Life Course Socioeconomic Status and Healthy Longevity in China

Collin F. Payne and Kim Qinzi Xu

ABSTRACT In 2020, China’s population aged 60 or older exceeded 264 million, representing 25% of the global population in that age-group. Older adults in China experienced periods of dramatic political and social unrest in early life, as well as economic transformations leading to drastic improvements in living standards during adulthood and older age. However, the implications of life course socioeconomic status (SES) trajectories for healthy longevity in later life have not been systematically studied in China. We utilize data from the China Health and Retirement Longitudinal Study (CHARLS) to comprehensively investigate how early-life conditions and adult SES combine to influence healthy longevity in later life. We find that both childhood and adulthood SES are associated with late-life health. The largest disparities in life expectancy (LE) and disability-free LE are found between those with persistently low SES throughout life and those with consistently high SES. At age 45, the gap in total LE between the most advantaged and least advantaged groups is six years for men and five years for women. Despite China’s major policy changes prioritizing equity in income and health care in recent decades, our findings suggest that dramatic health inequalities among older adults remain. Our findings extend the literature on the effect of socioeconomic patterns across the life course on gradients in later-life health and highlight continuing disparities in healthy longevity among older adults in China.

KEYWORDS Healthy life expectancy • China • Aging • Socioeconomic disparities • Life course

Introduction

For scholars interested in the link between adult health and socioeconomic status (SES), China’s immense population, rapid aging, volatile macrosocial environment, and rapid social and economic development in recent decades make the country a distinct and globally important context to study. As a result of sharp declines in fertility and mortality over the past few decades, China’s population is aging rapidly. More than 264 million people aged 60 or older reside in China, representing more than 17% of the total Chinese population and 25% of the population aged 60 or older worldwide (National Bureau of Statistics of China 2021; United Nations 2019). This population

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will grow rapidly in the coming decades and is projected to nearly double by 2050 (United Nations 2019). In conjunction with these compositional shifts, life expectancy (LE) has expanded in recent decades: between 1970 and 2020, female LE grew from 63.2 to 79.7, and male LE increased from 60.2 to 75.4 (United Nations 2019).

Today’s older adults in China have lived through periods of dramatic political, social, and economic transformations. Many have suffered poor living conditions and were affected by famines, wars, and political upheavals during their childhood and early adulthood. Notwithstanding continued social and health inequalities in contemporary China (Liu et al. 2010), most older Chinese adults have experienced drastic improvements in their living standards during adulthood and older age. This disconnect between the conditions under which they grew up and their later-life socioeconomic conditions could profoundly affect their later-life health. However, the implications of life course SES trajectories for healthy longevity in later life have not been systematically studied in China.

Research on the life course determinants of healthy aging in China has primarily focused on the role of childhood conditions, often proxied by urban/rural residence (Zeng et al. 2007), or on adult conditions, such as place of residence and SES (Chen et al. 2010; Liu et al. 2019; Zimmer et al. 2015; Zimmer et al. 2010). Relatively little research has explored how childhood socioeconomic conditions and adult SES combine to affect later-life health and longevity among older adults. The few studies that have investigated the influence of factors from across the life course have generally used simplified measures of SES, such as agricultural/nonagricultural employment, parental employment, and educational attainment (Wen and Gu 2011; Zhong et al. 2017; Zimmer et al. 2012).

In addition, most work on the link between SES and health in China has treated later-life health and well-being as a fixed characteristic (Wen and Gu 2011; Zhong et al. 2017). Cross-sectional analyses may overlook differences between groups that arise from different patterns of relapsing and remitting between health states. Research investigating how life course processes relate to later-life health must incorporate a dynamic view of the well-being of older adults rather than treating these processes as essentially fixed. Accurately accounting for these transitions leads to a more nuanced understanding of the lived experience with disability and avoids generating biased estimates of the level of disablement at the population level (Cai et al. 2006).

In this article, we utilize data from the China Health and Retirement Longitudinal Study (CHARLS) to comprehensively investigate how early-life conditions and adult SES combine to influence healthy longevity in later life. We estimate differences in healthy longevity across the spectrum of early-life socioeconomic conditions, exploring both how early-life conditions influence later-life health and how the influence of childhood conditions is moderated by life course SES trajectories. These analyses develop a fuller picture of the life course processes producing healthy longevity among older adults in one of the world’s most rapidly aging populations.

