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

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Abstract

There is much interest in the causes of several adverse health outcomes in middle and old age. In searching for new explanations for adverse health outcomes later in life, researchers have started to look beyond behavioural risk factors to examine the effect of shocks to health *in utero* and in childhood on health in old age. In this paper we extend this literature to examine the long-term health effects of mass political violence experienced *in utero* and in childhood 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, but we find no evidence that being *in utero* has adverse effects on other health indicators later in life. We find more evidence that being an adolescent in the Cultural Revolution has an adverse effect on health later in life. Specifically, we 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. We also find that males who were adolescents in the Cultural Revolution have reduced cognitive skills later in life, while females who were adolescents in the Cultural Revolution have reduced lung capacity in middle and old age.

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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. Cognitive decline, which covers a broad spectrum from normal cognitive aging to dementia, is the most feared aspect of growing old. While dementia affects around 5 per cent of people over the age of 65 and around 25 per cent of those over the age of 85 (Hofman *et al.,* 1991), cognitive decline affects a much larger proportion. There is also growing concern that these adverse health outcomes impose serious economic and health costs on both the individual and society more generally. Blood pressure is a key risk factor of cardiovascular disease, type 2 diabetes, musculoskeletal disorders and certain kinds of cancers, which cause substantial disability and premature death (Fontaine *et al.,* 2003). Cardiovascular disease is the fastest growing reason for hospitalization in the United States and the most expensive (Thornburg, *et al.*, 2010). The costs for cognitively impaired individuals, in terms of their own quality of life and to society in the form of old age care are high and are expected to increase in the coming decades (van den Berg *et al.*, 2010).

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 pressure between individual people and populations (Barker *et al.*, 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 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. From a public policy perspective, 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. Cutler *et al.* (2007) extended this literature to examine the long-run effects on health of a negative income shock experienced *in utero* or childhood associated with the Great Depression. 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. 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. Some have argued that the Cultural Revolution concluded with the suppression of mass factions in the summer of 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 & 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 & 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 to 1.5 million were killed, with roughly the same number permanently injured. Chang and Holiday (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 & 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".

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 eg. Barker, 1990; Barker *et al*, 1993). The second are economic studies of the effects of *in utero* health and childhood health on employment, health and socioeconomic outcomes later in life (Case *et al.,* 2005; Cutler *et al.,* 2008; van den Berg *et al.* 2010). 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. The existing literature has focused on shocks due to disease, famine, war and economic downturns. For example, Neelsen and Stratmann (2011) and Stanner *et al.* (1997) examined long-run health effects in which the shock was famine and war respectively, while Almond (2006) examined the long-run health effects of disease. Studies which have considered the long-run health effects of negative income shocks include Cutler *et al.,* (2007), in which the relevant shock was the Great Depression in the United States, and Banerjee *et al* (2007), in which the relevant income shock was the phylloxera plague in nineteenth century France.

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 & Steinbach, 2001). This literature also includes the adverse effect of socio-political violence on children in terms of generating disturbances in development if not clinical disorders and the lasting effects of such disorders (Belsky, 2008) as well as the effect of socio-political

violence on the transmission of posttraumatic stress disorder from parents to children either *in utero* or as post-natal young children (Kaitz *et al.* 2009). The study is related to a literature in sociology on historical trauma, which refers to historical and social events that have led to intergenerational stress responses among individuals and groups. Examples are American Indian populations and Holocaust survivors (see eg. Estrada 2009; Sotero 2006).

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 eg. 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 eg 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.

Hypotheses

We formulate hypotheses, differentiating between a shock to the initial health endowment (*in utero*) and a shock to initial investments in health in childhood. In each case we examine these differential effects on our measures of health – activities of daily living (ADL), blood pressure, lethargy, self-reported health, lung capacity and word count - in old age.

