A life course perspective on early life conditions and mortality in very late life stage

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The effect of early life conditions on health has been well documented in Western countries. I extend this research to China, with its distinct social, institutional, and cultural gradients, proving that early life conditions affect mortality risk even for the oldest old. It demonstrates that different patterns exist for males and females in terms of which gradients and how these gradients matter in this process. For females, social origin, measured using father's occupation and family resource distribution among siblings during childhood, is crucial for later health outcomes, operating through education and social mobility, as well as the health behaviors. Interestingly, social origin and SES in adulthood affect the mortality risk in late life interactively, rather than additively. Arm length, as a biomarker of early life nutrition and other conditions in childhood, also predicts mortality risk later in life. For males, father's occupation also matters for mortality risk late in life, however, there's no mediating factor identified, except for physical exercise.

Social inequality in health has been well documented in western countries (House et al. 1994; Kitagawa and Hauser 1973; Preston and Taubman 1994). Generally, persons of higher socio-economic status (SES) have healthier lives and experience lower mortality risk than their lower SES counterparts (Moore and Hayward 1990; Preston and Elo 1995; Ross and Mirowsky 1999; Smith and Kington 1997). From a life course perspective, SES is crucial not only for its immediate effect but also for its influence on health outcomes across the life span. Accordingly, health status and mortality risk at any life stage should be seen as a reflection of past experience and activities under specific socioeconomic environment (Mare 1990). In fact, this life course perspective on SES and health originated at least 70 years ago, when Kermack et al. reported that health in adulthood is strongly influenced by living conditions during early life (Kermack, McKendrick, and McKinlay 1934). In 1977 Forsdahl advanced a theory relating nutritional deprivation in childhood followed by relative affluence to the risk of ischaemic heart disease (Forsdahl 1977). Recently, studies have explored the association between early life conditions and later health outcomes (Hayward and Gorman 2004; Preston, Hill, and Drevenstedt 1998). This research ranges from ecological studies with aggregate data (Elford, Shaper, and Whincup 1992) to longitudinal studies with individual level data (Preston et al. 1998). The indicators of early life conditions used in these studies include access to nutrients for the mother during pregnancy, the disease load on the mother during pregnancy, the fetus' nutrients, the disease load during the first year of life (Bengtsson and Lindstrom 2000), birthweight, height (Power and Matthews 1997), and a variety of household characteristics (Beebe-Dimmer et al. 2004). Proxies of health status involve cause-specific mortality (Frankel et al. 1998), and all-cause mortality (Kuh et al. 2002; Osler et al. 2005).

However, "little is known about these associations between SES and health outside the Western countries" (Zimmer and Kwong 2004). The associations should not necessarily be generalized globally, since such developing countries as China share little similarity with Western countries in economic,

cultural and institutional gradients. For example, in USA, health inequality narrows with age, partly due to universal access to health care through Medicare. The SES gradation in health may not converge in the same way in China, given its lack of a national health care system and the fact that access to health care depends on a personal financial means. Among the relevant research, a number of studies identified the socioeconomic gradients in old age mortality in Mainland China, Hong Kong, and Taiwan (Ho 1991; Liang, e al., 2000; Liu, Hermalin, and Chuang 1998). Others examined how health, as measured by psychological well-being and functional status are associated with economic well-being, medical care, and family support (Barker et al. 2004; Chen and Silverstein 2000; Sun 2004; Zimmer et al. 1998). Some argued that economic reform in China, initiated in 1980s, which privatized health services has made health care less accessible to lower social class, and this ongoing rapid social change explained why health differentiated unequally along socioeconomic lines in Taiwan and Beijing which share a similar Chinese culture (Baker et al. 2004). In mainland of China, the rural/urban dichotomy became more severe in terms of health conditions of residents and access to health services (Zimmer and Kwong 2004), in response to the disorganization of "bare foot" medical system that had provided basic, but universal health services in rural China. This research provided useful insights into the associations between SES and health under the Eastern social settings. Very few of these studies, however, consider health under a life course framework and take early life conditions into consideration.

Also, most evidence about the SES and health relationship is limited to the working ages. Little is known about the old age groups, especially the very old (oldest old), which may be partly due to lack of sufficient representation of the oldest old in national surveys (Zeng Yi et al. 2002a). In addition, researchers believe social inequality on health would decline eventually in old age since selective survival leaves more robust individuals of lower social class alive than their counterparts in upper

social class. Actually, even Rose and Wu, whose accumulative advantage health theory argues that social inequality of health would increase in later life stage, hesitate to extend this accumulative advantage to the very old age groups (Ross and Wu 1996). In China, most of the impressive research about the oldest old is being carried out by Zeng Yi and his research team. Nevertheless, their work focuses more on documenting the socio-demographic and health profiles of the oldest old Chinese (Zeng et al., 2001, 2002a, 2002b), rather than exploring the association between the SES and health or mortality. One exception is that Zeng and Vaupel (2003) examined the association between late childbearing and healthy longevity among the oldest old Chinese.

My study would contribute by focusing on whether and how the early life conditions affect mortality risk for the elderly. Specifically, it would answer the following questions: 1) the oldest old, as the "biological elite", are they highly homogeneous biologically, which means they are far freer of this social inequality of health? Or do they still differ along socioeconomic lines, particularly, with a mark of early life conditions? 2) If the latter are observed, what might be the latent channels associating early life conditions with health outcomes later and which mechanism might be crucial to this far-reaching effect?