Background

The Chinese Context

China was affected by a series of social, cultural, and economic upheavals in the twentieth century. The country saw war-related disruptions and deprivation at the national
level in the first half of the twentieth century, including the battles between the Nationalists and Communists during the 1920s and 1930s, the Second Sino-Japanese War (1937–1945), and the Chinese Civil War (1945–1949). Political and economic instabilities continued after the establishment of the People’s Republic in 1949. The Great Famine caused 20–30 million excess deaths between 1959 and 1961 (Cai and Wang 2005). The famine was soon followed by the Cultural Revolution (1966–1976). The commencement of the post–Cultural Revolution reform in the late 1970s initiated a massive shift from a centrally planned to a market-based economy, resulting in widening inequality between rural and urban China. In the reform era, the old medical insurance schemes almost completely collapsed (Zhao et al. 2020). The government’s relaxation of health sector price controls resulted in sharp increases in the fees for medical treatments (Xiong et al. 2018), exacerbating difficulties in accessing health care and medical treatments among those who were poor.

Nonetheless, China’s recent reform has ushered in a period of rapid socioeconomic development and improvement in welfare and living standards. The number of Chinese people living below the poverty line declined from 250 million in 1978 to 30.46 million in 2017, or from more than 25% to slightly more than 2% of the total population (Liu et al. 2019). Food consumption increased substantially, with the per capita availability of calories doubling from less than 1,500 kilocalories in the 1970s to more than 3,000 kilocalories in 2015 (van der Eng and Sohn 2018).

Despite widening inequality in health care systems in the reform era, China has made considerable progress in providing health care. The number of hospitals increased from 9,293 in 1978 to 29,140 in 2016; the number of hospital beds increased from 2.1 million to 7.4 million, or 2.1 to 5.4 per thousand population (Zhao et al. 2020). Health care has become more accessible in recent decades with the reestablishment of universal health insurance schemes, such as the Urban Employee Basic Medical Insurance (UEBMI), Urban Resident Basic Medical Insurance, and New Rural Cooperative Medical Scheme (NRCMS). Inequalities in coverage and access to care remain between urban and rural regions, however: compared with UEBMI, the NRCMS provides a modest benefits package in terms of the range of services covered and the fraction of the cost that is reimbursed (Meng and Xu 2014; Qin et al. 2014).

At the population level, the rapid aging of the Chinese population is driving a substantial rise in the fraction of the population experiencing disabilities and other limitations on physical and functional health (Jiang et al. 2016). These rising rates of disability are partly responsible for a rapid rise in health care expenditures at older ages in China (Feng et al. 2015; Li et al. 2020; Loyalka et al. 2014). Further, the complex needs of disabled individuals pose a substantial challenge for Chinese individuals and families serving as caregivers (Chen et al. 2018; Peng et al. 2015).

Theoretical Framework for the Role of Life Course SES in Later-Life Health

Although adult SES circumstances remain among the most researched determinant of later-life health disparities, there is a growing recognition that early-life SES can

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1 The official poverty line in 1978 was 100 yuan per person per year. This standard was quite low, ensuring an intake of 2,100 calories per day per person. Food expenditures amounted to 85% of total expenditures. In 2017, the poverty line was adjusted to 2,952 yuan per person per year to reflect rising costs of living.
have lasting impacts on late-life health and mortality (Ben-Shlomo and Kuh 2002; Blackwell et al. 2001; Hayward and Gorman 2004; Montez and Hayward 2014; O’Rand and Hamil-Luker 2005). Early-life disadvantages can affect later-life health independent of subsequent living conditions, and exposure to adverse conditions at critical and sensitive periods of development has lifelong impacts on health and well-being. Barker’s (1997) study on the link between low birth weight and cardiovascular disease in adulthood suggests that prenatal nutrition plays a role in the development of chronic diseases. Nutritional insults in early life increase the risk of adult chronic conditions, which are strongly associated with disability and mortality (Gluckman et al. 2008; Lundberg 1991). In addition, exposure to infectious diseases and inflammation in infancy and childhood has been tied to later-life health problems, such as heart disease, adult respiratory disease, and cognitive impairment (Elo and Preston 1992; Finch and Crimmins 2004).

