some scholars define the Cultural Revolution as the much shorter period from 1966 to 1968 (Unger 2007). The least that can be said is that this period represents the most intense period of the Cultural Revolution defined more broadly, in which the level of political violence was at its peak. In Table 6, we check the robustness of our results by focusing in the period from 1966 to 1968. However, defining the Cultural Revolution in this manner greatly reduces the sample size for individuals who were aged 0–2 or in the adolescent growth spurt during this period. Our results still suggest that the Cultural Revolution had adverse effect on lung capacity and blood pressure, but we found no evidence of adverse health effects for the other health indicators we examine here.

8 Discussion and Conclusion

We have examined the effect of mass political violence experienced in utero and in adolescence on long-term health outcomes using the Cultural Revolution as a natural experiment. The only health indicator for which we find that political violence experienced in the womb or infancy has an adverse effect on health later in life is lung capacity. We find consistent evidence that those either born, or in infancy, in the Cultural Revolution have lower lung capacity later in life. This result is consistent with findings from epidemiological studies which suggest that individuals born with lower birth weight have

Table 6 Robustness test 3: Intense period of the Cultural Revolution (1966–1968)

	ADL difficulty	Health status	Blood pressure	Lung capacity	Word count	Feel lethargic
Cultural Revolution (1966–1968)	0.006	−0.136	−0.002	−37.951***	−0.011	0.181
0–2 years	(0.009)	(0.142)	(0.188)	(10.635)	(0.100)	(0.158)
Cultural Revolution (1966–1968)	−0.000	−0.043	0.224*	−7.373	0.098	0.044
10–11 years, female	(0.006)	(0.096)	(0.119)	(9.041)	(0.079)	(0.109)
Cultural Revolution (1966–1968)	−0.001	0.018	0.247**	23.214*	0.057	−0.092
12–13 years, male	(0.005)	(0.092)	(0.125)	(13.145)	(0.070)	(0.110)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.296					
Pseudo R^2		0.049	0.061	0.040		0.044
N	1864	1859	1863	954	1864	1636

Notes as per Table 2. In this table Cultural Revolution treated as 1966–1968, which differs from earlier tables, in which it is treated as 1966–1976

reduced lung capacity in adult life (Vrijlandt et al. 2006) and that children exposed to traumatic stress, such as physical and sexual abuse, have a higher incidence of respiratory problems decades later (Anda et al. 2008). The results are also consistent with findings that living in violent environments promotes respiratory diseases (Wright and Steinbach 2001).

Apart from lung capacity, we find little support for the proposition that political violence experienced in utero has adverse health effects later in life. This outcome is similar to other recent studies that have found little evidence that adverse income shocks in utero have lasting health effects (see Banerjee et al. 2010; Cutler et al. 2007). One possible explanation for this result is that despite the adverse political shock in utero, health status may have been protected by other factors, such as improved public health infrastructure (Cutler et al. 2006). Beginning with the Cultural Revolution there was a significant improvement in public health care in China, particularly in the rural areas where the barefoot doctor scheme was rolled out (see, e.g. Sidel 1972). Another possible explanation is that the adverse effects of political shocks in the womb were offset by countercyclical health behaviour, such as greater adherence to positive medical protocols (Cutler et al. 2007). It might be that improved public health provision in rural areas in China in the Cultural Revolution made it easier for individuals to adhere to positive medical protocols so that both explanations are reinforcing.

We find more evidence that exposure to political violence in the adolescent growth spurt has adverse effects on health later in life. If we focus on the Cultural Revolution defined more broadly as 1966–1976, we get fairly robust findings that exposure to violence in the adolescent growth spurt results in reduced ADL and higher blood pressure later in life for both males and females. We find some gender differences in the effect of exposure to political violence in adolescence on health outcomes in later life. The reasons for gender differences in the pathophysiologic response to an adverse adolescent environment are not well-known. In their survey paper of childhood human capital development, Almond and Currie (2011a, p. 1371) state: "Several studies reviewed suggested that both shocks and interventions can have different long-term effects on males and females. But these findings are too new for us to be able to predict when this difference will occur, and we have virtually no evidence about why it occurs". Epidemiological studies, none the less, suggest

a role for sex hormone involvement. In particular, sex differences are a constant feature of early life programming of stress responsiveness (Kajante and Raikkonen 2010).

We find fairly robust evidence that females exposed to political violence in adolescence experience reduced lung capacity later in life, while there are no similar effects for males. This result is consistent with epidemiological research which suggests that women exhibit several anatomic and physiologic characteristics that differ from men (Harms 2006). Specifically, Harms (2006) found that women have smaller vital capacity and maximal expiratory flow rates, reduced airway diameter, and a smaller diffusion surface than age- and height-matched men. These differences potentially make women more vulnerable to the effects of external shocks such as political violence on lung capacity. Another possible explanation is that boys may be less robust than girls so that a given health shock will cull boys while girls survive. If so, the average lung capacity of male survivors might be better than female survivors (Almond and Currie 2011a). There is some evidence that the sons, more than the daughters, of "four-type" (*silei fenzi*) households were the direct targets of political violence in the Cultural Revolution because the perpetrators of such violence feared greater retribution from the sons if they were allowed to live until adulthood (Su 2006).

Meanwhile, we find that males exposed to political violence in adolescence experience reduced cognitive function later in life. There is mixed evidence about the rate of cognitive decline in men and women (Stewart and Newton 2010). Our findings are consistent with Norman et al. (2000) who found that women in three age-groups (less than 40, 40–60, and over 60) out-performed men in their ability to recall words. This result might be due to so-called "male vulnerability". Male vulnerability focuses on the fact that males have an unprotected Y chromosome which has been shown to be associated with higher rates of brain disorders in males and higher prevalence of cognitive diseases in males such as dementia (Low 2000). Male vulnerability potentially makes cognitive decline in males more susceptible to idiosyncratic shocks to childhood health (van den Berg et al. 2010).

There is evidence that the transmission mechanism between political violence in the Cultural Revolution and health in later life manifests itself through childhood health and educational outcomes. That adverse childhood health and educational outcomes are manifested in adult health outcomes is consistent with life course models, which emphasise the lasting effects of illness and deprivation in childhood on health and labour market outcomes later in life. Case et al. (2005) show that such human capital outcomes in childhood not only have adverse effects on one's economic circumstance and health later in life, but are also transmitted from one generation to the next. Specifically, individuals who experience adverse educational and health outcomes as children will have lower earnings and poorer health in adulthood and will be less able to invest in the education and health of their own children. Our results are important because they suggest that external events, such as a violent mass political movement, can either act as a trigger for, or exacerbate, this adverse spiral of events.

The fact that we find fairly strong evidence that exposure to violence in adolescence has long-run health implications has important policy implications for communities exposed to violence. Social cohesion is strongly correlated with violence in neighbourhood communities (Wright and Steinbach 2001). Our results suggest that policies to promote social capital are likely to have positive long-run health outcomes. In addition to the direct medical channel, improved social cohesion is likely to have indirect positive effects on health outcomes. Social cohesion may promote the diffusion of health information and increase access to local public health infrastructure (Wright and Steinbach 2001). That we find evidence that idiosyncratic shocks are transmitted through education and child health is also encouraging in the sense that these risk factors are modifiable. Investment in

education and childhood health can be protective of health in later life and reduce the impact of adverse idiosyncratic shocks.

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