Possible mechanisms under the association between early life conditions and adult health

Barker et al proposed a fetal origins hypothesis which emphasized the fetal life and infancy as "critical", sensitive time during which adverse exposures like under nutrition might permanently "damage structure, physiology and metabolism" and hence increase such risks as coronary heart disease, type 2 diabetes, stroke and hypertension in adult life by "biological programming" (Barker 1997; Barker and Clark 1997; Barker et al. 2002). Based on a systematic review of clinical and epidemiologic studies, Elo and Preston concluded that there exist a biological link between early life

conditions and such adult diseases as specific long-term effect infectious agents like Respiratory Tuberculosis, Hepatitis B, Cirrhosis, etc. Some diseases might lead to death by impairing organ systems and resulting in chronic debility; some other infections acquired in childhood may have a more protracted impact on health and might manifest even decades later (Elo and Preston 1992). This biological mechanism, through which malnutrition in childhood damages cognitive development, has also been employed to explain associate between early life poverty and adverse academic achievement and educational attainment (Miller and Korenman 1994).

In contrast to "biological programming" that emphasizes independent health effect of discrete events in early life, "social programming" addresses the importance of such factors as behavioral risks, socio-psychological and material gradients, though which early life conditions influence subsequent life trajectories, and focuses on how those gradients and events along life span influence health outcomes accumulatively, and/or interactively (Power and Hertzman 1997).

SES represents an individual's opportunity to take advantage of economic and social resources for the universal goals of healthiness and longevity (Preston et al.1998). Upper class means better living conditions and superior neighborhood contexts (Ambrose 2001), easier access to good health care (Williams 1990), avoidance of adverse working conditions (Siegrist and Marmot 2004), and other necessities to maintain good health conditions. Although SES is dynamic and social mobility exists universally (Blau and Duncan 1967), the destination of occupation is bounded by social origin that is usually measured by father's occupation. There is evidence of continuity of occupational strata among parents and children (Breiger 1981; Rosenfeld 1978). This intergenerational occupational inheritance occurs most often in professional occupations with the help of family cultural resources (Faris 1947). Also, family economic conditions in early childhood are crucial in achieving education and labor market success. In addition, children of higher social-class origins have more desire and a greater

possibility of achieving a higher educational and occupational goal, which contributes to upward social mobility across the life span (Duncan 1998). Thus, social origin may not only represent what the family could provide for a child in early life, but also predicts social strata destination in adulthood and corresponding socioeconomic resources available for health, as well as health outcomes and mortality risk the child faces as he/she ages.

Behaviors such as smoking and alcohol abuse have been well identified as health risk factors. For example, cigarettes are seen as common cause of lung cancer (Finkelstein 1960; Flaherty and Martinez 2004); alcohol use and misuse are associated with multiple negative health, social, and economic outcomes (Sindelar, Barnett, and Spirito 2004). Childhood socioeconomic circumstance has an independent effect on these health related behaviors. Individuals growing up in lower socioeconomic environments are more likely to adopt unhealthy behaviors, even after controlling for their current SES (van de Mheen et al. 1998). Parental supervision and parenting style also matters. For example, the authoritative parenting style is found to be associated with several positive outcomes including less substance use (Furstenberg and Foley 1999).

Psychosocial gradients are crucial in shaping social inequality in health. Negative psychosocial conditions such as stress, depression, measured by such major life events as divorce, unemployment, etc or chronic role-related strains, are usually associated with adverse health outcomes, possibly by lowering the immunity to disease (see (Kaplan 1991) for a review of psychosocial factors affecting the immune system). Family economic pressure, associated with adolescent perceptions of hardship reduces the adolescent's sense of control or mastery over time, which in turn increase emotional distress (Conger et al. 1999). Stressful events experienced by parents also lead to children's psychological dysfunction (Ge, 1994). In addition, early life stage is crucial for achieving stability and predictability, as well as some meaning that can motivate further actions. Parental response to these

actions, in turn, would stimulate children to develop the sense of manageability during this period. Thus, childhood conditions, defined by social position of the family, the economic conditions and the social relations within the family, should be of importance for the formation of such psychological characteristics as a strong (or weak) sense of coherence (Antonovsky 1993).

A harsher childhood health environment does not necessarily mean worse health conditions and higher mortality in adulthood. As Preston (Preston et al. 1998) summarized, there are four mechanisms of which two suggest adverse early life conditions lead to higher adult mortality and two suggest adverse early life conditions lead to lower adult mortality. The two positive mechanisms of which one is termed "scaring" and the other termed "correlated environments" are very similar to the "biological programming" and "social programming", respectively. However, adverse environment in early life might equip individual with the "acquired immunity" to the diseases once exposed to such as influenza, hence lowering the mortality risk of these disease at a later life stage. Another indirect and negative influence is due to "selection", in the sense that only those who are the most robust genetically could survive early life hardships, and this selective group would experience a lower mortality than average people in adulthood.

Most of these mechanisms are well supported by abundant evidence in Western countries. Instead of proposing some new mechanism to connect the early life conditions with adulthood health outcomes, I assume these mechanisms are also suitable for research in an Eastern social setting.

Data

The following research takes advantage of data from the Chinese Longitudinal Survey on Healthy Longevity (CLSHL). Conducted in 631 counties and 777 cities that house 85 percent of the total

population of China, while the sampling is not random, the coverage of the survey makes the sample largely representative. CLSHL provides the broadest and best information to date on the oldest old Chinese. The survey contains information on the following: family structure, living arrangements, number, age, and proximity of children, activities of daily living (ADL), self-rated health, self-evaluation of life satisfaction, cognitive function, medical care, social and religious activities, diet, smoking and alcohol consumption, psychological characteristics, economic resources, caregivers and family support. The baseline survey was conducted in 1998 and follow-up surveys took place every two years. This research uses the data from the baseline survey and the second wave.