Early-life SES may also affect later-life health by directing individuals into life trajectories that shape health outcomes. For example, the cumulative advantage/disadvantage theory posits that advantaged individuals or groups may retain a permanent and increasing health advantage relative to others as they age (O’Rand and Hamil-Luker 2005; Willson et al. 2007). The converse is also true: those who are disadvantaged may become increasingly disadvantaged over time. Central to this process is the concept of path dependency, with advantages/disadvantages at a given point being dependent on previous advantages/disadvantages (Willson et al. 2007). Early disadvantage may set in motion “cascading socioeconomic and lifestyle events” that negatively affect later-life health (Hayward and Gorman 2004:103).

Empirical research has provided evidence for the pathway effects of early-life conditions on later-life health. Sources of childhood adversity (including lower parental education, economic hardship, and family instability) are associated with lower educational attainment, income, and occupational status in adulthood (O’Rand 2011); increased exposure to stressful and hazardous working conditions (Marmot et al. 1997; Marmot and Shipley 1996); and an increased likelihood of engaging in risky behaviors (Elder 1998; Pol and Thomas 2013). All of these are significant facets of adults’ socioeconomic position that are linked with higher mortality, disability, and functional limitations, as well as increased disease risk (Blackwell et al. 2001; Hayward and Gorman 2004; Montez and Hayward 2014; O’Rand and Hamil-Luker 2005).

At the same time, growing evidence suggests that lifetime SES, measured as persistent advantages/disadvantages over the life cycle, is associated with later-life health disparities (Kim and Durden 2007; Torres et al. 2018; Wickrama et al. 2013). In other words, disadvantages may accumulate from childhood to adulthood and have a combined effect on later-life health. Changes in SES trajectories over the life course may also shape late-life health disparities. Studies of the link between SES mobility and late-life health have frequently reported a dose–response relationship (Luo and Waite 2005; Turrell et al. 2002).

Most prior research on life course SES and later-life health has focused on high-income countries (McEniry 2013). In China, advantageous adult conditions have been shown to protect against functional limitation and mortality (Liu et al. 2010; Liu et al. 2019; Zimmer et al. 2012). However, evidence regarding the association between childhood SES and later-life health is mixed. Whereas some studies reported independent effects of childhood SES on a host of late-life health outcomes (Gu et al.
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2009; Wen and Gu 2011; Zhang et al. 2010; Zhong et al. 2017), others found that the protective effects of childhood SES on later-life health disappeared or weakened when adulthood conditions were incorporated (Brown et al. 2012; Zeng et al. 2007). One study found that favorable childhood conditions had a direct negative effect on survival among older adults in China owing to mortality selection; at the same time, higher SES in childhood was linked to improved adult SES and indirectly promoted late-life health (Shen and Zeng 2014).

Taken as a whole, studies in China highlight the long-term effects of early-life conditions on late-life health through direct or pathway mechanisms. They also suggest that poor late-life health may result from the accumulation of adverse experiences throughout life. Most of these studies reported significant effects of both early-life and adult conditions on late-life health (Gu et al. 2009; Wen and Gu 2011). Little research has explored how SES mobility affects late-life health. In one notable exception, Wen and Gu (2011) found that social mobility had links with cognitive status and mortality but not disability and self-rated health. This lack of association between social mobility and disability stands in contrast to the evidence from high-income countries (Luo and Waite 2005; Turrell et al. 2002).

Our analyses examine socioeconomic differences in LE and disability-free LE, a combined measure of mortality and disability measuring the average number of remaining years of life an individual can expect to live free of disability. We conceptualize disability within the framework of the disablement process (Verbrugge 2016; Verbrugge and Jette 1994)—that is, we view disability as the culmination of a pathway process that is affected by both impairments resulting from acute or accumulated life course exposures and an individual’s proximate access factors, such as medical care, accommodations, and physical and social supports. This framework is well-suited to exploring how early-life exposures and later-life conditions may combine to impact physical and functional well-being at older ages.