Shock to initial health endowment on health outcomes in old age

It is well recognised in the epidemiology literature that 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 (Wright & Steinbach, 2001). Several studies suggest that maternal prenatal stress creates adverse conditions *in utero* for the unborn baby (Demmelmair *et al.*, 2006) and that there are potential long-term health outcomes for the unborn baby from maternal prenatal psychological stress (Kajante & Raikkonen, 2010). To maximize survival to reproductive age, the fetal programming hypothesis posits that adverse conditions *in utero* cause a developing fetus to protect some physiological systems more than others, differentially compromising functions that are operative later in life (Barker, 1990). As a result, physiological adaptations made by a fetus in response to *in utero* stressors give rise to chronic diseases later in life (Barker, 1990).

Among chronic health problems traced to the womb, the epidemiology literature has shown that shocks *in utero* are correlated with high blood pressure/hypertension in old age (Barker, 1990). The epidemiology studies have found that the highest blood pressure in older adults is

found in people who had been small babies with large placentas. These studies find that greater placental weight at any birth weight is associated with a decrease in the ratio of length to head circumference. This disproportionate growth is consistent with diversion of blood away from the trunk in favour of the brain in response to *in utero* stressors. Reduced blood flow to the trunk induced in a fetus that is small in relation to its placenta alters the arterial structure resulting in higher blood pressure later in life (Barker *et al.,* 1990).

H1: A shock to health *in utero* will lead to high blood pressure in old age.

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

H2: A shock to health *in utero* will lead to reduced lung capacity in old age.

During the first half of pregnancy, when neurogenesis (6-18 weeks of gestation) and cell migration (until 26 weeks of gestation) takes place, the embryonic brain is particularly sensitive to psychological stress (de Groot *et al.,* 2011). 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 in conditions in which the physiological processing of the brain is compromised, such as at older ages (de Groot *et al.*, 2011). We are not aware of studies that have examined the effects of maternal stress of the sort generated by mass political and social upheaval on cognitive function in old age. However, larger head circumference at birth is associated with better cognitive outcomes (Gale *et al.* 2003), while low birth weight is associated with poorer cognitive outcomes in old age (see eg. Erickson *et al.*, 2010).

H3: 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. In addition to heightened blood pressure and hypertension, the epidemiology literature has shown that shocks *in utero* are correlated with a range of physical health problems later in life including cardiovascular disease (Barker, 1993), non-insulin dependent diabetes (Barker, 1993), osteoporosis (Barker, 1993) and obesity (Higgins *et al.*, 2011) or all of these conditions together (Louey & Thornburg, 2005). 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.

H4: A shock to health *in utero* will lead to a decline in self-reported health in old age.

H5: A shock to health *in utero* will result in less ability to engage in ADL in old age.

H6: A shock to health *in utero* will result in feeling lethargic in old age.

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 & Steinbach, 2001). Traumatic events impacting on cognitive development in childhood also affect educational attainment and occupational choice. A decline in cognitive function in old age is related to educational attainment. 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). Education plays a role in supporting adherence to medical protocols (Goldman & Smith, 2003) and makes it more likely individuals will select into white collar occupations. This becomes important later in life because white collar workers are at a lower risk of neurotoxicants, that accelerate cognitive decline, in the workplace than blue collar workers (Schwartz *et al.,* 2000). Alternatively, animal studies have shown that environmental experiences can modify brain anatomy and function (see eg. Diamond *et al.,* 1972). Studies with humans suggest that workplace environment is important. Stern *et al.* (1995) found that interpersonal skills, which are generally required at higher levels of occupation are particularly important in maintaining brain reserve that protect cognitive skills in old age.

H7: A shock to childhood health will lead to lead to a decline in word count recall in old age.

Exposure to violence has been shown to be correlated with reduced lung capacity and respiratory problems later in life (Wright & 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. Stress is also been shown to alter the immune system, which predisposes individuals to respiratory tract infections which impair lung function later in life (Wright & Steinbach, 2001). 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 & Steinbach, 2001).

H8: A shock to childhood health will lead to reduced lung capacity in old age.