The accuracy of self-reported age of the oldest old might be a concern because of the lack of an official statistical system in Old China. However, by matching the year of birth with an "animal year" (*shuxiang)*, Han Chinese usually remember their age accurately. Coale and Li (1991) found that in most of the provinces of China where Han Chinese constitute the majority, the age reporting of the oldest old was as reliable as that in the developed countries. Similar conclusions are drawn by Wang et al (1998) after a rigorous comparison of demographic indices of age reporting with Sweden, Japan, France, and Italy. A more general and positive evaluation about the data quality of the 1998 survey has been also made by Zeng Yi et al (2001). For more information see the introduction to Chinese Longitudinal Survey on Healthy Longevity, as well as Zeng Yi et al 2001.

Among the 8,959 respondents aged 80 and above in the 1998 baseline survey, 4,744 were alive and re-interviewed in the second wave in 2000, and 3,355 were known to have died. The other 860 respondents could not be followed up in the second wave and thus were excluded from the sample. In addition, 996 cases were excluded because they have missing values for those variables included in the analysis (Table 1 provided more details about the missing values). Thus, the analysis sample consists of 7,103 individuals, 4,224 of whom are female and 2,879 are male.

Descriptions of variables

I estimate separate models for males and females, and these models contain identical variables. For both males and females, I control for two demographic variables of age and ethnicity. Age was measured in single years at the time of the baseline survey in 1998. China is a multi-ethnic country, with Han being the dominant ethnicity. In the sample, I use the 92.32% of Han respondents as a reference group and combine respondents of other ethnicities into the category labeled "other".

Early life conditions I use respondent's place of birth, father's occupation, sibling composition, and arm length as proxies for social conditions in childhood. Each variable represents one dimension of early life conditions.

Social origin is often represented by the occupation of the head of a family. Here I use father's occupation as an indicator of social origin and divide it into three categories: 1) the agricultural, including agriculture, forestry, animal husbandry, fishing; 2)non-agricultural, including professional and technical, governmental, institutional or managerial, industrial, commercial, and military; 3) housework and other. Here, "other" refers to those occupations not listed above and open to be filled by respondents. Housework constitutes about 26 % of this category. Because old China was an agricultural society, the agricultural sector contains around 75% of the father's occupations. The non-agricultural sector represents a higher social class in terms of income and other social economic advantages. For example, in this sample, 52% children whose fathers worked in nonagricultural sector received some education. Only 26 % and 28% of children whose fathers were employed in agricultural sector and housework &other receive any education, respectively.

Sibling composition is found to be associated with the distribution of family resources and educational and career opportunities of individuals (Choe, Hao and Wang 1995; Muhuri and Preston

1991). I measured the composition of siblings by categorizing individuals into the following groups: have both brothers and sisters, have only sisters, have only brothers, and have no siblings.

For place of birth, I only distinguish between urban and rural areas. The region-of-birth's effect on children mortality and other outcomes has been well documented (see Elo and Preston 1992 for a review).

Arm length is used as an indicator of the nutrition condition in childhood, instead of height at the end of childhood which has long been seen as "the best indicator of an individual's dietary and infectious disease history" (Elo and Preston 1992). I do not use height for the following reasons: no retrospective information about height at the end of childhood is available, and "arm length is less affected than height by the aging process and more easily obtained in the bedfast patient" and it "provides a more accurate reflection of stature when performing nutritional assessments of the elderly" (Mitchell and Lipschitz 1982).

Socioeconomic conditions in adulthood education and occupation before age 60 and financial support are included as three components of socioeconomic conditions in adulthood, as well as living arrangement to represent social capital.

Educational attainment is measured by a dummy variable of "literate" or "illiterate". For those who never attended school, education is coded as "illiterate". Those having at least one year of schooling are coded as the "literate". All respondents in the sample were born before the 1920s, prior to the introduction of the modern educational system in China. In the early 20th century, *Sishu* was the most popular education pattern. The purpose of studying in *Sishu* was to learn traditional Chinese and ethics. In traditional China, females had much fewer opportunities to be educated than males. In the sample, 61.4% of males are literate, while this proportion is only 11.5% for females.

As an important indicator of socioeconomic status in adulthood, the occupation of respondents before age 60 is included. To maintain consistency, I divide the occupations into the same three categories as father's occupation: agricultural, non-agricultural, housework/other.

The variable "financial support" measures the composition of financial resources. I specify financial resources as the following: pension only, pension and other resources, family only, family and other resource, government only, as well as the category of "other". The hope is to not only identify different channels of financial resources but also to differentiate multiple resources from single one.

Excluding those living in a nursing home or alone, I divide the respondents into four subgroups according to their living arrangements: with son but no spouse, with spouse, with daughter but no spouse and son present, with other family members. Within Confucian philosophy and traditional Chinese culture, the offspring, especially the son, are supposed to provide financial support and instrumental assistance to the elderly (Sun 2004). This design would offer the opportunity to examine whether living with a son means a stronger support in late life.

The health-related behaviors included in the analysis are smoking, alcohol consumption, and physical exercise. For each of the three behaviors, those who responded that they never had this behavior were coded as "never", those who did in the past but had quit then were coded as "former", and those who currently have this behavior as "current".