Our study adds to this growing body of literature by assessing the link between life course SES trajectories and healthy longevity. Drawing on critical period theory and cumulative advantage/disadvantage theory, we investigate how early-life circumstances combine with adulthood conditions to produce disparities in healthy longevity. Specifically, our analysis disentangles the relative influence of childhood and adulthood SES in influencing healthy longevity and examines whether the accumulation of advantage/disadvantage throughout the life course is linked with late-life functioning and mortality.

Data, Measures, and Methods

Data

Our data come from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative sample of Chinese residents aged 45 or older (Zhao et al. 2014). Adopting a multistage stratified sampling, the CHARLS surveyed approximately 10,000 households in 28 provinces. The study was initiated in 2011, with two following waves in 2013 and 2015. In 2014, a life history survey collected detailed information on respondents’ SES, adverse experiences, and health during childhood.
For individuals dying during the survey period, year and month of death were ascertained through exit interviews conducted in the 2013 and 2015 survey waves. The databases created from these surveys are available online for research use. Figure S1 in the online appendix contains a sample flow diagram. The final analysis sample contains all individuals from the CHARLS survey who were aged 45 or older, had valid responses to the activities of daily living (ADL) questionnaire, and had data for two or more components of the adulthood and childhood SES measures. The final analytic sample comprises 16,306 respondents.

Measures

Disability Measures

Our primary outcome is functional disability, as parameterized by the Activities of Daily Living (ADL) scale (Katz et al. 1963). ADL limitations represent quite profound disability and generally indicate that an individual is unable to live independently. Disability is understood as a gap between an individual’s capacities (physical, sensory, or cognitive) and a given activity’s demands, taking into account available accommodations and external supports (Verbrugge 2016). ADL disability is defined as reporting difficulty on any of five activities: bathing, eating, getting in/out of bed, toileting, and walking across a room. In rare cases, proxy responses on ADL limitation were used.\(^2\) We investigate patterns of self-reported disability by using the ADL scale to classify individuals with two distinct states of physical health: (1) disability-free individuals with no reported ADL limitations and (2) ADL-disabled individuals with one or more ADL limitations.

Our primary outcome measure is disability-free LE, an easily interpretable metric for comparing population-level disability. Its calculation procedure is outlined in the Methods section. Disability-free LE distinguishes between life-years spent free of disability and years with an ADL disability, providing a more nuanced view of population-level disability than simple estimates of LE or disability prevalence. It combines mortality and disability into a single measure, providing a convenient metric for measuring population-level functional health (Minicuci et al. 2004).

Estimating Childhood and Adulthood SES

We constructed separate childhood and adulthood SES indices by estimating principal components analysis (PCA) models on multiple measures of socioeconomic conditions in different life course stages. We chose this approach for theoretical and practical reasons. Previous studies have noted that childhood and adulthood SES are multifaceted and multidimensional (Hayward and Gorman 2004; Montez and Hayward 2014; Wen and Gu 2011). Childhood SES reflects parental and community educational, economic,

\(^2\) Fewer than 8% of respondents required a proxy’s assistance to answer the ADL items in each wave. Our findings were unchanged in supplemental analyses conducted without proxy respondents (results available on request).
social, and cultural resources, which are tied to various aspects of adult conditions, including educational opportunities and income trajectories. Previous work has advocated for composite SES indices to provide a more comprehensive view of individuals’ general living conditions and to capture the accumulation of experiences during different stages of the life course (Montez and Hayward 2014). Composite indices, however, assume that the individual dimensions have equal weight—an assumption that does not seem to hold when the link between specific facets of life course SES and late-life health are investigated (Hayward and Gorman 2004; Wen and Gu 2011). Our approach relaxes this assumption on the relationship across different aspects of SES. We posit each SES measure offers some information on one’s economic, social, and cultural resources at different life stages. In measuring this underlying construct, we aim to ultimately gauge the inequitable distribution of socioeconomic resources, which has been identified as a fundamental cause of health disparities (Link and Phelan 1995).

We examine gradients in healthy longevity by SES in both childhood and adulthood. The 2011, 2013, and 2015 CHARLS surveys extensively measured respondents’ current socioeconomic conditions. In this analysis, we used PCA to combine six measures—respondents’ educational attainment, current household registration (hukou) type, whether the individuals’ current or pre-retirement primary occupation was in a nonagricultural setting, annual household income, annual household consumption expenditure, and household wealth3—into a single adulthood SES index.