Epidemiologists argue that 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 & Paxson, 2008). Several studies suggest a link between cognitive decline and decline in physical health in old age (Case & Paxson, 2008). Studies have shown that blood pressure is associated with individual differences in cognitive function (Anstey & Christensen, 2000) and that experiencing a stroke in old age is strongly correlated with cognitive decline (Van den Berg *et al.*, 2010). As with cognitive decline, education also plays a role. Individuals who experience health shocks as children are likely to have poorer educational outcomes, which translate into more limited occupational choices concentrated on unskilled blue collar jobs. Case and Deaton (2003) report that individuals in blue collar occupations exhibit a more rapid deterioration in self-reported health compared with those in white collar jobs. 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.

H9: A shock to childhood health will lead to high blood pressure in old age.

H10: A shock to childhood health will lead to a decline in self-reported health in old age.

H11: A shock to childhood health will result in less ability to engage in ADL in old age.

H12: A shock to childhood health will result in feeling lethargic in old age.

Data and Descriptive Statistics

We use pilot data from the China Health and Retirement Longitudinal Survey (CHARLS), which is the first publicly available data set focusing on the elderly in China (see Zhao *et al.*, 2009). It provides a wide range of information about household characteristics as well as individual information on respondents, their spouses and children. CHARLS contains data from 1,563 randomly selected households collected from two provinces, Zhejiang and Gansu, in 2008. CHARLS sampled one person, plus their spouse if one exists, in each household. Hence, overall CHARLS contains information on 2,951 individuals. Gansu and Zhejiang were chosen as the two provinces as one is representative of an inland, poorer province and the other is representative of a prosperous coastal province. Events in both provinces in the late 1960s were typical of the Cultural Revolution elsewhere in China. 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 persecutions and violence. Walder and Su (2003) suggest that on average there were 58 deaths per county in Gansu throughout the Cultural Revolution, which is typical of other rural provinces.

County level units are chosen by Probability Proportional to Size (PPS), stratified by whether the unit was an urban district (*qu*) or rural county (*qian*) and by region within each classification. Both urban districts and rural counties can contain both urban and rural communities, but the concentration of urban and rural populations differs between the two. With the objective of sampling 16 county-level units per province, the number of counties to be sampled in each stratum was determined based on population size. Counties were randomly selected within each stratum with PPS measured by population. Based on this

sampling procedure, 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. In examining the health status of the elderly in China, the CHARLS data has the advantage that it contains a rich set of variables on health status that would otherwise be difficult to obtain. We use six alternative measures of health, spanning cognitive function and physical health; namely, ADL, blood pressure, lethargy, lung capacity, self-reported health and word count.

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 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 metres, walking one kilometre, sitting for two hours, 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 3litres/minute. 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 summarizes descriptive statistics for all health variables, variables of interest, and other controls. It shows that 3.8 per cent of respondents were aged two or under in the Cultural Revolution and 37.7 per cent 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 per cent not attending school at all. The average age in our sample is about 59 years, 52 per cent are female, 83.5 per cent live in a rural area and 46.2 per cent are from Gansu province with the rest being from Zhejiang province.

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.[1] 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 eg. Case *et al.*, 2005). The specific respondents' characteristics for which we control are age, education, gender, health status during childhood, height, whether he/she lives in a rural or urban area and a province fixed effect. We use self-reported health during childhood. Using health status during childhood 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 equation (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*,

[1] One possible shortcoming of our approach is that we only consider the health of adults who survive to old age. As discussed above, the Cultural Revolution resulted in the deaths of many adults and children. As we do not have information on mortality, our estimates would be downward biased.

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.

Results

Table 2 presents the baseline results using only the set of Cultural Revolution dummies. 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 is consistent with the hypotheses that a violent political will have adverse health effects later in life. 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 0-1, 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.[2] 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. Of the hypotheses concerning a shock to health *in utero*, there is support for *H2* – those who were *in utero* or infancy during the Cultural Revolution have reduced lung capacity in old age. There is no support for *H1* or *H3*-*H6* at the 5 per cent level or better. For H5, there is some weak support that children in *in utero* have higher difficulty in ADL activity (at the 15 per cent level). This should be noted considering our small sample size. Of the hypotheses concerning a shock to childhood health, where the proxy for childhood is the adolescent growth spurt, there is support for *H7* (for males), *H8* (for females), *H9* and *H11*. Males and