Descriptive statistics for independent variables are presented in Table 2, for males and females separately. As shown by Table 2, females and males significantly differ from each other in terms of age, education, occupation before age 60, financial support, living arrangement, and health behaviors.

Methods

To estimate the effects of early life conditions on mortality risk at very late life stage, a series of logit regression models are employed for males and females separately, taking the following form:

Model 1:

$$\ln(\frac{m}{1-m}) = a + B_1 X_{demographics} + B_2 X_{earlylifeconditions} + \varepsilon$$

Model 2:

$$\ln(\frac{m}{1-m}) = a + B_1 X_{demographics} + B_2 X_{earlylifeconditions} + B_3 X_{education} + \varepsilon$$

Model 3:

$$\ln(\frac{m}{1-m}) = a + B_1 X_{demographics} + B_2 X_{earlylifeconditions} + B_3 X_{education} + B_4 X_{adulthoodconditions} + \varepsilon$$

Mode1 4:

$$\ln(\frac{m}{1-m}) = a + B_1 X_{demographics} + B_2 X_{earlylifeconditions} + B_3 X_{education} + B_4 X_{adulthoodconditions} + B_5 X_{healthbehaviors} + \varepsilon$$

Model5:

$$\ln(\frac{m}{1-m}) = a + B_1 X_{demographics} + B_2 X_{earlylifeconditions} + B_3 X_{education} + B_4 X_{adulthoodconditions} + B_5 X_{healthbehaviors} + B_6 X_{interaction} + \varepsilon$$

where m is the probability of dying in the two-year interval between 1998 and 2000.

Model 1 estimates the gross effect of early life conditions, controlling for age and ethnicity. They show whether early life conditions have a far-reaching impact on mortality risk in very late life stage.

In model 2, education is added to examine the strength of education in mediating the effect of early life conditions. Generally, family resources are not only proxies for the social environment in which children grow up, but educational opportunities. In turn, education is thought to be crucial in terms of shaping health behaviors and affecting occupation selection. Therefore, I pay particular attention to education as a single factor in the analysis.

Model 3 shows the effect of early life conditions, net of social conditions in adulthood that include occupations of respondents before age 60, financial support, and living arrangements in late life. Model 4 further controls for health behaviors such as smoking, alcohol consumption, and physical exercise.

Model 5 includes the interaction between father's occupation and the respondents' own occupation before age 60. I assume that social origin and current social class work on morality risk not dependently, but interactively.

The influence of early life conditions on mortality for females

Table 3 (model 1) shows the gross effects of early life conditions on mortality risk late in life. Father's occupation, sibling composition and arm length are significant predictors of mortality risk. Compared with those individuals whose father worked in the agricultural sector, those whose fathers were employed in non-agricultural sector have lower mortality risk late in life, while those whose father served as housekeepers or pursued other jobs have a greater mortality risk. This pattern reflects social/occupational inequality in China around the early 1900s. Individuals in non-agricultural employment have higher income and are more likely to be literate. Those working as housekeepers might lack the ability to work outside of the home for health reason, which, in turn, might lower the household income. In addition, the category of "others" possibly encompasses those temporary and seasonal jobs that might cause unstable income.

Sibling composition is found to be associated with mortality late in life for females. Females growing up in families that only have daughters are better off in terms of mortality than those in families with daughters and sons. There's no evidence showing an advantage of being the only daughter in a family. As the case in many other developing countries where son preference exists, this phenomenon might reflect the uneven resources distribution between sexes within the household. Specifically, family might pay more attention to and invest more in sons rather than daughters,

especially when family resources are limited. The respondents who have no siblings are at the greatest mortality risk. This might seem to contradict the logic that an only child should benefit because she has no siblings to share the family resources. However, in old China where the belief of "more offspring, more supports return to parents in late life" and son preference prevail, one daughter might not be the result of one child will, but due to some limitations on fertility, for example, the death of father or mother early in the life of the child. As a result, for female respondents, being the only child might reflect particular hardships experienced in childhood.

In addition, arm length turns out to be a significant predictor of mortality risk. I use arm length as a proxy for nutrition conditions in early life, admitting that measurement also proxies other factors such as genetics. Instead of assuming a linear effect of arm length, I employ a nonlinear model to examine how arm length is associated with the mortality risk. According to my estimations, the mortality risk decreases as arm length increases. This pattern reverses after arm length reaches 50 cm, meaning those whose arm length is around 50 cm have the lowest mortality risk, controlling for other factors.

In model 2, only education is added. As expected, education has a significant effect on mortality. Literate females have a much lower mortality risk than illiterate females; the odds ratio of mortality for the former is 70% of that for the latter. Compared with model 1, the coefficient of father's occupation in model 2 changed slightly. The protective effect of having a father in nonagricultural occupation comes down, which may reflect that upper-class families are more likely to send daughters to school than lower-class families; this in turn lower her mortality risk. In model 2, the mortality difference between those whose fathers are engaged in housework and other occupation and those whose fathers work in the agricultural sector is reduced slightly.

In model 3, I include SES in adulthood and social capital. For females, living arrangements do not affect mortality risk, but occupation before age 60 and financial supports do affect mortality risk.

Specifically, compared with those who worked in agricultural sector, those who served in housework and other occupations have significantly higher mortality risk. Those who worked in nonagricultural occupation are not found to have different mortality risk. Financial support in old age seems to be a powerful predictor of mortality risk. Individuals living only on pension have the lowest mortality risk, followed by those who have some pension but still need other sources of financial support. Those who depend on governmental subsidies are at the greatest mortality risk. Compared with those who get financial support solely from family members, the respondents getting fund from both family members and others and those living on other resources have no significant difference in mortality risk.