Compared with SES in adulthood, the 2011 CHARLS collected rather limited measures of SES in childhood. However, extensive measures of childhood socioeconomic conditions were included in the 2014 CHARLS life history survey. Although we could not use these detailed 2014 data directly in our analyses (because we would lack childhood SES information for those dying or leaving the sample between 2011 and 2014), we utilized the 2014 life history information to generate and validate a childhood SES measure in the 2011 data. In practice, this involved estimating a PCA using the expanded set of childhood SES measures collected in the 2014 CHARLS and then comparing this index against different permutations of indexes generated using the more limited 2011 CHARLS data on childhood SES. The best-fitting childhood SES scale based only on questions from the 2011 CHARLS sample was highly correlated with the childhood SES scale developed from the 2014 detailed life history data ($r=.74$). This high correlation indicates that the simpler index of childhood SES captures a significant amount of variation in early-life socioeconomic conditions, albeit with some information loss compared with the more detailed measure. Because the adulthood and childhood SES indices include discrete and continuous components, we conducted the PCA analyses using polychoric correlation matrices in Stata (Kolenikov and Angeles 2009; StataCorp 2017). A more detailed description of the adulthood and childhood SES indices and their construction is available in the online appendix.

3 Annual household income is the sum of all annual income at the household level, including income from earnings, capital income, pension income, income from government transfers, other income, and the total income from other household members. Annual household consumption expenditure includes expenditures on food and non-food consumption. Household wealth is the value of all financial assets at the household level minus mortgage and other debt. All three measures are denominated in yuan.
In our primary analyses, we divided both childhood and adulthood SES into tertiles. This approach emphasizes that we are most interested in SES as a relative measure to understand how an individual’s position on the SES spectrum at different points in their life relates to their adult health and longevity, rather than to assess specific educational, wealth, or asset thresholds. To limit the potential for age differences in income and consumption to bias the results, we generated the adulthood SES tertiles separately within 10-year age bands (45–54, 55–64, 65–74, 75–84, and 85+). Given that the multistate life table model used to estimate healthy longevity cannot incorporate time-varying covariates, our analyses also implicitly assumed that adult SES is stable over time. This assumption is likely to hold better for some components of the adult SES index (e.g., schooling attainment, hukou type, occupation, and wealth) than for income and consumption (Blundell et al. 2016; Hurd and Rohwedder 2013).

We first estimated healthy longevity differences in the three childhood SES groups, in keeping with prior work in China focusing on differences in later-life health by childhood conditions. We then explored differences in healthy longevity across life course SES by comparing LE and disability-free LE across the nine SES trajectories (3 childhood SES groups × 3 adulthood SES groups).

Methods

We generated multistate life tables to estimate healthy longevity by levels of childhood SES and by life course SES trajectory. In the first step, these models generated annual transition probabilities between disability-free life, disability, and death. Our analysis allowed individuals to transition between disability-free life and ADL-disabled life, with death being the only absorbing state. We initially converted the CHARLS data to a person-year time scale, assuming that transitions between disability states occur at a random time between observations. We modeled annual transition probabilities using a cumulative logistic regression model stratified by initial disability state. The model included age and age squared as continuous predictors, sex and SES as categorical predictors, and age × sex and age × SES interaction terms, with the proportional odds assumption relaxed for sex (Derr 2013). We then generated matrices of age-specific transition probabilities for each combination of sex and SES (either childhood SES or life course SES trajectory). We also tested models including a sex × SES interaction; because the coefficients were not significant at $\alpha < .05$, we removed this interaction in favor of the simpler model.