[2] We also considered zero-inflated negative binomial regression to account the fact that a large number of respondents could not recall any word. The results are very similar to that reported here using a negative binomial model.

females who were in the adolescent growth spurt in the Cultural Revolution 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 age, gender and dummies for whether the respondent lives in a rural area and is from Gansu province. The results are similar to what we report in Table 2. Inclusion of additional controls effect the economic significance of the coefficient estimates, but the statistical significance remains the same with exception of the coefficient on males aged 12-13 in the Cultural Revolution in the ADL regression and the coefficient on females aged 10-11 in the Cultural Revolution in the blood pressure regression.

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 and height. 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 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, while being taller and having being better educated improves lung capacity.

Overall, the results indicate that some of the effects of the Cultural Revolution on health in later in life are transmitted through education, child health and height and that when we include them in our regressors we lose some of the significance of our baseline results. 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 well-being 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 2. 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 experience more difficulties with ADL and have higher blood pressure later in life (supports *H9* and *H11*). 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 (supports *H2* and partially supports H8). Finally, males who were adolescents in the Cultural Revolution have lower cognitive ability in later life, proxied by word count recall (partially supports *H7*).

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. 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 eg. 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 find some support for this conjecture. We find that being *in utero* or being a female adolescent in the Cultural Revolution in a rural area has a stronger adverse effect on ADL later in life than for their equivalents from urban areas. We also find that males and females who were adolescents in the Cultural Revolution in rural areas have higher blood pressure later in life than their equivalents in urban areas.

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.

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 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 & 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 which have found little evidence that adverse income shocks *in utero* have lasting health effects (see Banerjee *et al.,* 2007; 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, eg. 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 (2010, p. 56) 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 & 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 & Currie, 2010). 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 & 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 & 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 & 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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Table 1: Descriptive Statistics

Obs.	Variable	Mean	Std. Dev.	Min.	Max.
ADL Difficulty	1946	0.069	0.099	0.000	0.725
Health Status	1860	3.803	1.019	1.000	5.000
Blood Pressure	1944	0.349	0.477	0.000	1.000
Lung Capacity	987	307.366	108.135	70.000	700.000
Word Count	1946	2.207	2.160	0.000	10.000
Feel Lethargic	1637	1.737	0.946	1.000	4.000
CR 0-2 years	1946	0.038	0.190	0.000	1.000
CR 10-11 years, female	1946	0.196	0.397	0.000	1.000
CR 12-13 years, male	1946	0.181	0.385	0.000	1.000
Born rural	1946	0.064	0.244	0.000	1.000
Height in cm	1946	158.270	8.502	106.500	185.500
Education	1945	3.202	3.529	0.000	15.000
Child health	1865	0.673	0.469	0.000	1.000
Age	1946	58.645	10.038	34.000	87.000
Female	1946	0.522	0.500	0.000	1.000
Rural	1946	0.835	0.372	0.000	1.000
Gansu	1946	0.462	0.499	0.000	1.000
GF 0-2 years	1946	0.179	0.384	0.000	1.000
GF 10-11 years, female	1946	0.076	0.265	0.000	1.000
GF 12-13 years, male	1946	0.075	0.264	0.000	1.000

Notes: CR denotes Cultural Revolution; GF denotes Great Famine.

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	0.014	-0.153	0.017	-42.123***	-0.143	0.171
0-2 years	(0.009)	(0.141)	(0.184)	(11.710)	(0.142)	(0.104)
Cultural Revolution	0.012*	-0.110	0.195*	-23.075***	-0.100	-0.063
10-11 years, female	(0.007)	(0.094)	(0.111)	(8.852)	(0.81)	(0.102)
Cultural Revolution	0.016**	-0.108	0.284**	8.640	-0.206**	-0.027
12-13 years, male	(0.007)	(0.094)	(0.117)	(11.423)	(0.080)	(0.106)
R^2	0.292					
Pseudo R^2		0.058	0.037	0.058		0.047
N	1946	1860	1944	987	1946	1637

Notes: [a]OLS, [b]Ordered Probit, [c]Probit, [d]Tobit, [e]Negative Binomial. Robust standard errors (in parentheses). ***, **, * indicate significance at the 1, 5, 10%-level, respectively. Control variables are age, Sex, Gansu and rural.