In model 4, health behaviors are added. Current drinkers have lower mortality than those who have never drunk alcohol. Former smokers have higher mortality risk than those who have never smoked. There's no difference in the mortality risk between current smokers and those who have never smoked, nor between former drinkers and those who have never drank. The effect of exercise on mortality is very significant. Compared with those who never exercised, the odds ratio of dying for current exercisers is reduced by about 50%. In model 4, the coefficient of education changed to be closer to zero, which means health behaviors attenuate the protective effect of education on mortality.

The interaction between father's occupation and respondent's occupations is significant. Model 4 shows, the mortality risk differs between those who served in housework and other occupation and those who worked in the agricultural sector, with people in housework and other occupation having higher mortality risk. However, this pattern seriously depends on father's occupation. As model 5 in table 3 indicates, for those whose fathers served in the agricultural sector, there's no significant difference in mortality risk between those who themselves served in housework and other occupations and those in the agricultural sector; for those fathers served in housework and other occupations, the individuals who served in housework and other occupation even have lower mortality risk than those

who worked in the agricultural sector; for those whose fathers served in the non-agricultural sector, the individuals served in housework and other occupations have higher mortality risk than those who worked in the agricultural sector. Accordingly, for those whose fathers worked in the agricultural sector, those who themselves worked in non-agricultural sector have higher mortality risk than those in the agricultural sector; For those whose father served in housework and other occupations, the individuals worked in non-agricultural sector also have higher mortality risk than those who worked in the agricultural sector, and the difference even enlarge significantly.

The influence of early life conditions on mortality risk for the males

Table 4 reports the results for males. As model 1 shows, sibling composition, place of birth, and arm length are not associated with mortality risk late in life. However, father's occupation is a significant predictor of males' mortality risk, similar to the pattern observed for females. The offspring of those who were employed in the agricultural sector have the lowest mortality risk, followed by those whose father worked in non-agricultural sector, and then those whose fathers served in housework and other occupation. Ethnicity is also significantly associated with mortality risk. Compared with *Han*, the majority of Chinese, the other minorities have a higher mortality risk.

As shown by the results in model 2, the effect of education on mortality is not significant for males. Therefore, the effect of early life conditions on mortality change little after education was introduced in model 3.

Model 3 indicates, for males, the living arrangements, but not financial support, affect mortality risk late in life. Compared with the males who live with at least one son (no spouse present), the males

living with spouses have a significant lower mortality, while those who live with daughters rather than sons or spouses have a greater mortality risk.

Model 4 identifies physical exercise as the only health behavior affecting mortality risk. Compared with those never exercised, those who formerly exercised have higher mortality risk, and those who currently exercise have much lower mortality risk.

For male, the interaction of father's occupation and respondent's own occupation are not significant. As the results of model 5 shows, only father's occupation matters for mortality risk late in life, and this influence does not vary with respondent's own occupation.

Discussion

This research helps to understand the association between early life conditions and mortality risk more broadly by extending the life span to the very late stage, and by shifting the social context from the Western to the Eastern. Our research indicates that the mark of early life events and conditions can be carried over into the later life stage. The oldest old, despite being the "biological elite", can not escape this mark of social inequality on health.

Social origin, measured by father's occupation in this research, triggers this health inequality. For both males and females, father's occupation is a very significant predictor of mortality risk in late life. Occupation determines income and other working reward, and itself reflects the level of education of the practitioner. Individuals who are employed in non-agricultural sector, with higher incomes and more knowledge, bring multiple benefits to the development of their children. Some of these benefits are observed, like higher education and better occupational trajectory. Some of these benefits are just speculative in this study, like better nutrition in early life, and easier access to medical care. In contrast, the offspring of those who served in housework and other occupations have the highest mortality risk.

With traditional Confucianism in Old China, housework is always supposed to be done by females. Reasonably, a "male housewife" might be unable to work outside the home for health reasons, which may lead to family economic hardship. The other occupations which include temporary and seasonal jobs indicate unstable income, resulting in anxiety. Ge (1994) argued that economic hardship, as well as psychological pressure of the family could damage the health of children, and this negative influence may continue throughout the whole life or manifest decades later.

I pay particular attention to the possible uneven distribution of family resources among children based on sex discrimination. Instead of comparing health outcomes between sexes directly, I examine how sex composition of siblings affects mortality risk. The results indicate that sibling structure does matter for female. Females growing up with only sisters have the lowest mortality risk in the late life stage; the odds ratio of dying is just half that of those who have both brothers and sisters, which might reflect the fact that many families invest more in their sons. In households both with sons and daughters, family resources are possibly concentrated on the sons and the daughters are sacrificed under this situation. In contrast, a lack of a male child is likely to lead to an even distribution of family investment among children. This finding conflicts with some previous studies about child mortality that find girls born into households with many daughters fare particularly badly in health (Muhuri and Preston 1991). The relevant explanation is that the sex discrimination is selective. Coexisting with the preference for sons is the desire for a balanced sex composition. Thus parents may selectively discriminate against children with certain sex-birth-order characteristics to attain their desired sex composition (Scrimshaw 1978). This study is not challenging the validity of the selective discrimination theory. Actually, if the son preference culture overwhelmingly dominates a society and son is definitely preferable to a daughter, the situation may resemble what this study reveals. Old China was just that kind of society. This finding implies that a broader measurement of early life conditions deserves more attention.