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 Counte	Feel Lethargic[b]
Cultural Revolution	0.010	-0.157	0.029	-34.708***	-0.089	0.164
0-2 years	(0.009)	(0.141)	(0.185)	(10.779)	(0.140)	(0.099)
Cultural Revolution	0.009	-0.081	0.175	-27.376***	-0.121	-0.052
10-11 years, female	(0.007)	(0.094)	(0.113)	(8.773)	(0.078)	(0.103)
Cultural Revolution	0.014**	-0.097	0.293**	5.919	-0.211***	-0.019
12-13 years, male	(0.007)	(0.094)	(0.119)	(11.270)	(0.077)	(0.107)
Height in cm	-0.001**	-0.001	-0.002	2.251***	0.018***	-0.004
	(0.000)	(0.004)	(0.005)	(0.451)	(0.004)	(0.005)
Education	-0.002***	-0.023***	0.003	3.439***	0.070***	-0.017*
	(0.001)	(0.008)	(0.011)	(0.939)	(0.006)	(0.010)
Child health	-0.012***	-0.405***	0.039	9.759	0.095**	-0.122**
	(0.004)	(0.051)	(0.066)	(6.020)	(0.046)	(0.060)
R^2	0.298					
Pseudo R^2		0.060	0.041	0.070		0.043
N	1864	1859	1863	954	1864	1636

Notes: [a]OLS, [b]Ordered Probit, [c]Probit, [d]Tobit, [e]Negative Binomial. Robust standard errors (in parentheses). ***, **, * indicate significance at the 1, 5, 10%-level, respectively. Control variables are age, Sex, Gansu and rural.

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	-0.159	0.035	-36.648***	-0.104	0.153
0-2 years	(0.009)	(0.144)	(0.192)	(11.477)	(0.102)	(0.163)
Cultural Revolution	0.015**	0.007	0.335**	-24.774**	-0.072	-0.088
10-11 years, female	(0.007)	(0.109)	(0.138)	(10.573)	(0.091)	(0.121)
Cultural Revolution	0.017**	-0.053	0.370***	7.371	-0.179**	-0.024
12-13 years, male	(0.007)	(0.102)	(0.132)	(12.067)	(0.083)	(0.117)
Great Famine (1958-61)	-0.004	-0.060	-0.080	-3.892	-0.057	0.000
0-2 years	(0.004)	(0.078)	(0.105)	(9.231)	(0.059)	(0.094)
Great Famine (1958-61)	0.003	0.033	0.122	-12.765	0.023	0.017
10-11 years, female	(0.009)	(0.121)	(0.137)	(10.599)	(0.107)	(0.122)
Great Famine (1958-61)	0.009	0.173	0.235*	22.422**	0.052	-0.147
12-13 years, male	(0.010)	(0.121)	(0.135)	(11.034)	(0.103)	(0.125)
Other controls[f]	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.298					
Pseudo R^2		0.038	0.055	0.036		0.041
N	1864	1859	1863	954	1864	1636

Notes: [a]OLS, [b]Ordered Probit, [c]Probit, [d]Tobit, [e]Negative Binomial. [f]Set of controls from Table 3. Robust standard errors (in parentheses). ***, **, * indicate significance at the 1, 5, 10%-level, respectively. Control variables are age, Sex, Gansu and rural.

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	0.007	-0.138	0.072	-33.938***	-0.069	0.150
0-2 years	(0.009)	(0.144)	(0.188)	(10.762)	(0.104)	(0.165)
Cultural Revolution	0.043*	-0.295		-37.336	-0.300	0.187
0-2 years x Born rural	(0.025)	(0.595)		(30.286)	(0.283)	(0.465)
Cultural Revolution	0.010	-0.090	0.173	-24.616***	-0.131	-0.079
10-11 years, female	(0.007)	(0.096)	(0.116)	(8.817)	(0.081)	(0.104)
Cultural Revolution	-0.012	0.136	0.038	-42.331	0.136	0.385
10-11 years, female x Born rural	(0.013)	(0.243)	(0.348)	(31.582)	(0.155)	(0.301)
Cultural Revolution	0.013*	-0.089	0.255**	6.389	-0.200**	-0.051
12-13 years, male	(0.007)	(0.096)	(0.122)	(11.602)	(0.079)	(0.109)
Cultural Revolution	0.017	-0.109	0.504*	-9.267	-0.123	0.480
12-13 years, male x Born rural	(0.012)	(0.232)	(0.305)	(27.397)	(0.159)	(0.301)
Born rural	-0.002	-0.008	-0.217	10.830	-0.017	-0.195
	(0.009)	(0.120)	(0.182)	(14.188)	(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: [a]OLS, [b]Ordered Probit, [c]Probit, [d]Tobit, [e]Negative Binomial. [f]Set of controls from Table 3. Robust standard errors (in parentheses). ***, **, * indicate significance at the 1, 5, 10%-level, respectively. Control variables are age, Sex, Gansu and rural.

Table 6: Robustness Test 3: Intense period of the Cultural Revolution (1966-1968)

	ADL Difficulty[a]	Health Status[b]	Blood Pressure[c]	Lung Capacity[d]	Word Count[e]	Feel Lethargic[b]	ADL Difficulty[a]	Health Status[b]	Blood Pressure[c]	Lung Capacity[d]	Word Count[e]	Feel Lethargic[b]
Cultural Revolution (1966-68)	0.006	-0.137	0.008	-38.934***	-0.012	0.178	0.004	-0.118	0.056	-36.441***	-0.001	0.152
0-2 years	(0.008)	(0.142)	(0.188)	(10.754)	(0.100)	(0.158)	(0.009)	(0.144)	(0.191)	(10.749)	(0.104)	(0.166)
Cultural Revolution (1966-68)							0.032	-0.259		-79.101***	-0.148	0.343
0-2 years Born rural							(0.024)	(0.597)		(15.575)	(0.263)	(0.410)
Cultural Revolution (1966-68)	-0.000	-0.044	0.230*	-7.816	0.097	0.042	0.001	-0.033	0.242**	-6.311	0.077	0.021
10-11 years, female	(0.006)	(0.096)	(0.119)	(9.055)	(0.079)	(0.109)	(0.007)	(0.101)	(0.123)	(9.209)	(0.085)	(0.113)
Cultural Revolution (1966-68)							-0.014	-0.158	-0.181	-21.656	0.214	0.278
10-11 years, female Born rural							(0.014)	(0.295)	(0.439)	(38.915)	(0.180)	(0.389)
Cultural Revolution (1966-68)	-0.001	0.018	0.246**	22.846*	0.058	-0.093	-0.002	0.060	0.236*	22.505*	0.057	-0.125
12-13 years, male	(0.005)	(0.092)	(0.125)	(13.110)	(0.070)	(0.110)	(0.005)	(0.095)	(0.129)	(13.632)	(0.074)	(0.113)
Cultural Revolution (1966-68)							0.016	-0.614**	0.180	5.867	0.015	0.468
12-13 years, male Born rural							(0.015)	(0.281)	(0.458)	(42.601)	(0.186)	(0.387)
Born rural	0.001						0.000	0.055	-0.087	4.356	-0.049	-0.065
	(0.007)						(0.007)	(0.113)	(0.163)	(13.625)	(0.091)	(0.156)
Other controls[f]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

R^2	0.296						0.295					
Pseudo R^2		0.049	0.061	0.040		0.044		0.050	0.060	0.040		0.044
N	1864	1859	1863	954	1864	1636	1864	1859	1858	954	1864	1636

Notes: [a]OLS, [b]Ordered Probit, [c]Probit, [d]Tobit, [e]Negative Binomial. [f]Set of controls from Table 3. Robust standard errors (in parentheses). ***, **, * indicate significance at the 1, 5, 10%-level, respectively. Control variables are age, Sex, Gansu and rural.