Specifically, both how social resources are distributed among households according to the social status and how family resources are distributed among children are crucial in capturing early life environment, especially when social resources are scarce.

As expected, education mediates the effect of early life conditions on mortality risk. Theoretically, upper-class families provide children with more opportunities to get education, and educated people are more likely to have healthy behaviors and to retain their upper social status, which improve their health and lower the mortality risk. The findings are consistent with this assumption. In addition, I find more benefit of education on health comes from its association with health behaviors, rather than its association with social economic status in adulthood. Remarkably, the effect of education is significant only for females. Christenson and Johnson's research (1995) sheds light on the possible explanation. They find that women appear to benefit more than men from elementary and secondary schooling. Men benefit more from postsecondary schooling only when enough benefits from education allow them to invest in healthy lifestyles. For the oldest old Chinese, the average schooling years for the literate male and female are 5.6 and 4.8 years, respectively. This implies some elementary education. Thus, this low level of education for the oldest old Chinese might be the reason for the educational differentials in mortality by gender. Deaton and Paxson (1999) also argue that education affects mortality differently for men and women. For men, education influences mortality only through its association with income, but education has a separate protective effect for women. Given that the association between income and education becomes weaker for individuals in old age, and the separate protective effect for female persist as they age, it is not surprising to see this disappearance of educational mark on health inequality for males but not for females.

Financial resources and living arrangements reflect economic and psychological support and daily care for the elderly. However, neither of the two factors influence both male and female. Instead,

financial resources affect the mortality risk for female only, while living arrangements only influence male. For female, those who are fully covered by pensions have the lowest mortality risk, followed by those only covered by some pensions. In China, having a pension means not only a stable income but also access to a government health care plan that is limited to employee or former employee of state-owned industries and organizations. Thus, pension owners have more resources than the others to fulfill the goal of healthy longevity. In addition, these individuals are more likely to have self-esteem because they are not dependent on others for living resources. The government subsidies are usually hard to meet the minimum living standard, which makes receivers suffer from shortage in materials and services necessary to maintain health status. The male oldest old are sensitive to living arrangement. Particularly, living with a spouse reduces mortality risk, which is somewhat consistent with the findings that marriage provides an important and supportive relationship late in life (Wenger 1996) and that marital relationship is particularly important for older men (Askham 1994; Davidson 1999). In fact, males tend to see marital partners as the most emotionally close confidant (Fuhrer et al. 1999). Older women, on the other hand, tend to have more extensive friend networks and more often develop new friendships late in life (Jerrome 1996). The distinct effect on mortality of living with a spouse for males and females also may be associated with the Chinese nuptial pattern. In traditional China, the wife is usually much younger than her husband. Thus, for males, living with a spouse implies support from a younger wife. For females, it implies the burden of care for an older husband.

Social origin and social status of respondents are found to influence mortality risk interactively, rather than additively. In a sense, those born in lower-class families seem robust to the lower socioeconomic status of their own in adulthood, and the upward social mobility brings no benefit to them. Also, the upper social origin respondents suffer most from downward social mobility. This

finding indicates that without information on early life conditions, estimations about the effect of adult social conditions might be biased.

Arm length, seen as the biomarker of early life nutrition and disease history, is found to be significantly associated with the mortality risk for elderly female. However, we are cautious about this interpretation. We can not exclude the possibility that this association is caused by the effect of height. Some research has reported greater height is associated with reduced risk of coronary heart disease, stroke and respiratory death (Davey-Smith et al. 2000), even after adjusting for social economic factors. In this research, father's occupation could not attenuate the effect of arm length, which indicates that father's occupation might fail to catch the nutrition conditions in early life. I am also aware of the possibility of reversal causality with the independent and dependent variables. My assumption is that health behaviors affect health status and mortality risk, however, the reverse may be true. For example, unhealthy individuals may quit some risky behaviors. The results show that former female smokers have a higher mortality risk as compared to those who have never smoked. This is also the case for females who exercise. Although I could not exclude the possibility that changes in these health behaviors result in an increased mortality risk, the alternative explanation seems more plausible that the respondents quit these behavior because of inferior health status, and it is this inferior health status rather than the changes in behaviors that leads to a higher mortality risk for the oldest-old.

Despite the limitations I have discussed, this research reveal that social inequality in health persist throughout the life course. The health and mortality risk for the oldest old is still influenced by events and conditions in early life. This pattern is distinct for males and females in terms of what gradients and how those gradients come together to influence the mortality risk late in life. As an implication to policy maker, education, net the effect on labor market success and health behaviors, has extensive protective influence on health in longevity process.

Table1: The number and proportion of case with missing values by variables included in the analysis.

Name of Variable	Number	Proportion
Age	0	0.00%
Sex	0	0.00%
Ethnicity	12	0.15%
Place of birth	2	0.02%
Siblings	651	8.04%
Arm Length	306	3.78%
Father's occupation	43	0.53%
Education	44	0.54%
Own occupation	4	0.05%
Living arrangement	27	0.33%
Financial aid	3	0.04%
Alcohol consumption	23	0.28%
Smoking	20	0.25%
Physical exercise	21	0.26%
Initial sampling size	8099	------
Final sampling size	7103	-----

Note: the initial sampling size is the number of interviewees tracked both in the baseline survey in 1998 and the follow-up survey in 2000; the final sampling size excludes the cases from the initial sampling that have missing values for variables included in analysis . Because cases with missing values overlap, the difference between the initial sample size and final sample size does not equal to the sum of cases having missing values.

Data source: Chinese Longitudinal Healthy Longevity Survey

Table 2 Characteristics of respondents aged 80+ in 1998 baseline survey (N=7103)

Independent variables	Male		Female	
	n	Percentage (%) or mean	n	Percentage (%) or mean
Demographics				
Age	2879	90.41 (6.91)	4224	93.75 (7.62)
Ethnicity *(Han)*	2659	92.36	3861	91.41
Other	220	7.64	363	8.59
Early life conditions				
Siblings *(both brothers and sisters)*	1654	57.45	2375	56.23
None	238	8.27	404	9.56
Only brother	639	22.20	957	22.66
Only sister	348	12.09	488	11.55
Place of birth *(rural)*	2492	86.56	3694	87.45
Urban	87	13.44	530	12.55
Father's occupation *(agricultural[1])*	2148	74.61	3157	74.74
Non agricultural[2]	613	21.29	788	18.66
Housework & Other[3]	118	4.10	279	6.61
Arm length (cm)	2879	52.21 (5.52)	4224	47.97 (5.20)
Socioeconomic conditions in adulthood				
Occupation of respondents before age 60 (*agricultural[1]*)	1720	59.74	2467	58.40
Non- agricultural [2]	1068	37.10	468	11.08
Housework &other[3]	91	3.16	1289	30.52
Education (*illiterate)*	1120	38.90	3751	88.80
Literate[4]	1759	61.10	473	11.20
Financial support *(family only*)	1567	54.43	2892	68.47
Family and others	367	12.75	898	21.26
Pension only	283	9.83	71	1.68
Pension and other	506	17.58	150	3.55
Government only	88	3.06	159	3.76
Other[5]	68	2.36	54	1.28
Living arrangement *(with son, no spouse present)*	1202	41.75	2324	55.02
With spouse	882	30.64	192	4.55
With daughter, no spouse or son present	176	6.11	437	10.35
With other family members	271	9.41	671	15.89
In a nursing home	90	3.13	144	3.41
Alone	258	8.96	456	10.80
Health behaviors				
Alcohol consumption (*never)*	1399	48.59	3154	74.7
Former	493	17.12	310	7.34
Current	987	34.28	760	17.99
Smoking *(never)*	1194	41.47	3556	84.19
Former	733	25.46	342	8.10
Current	952	33.07	326	7.72
Exercise *(never)*	1591	55.26	3160	74.81
Former	240	8.34	281	6.65
Current	1048	36.40	783	18.54

Note: The descriptions are based on the Chinese Longitudinal Healthy Longevity Survey-1998 baseline.

1 agricultural, forest, animal husbandry, and fishery worker

2 professional and technical personnel, governmental, institutional or managerial personnel, industrial worker, commercial or service worker, military personnel

3 not listed and open to fill by respondents

4 has at least one year schooling

5 work or other resources not listed

Table 3 Estimation from logit regression on a two-year probability of dying, female Chinese aged 80+ in 1998-2000 (N=4224)

Independent variables	Bivariate	Model 1	Model 2	Model 3	Model 4	Model 5
Demographics						
Age	0.1097**	0.1114**	0.1100**	0.1054**	0.1063**	0.1049**
Ethnicity *(Han)*						
Other	0.0103	0.0232	0.00615	0.0713	0.0243	0.0206
Early life conditions						
Siblings *(have both brothers and sisters)*						
None	0.3932**	0.3736**	0.3745**	0.3204**	0.3425**	0.3639**
Only brother	0.0825	0.0777	0.0767	0.1007	0.0981	0.1105
Only sister	-0.5192**	-0.5055**	-0.5052**	-0.5077**	-0.5379**	-0.5665**
Place of birth *(rural)*						
Urban	-0.0429	-0.0273	-0.00240	-0.0251	-0.0259	-0.1004
Father's occupation *(agricultural[1])*						
Non agricultural [2]	-0.2269**	-0.2135**	-0.1807*	-0.1814*	-0.1861*	-0.2828**
Housework & other[3]	0.3312**	0.3084**	0.2958**	0.2399*	0.2596*	0.5146**
Arm length (cm)	-0.0205**	-0.1044*	-0.1003*	-0.0891*	-0.0975*	-0.0988*
Square of arm length (cm^2)		0.000977*	0.000942^{+}	0.000802	0.000907^{+}	0.000898^{+}
Education *(illiterate)*						
Literate[4]	-0.1942**		-0.1816**	-0.1755**	-0.1472*	-0.1853**
Adulthood conditions						
Occupation of respondents before age 60 (*agricultural[1]*)						
Non-agricultural [2]	-0.1102			0.1362	0.1630^{+}	0.5019**
Housework &other[3]	0.2553**			0.1601*	0.1330*	0.0201
Financial support (*family only*)						
Family and others	0.1436			0.1551	0.1352	0.1470
Pension only	-0.7261**			-0.7778**	-0.6824**	-0.6907**
Pension and other	-0.3494*			-0.4020*	-0.3295^{+}	-0.3388^{+}
Government only	0.5532**			0.6627**	0.5926**	0.5921**
Other[5]	0.3173			0.3168	0.2829	0.2818
Living arrangement *(with son, no spouse present)*						
With spouse	-0.2304*			-0.1665	-0.1607	-0.1637
With daughter, no spouse or son present	-0.0238			0.0201	0.0429	0.0375
With other family members	0.009			0.0880	0.0405	0.0303
In a nursing home	0.3171*			-0.0505	-0.0690	-0.0373
Alone	-0.0522			0.0204	0.0381	0.0354

Note: $^{+}$ p<0.1* p<0.05 ** p<0.01

Data source: Chinese Longitudinal Healthy Longevity Survey in 1998 and 2000 waves.

1 agricultural, forest, animal husbandry, and fishery worker

2 professional and technical personnel, governmental, institutional or managerial personnel, industrial worker, commercial or service worker, military personnel

3 not listed and open to fill by respondents

4 has at least one year schooling

5 work or other resources not listed

Table 3 (continued)

Health behaviors						
Alcohol consumption *(never)*						
Former	0.1818^{+}				0.1295	0.1276
Current	-0.1434^{+}				-0.1591^{+}	-0.1656*
Smoking *(never)*						
Former	0.1928*				0.2132*	0.2129*
Current	0.0683				0.0857	0.0730
Exercise *(never)*						
Former	0.0929				0.0723	0.0631
Current	-0.3774**				-0.3512**	-0.3527**
Father's occupation * respondent's own						
*Housework &other *Housework &other*						-0.6449**
*Housework &other * nonagricultural*						0.6679**
*Nonagricultural *housework &other*						0.5076**
*Non agricultural *non agricultural*						-0.1721
-2 log L						
Intercept only		4402.9	------	------	-------	------
With covariates		4223.5	4213.6	4161.6	4103.1	4065.1
DF		10	11	23	29	33

Note: $^{+}$ p<0.1* p<0.05 ** p<0.01
Data source: Chinese Longitudinal Healthy Longevity Survey in 1998 and 2000 waves.

Table 4 Estimation from logit regression on a two-year probability of dying for male Chinese aged 80+ in 1998-2000 (N=2879)

Independent variables	Bivariate	Model 1	Model 2	Model 3	Model 4	Model 5
Demographics						
Age	0.0836**	0.0839**	0.0834**	0.0696**	0.0673**	0.0672**
Ethnicity *(Han)*						
Other	0.1550^{+}	0.1688*	0.1636*	0.1047	0.0676	0.0669
Early life conditions						
Siblings (have both brothers and sisters)						
None	-0.0581	-0.0711	-0.0650	-0.0910	-0.0800	-0.0762
Only brother	0.8627	0.0124	0.001	-0.0332	-0.0490	-0.0488
Only sister	0.1477	0.1625	0.1637	0.2015^{+}	0.1883^{+}	0.1855^{+}
Place of birth *(rural)*						
Urban	-0.0901	-0.0993	-0.0926	-0.0449	-0.0445	-0.0517
Father's occupation *(agricultural)*						
Non-agricultural	-0.2651**	-0.2217*	-0.2061*	-0.1446	-0.1582	-0.2566
Housework & others	0.4299**	0.4313**	0.4267**	0.4889**	0.4861**	0.5070**
Arm length (cm)	-0.0031	-0.0370	-0.0364	-0.0483	-0.0275	-0.0272
Square of arm length		0.000355	0.000348	0.000457	0.000247	0.000243
Education *(illiterate)*						
Literate	-0.0838^{+}		-0.0678	-0.0530	-0.0128	-0.0.31
Adulthood conditions						
Occupation of respondents before age 60 *(agricultural)*						
Non-agricultural	-0.2921**			-0.1651	-0.1231	-0.1088
Housework &other	0.2805			0.1392	0.0995	0.0896
Financial support (family only)						
Family and others	-0.0141			-0.0401	-0.0527	-0.0535
Pension only	-0.2558^{+}			-0.1335	-0.0204	-0.0165
Pension and other	0.0334			0.0639	0.1019	0.0996
Government only	0.1849			0.3547	0.2712	0.2736
Other	-0.2764			-0.4429	-0.4462	-0.4478^{+}
Living arrangement *(with son, no spouse present)*						
With spouse	-0.4390**			-0.3990**	-0.4159**	-0.4137**
With daughter, no spouse or son present	0.6447**			0.7246**	0.7485**	0.7464**
With other family members	0.0004			0.0545	0.0256	0.0210
In a nursing home	-0.312			-0.4634	-0.4586	-0.4518
Alone	-0.0110			-0.0151	-0.00413	-0.00527

Note: $^{+}$ p<0.1* p<0.05 ** p<0.01

Data source: Chinese Longitudinal Healthy Longevity Survey in 1998 and 2000 waves.

1 agricultural, forest, animal husbandry, and fishery worker

2 professional and technical personnel, governmental, institutional or managerial personnel, industrial worker, commercial or service worker, military personnel

3 not listed and open to fill by respondents

4 has at least one year schooling

5 work or other resources not listed

Table 4 (continued)

Health behaviors						
Alcohol consumption						
(never)						
Former	0.1468^{+}				0.0845	0.0881
Current	-0.1468*				-0.1323^{+}	-0.1327^{+}
Smoking (never)						
Former	0.0417				0.0534	0.0531
Current	-0.003				0.0174	0.0174
Exercise (never)						
Former	0.4011**				0.3651**	0.3744**
Current	-0.5592**				-0.5143**	-0.5174**
Father's occupation * respondent's own						
Housework &other						0.0326
**Housework &other*						
Housework &other						-0.0290
** nonagricultural*						
Nonagricultural						-0.1881
**housework &other*						
Non agricultural						0.1330
**non agricultural*						
-2 log L						
Intercept only		2908.1	--------	-------	-------	-------
With covariates		2847.8	2845.9	2787.9	2735.6	2734.9
DF		10	11	23	29	33

Note: $^{+}$ p<0.1* p<0.05 ** p<0.01
Data source: Chinese Longitudinal Healthy Longevity Survey in 1998 and 2000 waves.

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