To generate estimates of total LE and disability-free LE, we relied on microsimulation, a well-established tool in demographic research (Brown et al. 2012; Cai et al. 2010; Liu et al. 2019; Payne 2018; Payne et al. 2013). The transition probability matrices, estimated as described earlier, were applied via microsimulation to separate synthetic cohorts of 100,000 individuals in each age-group. These synthetic cohorts were assigned the same sex, SES, and disability state group distribution as the observed cohorts. We analyzed the resulting synthetic cohort, representing the simulated life courses of 100,000 individuals subjected to the transition rates observed in the CHARLS data between 2011 and 2015, to estimate total LE and disability-free LE. The analysis model is based on an adapted version of the SPACE suite of SAS programs (Cai et al. 2010; SAS Institute 2020). All multistate analyses used the
CHARLS person weights adjusted for nonresponse and accounted for province- and community-level sampling stratification. Point estimates shown were from transition probabilities estimated from the full sample. In the microsimulation approach, LE and disability-free LE estimates are not a deterministic function of the transition probabilities; they result from a complex interplay between disability state, age, and individual characteristics as individuals move year by year through the simulation. We calculated confidence intervals, which reflect the uncertainty of the estimated parameters and the uncertainty from the microsimulation, by reestimating the preceding analysis sequence using 499 bootstrap resamples for each age-group under study. We took the central 95% of the distribution of these bootstrapped parameters as the 95% confidence interval (Davison and Hinkley 1997).

Results

Sample Characteristics

Table 1 presents the baseline characteristics of the CHARLS sample in 2011. More than 90% of respondents were aged 45–74, and our sample has slightly more women...
than men (51% vs. 49%). Childhood SES and adulthood SES are approximately distributed into tertiles. The distribution of life course SES patterns shows considerable variation in the life course SES trajectories of members of the sample. Overall, respondents were most likely to stay in the same SES category from childhood to adulthood. However, there was also quite substantial movement both upward and downward across life course SES trajectories. For instance, half of individuals with low childhood SES were classified as having medium or high SES in adulthood. Although declining life course SES trajectories were somewhat less common, more than 45% of individuals with high childhood SES were classified as having medium or low SES in adulthood. These rates of life course mobility are quite high compared with estimates from high-income countries, such as the United States (Urahn et al. 2012).

Table S1 in the online appendix provides the breakdown of disability states in the sample over the three waves for men and women. Between 2011 and 2015, the proportion of men and women who reported on ADL difficulties increased from 15% to 18% and from 20% to 25%, respectively.

Modeling Healthy Longevity

Healthy Longevity by Childhood SES

Table 2 presents results comparing total, disability-free, and ADL-disabled LE among Chinese men and women at ages 45 and 65, by their level of childhood SES. We find substantial differences in overall LE by childhood SES: men and women with high SES during childhood had an additional total LE of two to three years at age 45 and one to two years at age 65. No substantial differences in total LE are evident between those with low childhood SES and medium childhood SES. Although this lack of difference may be initially surprising, these results align with prior research findings of limited mortality differences by schooling and other early-life SES markers in China and other middle-income countries, except among the most advantaged groups (Sudharsanan et al. 2020).

The observed gradients by early-life SES are even more pronounced for disability-free LE. At age 45, a man who grew up in a low-SES household could expect to live approximately 25 years without ADL limitations, compared with approximately 29 for a man from a high-SES household in childhood. Similar gradients are evident for disability-free LE among women, with a 4.5-year gap between women with a high childhood SES and those with a low childhood SES (28.29 vs. 23.73, respectively). Individuals with medium childhood SES could expect to live more disability-free years than those with low childhood SES, even though their total LEs were not markedly different. At all ages, men could expect to live proportionately more years of disability-free life than women. We find a clear and consistent gradient in the proportion of remaining life spent disability free: the estimated remaining life free of disability was lower for individuals with lower childhood SES than for those with higher childhood SES. Figures S2–S5 in the online appendix display the annual transition probabilities between disability-free life, ADL-disabled life, and death for men and women, along with the 95% confidence intervals based on bootstrap resampling.
Table 2  Microsimulation estimated disability-free, ADL-disabled, and total life expectancy (LE) at ages 45 and 65 by early-life SES, with 95% confidence intervals shown in brackets, CHARLS 2011–2015

<table>
<thead>
<tr>
<th>Childhood SES</th>
<th>Total LE</th>
<th>Disability-Free LE</th>
<th>ADL-Disabled LE</th>
<th>Proportion Disability Free</th>
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<tbody>
<tr>
<td><strong>Men</strong></td>
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<tr>
<td>Age 45</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>High childhood SES</td>
<td>35.04 [33.59, 36.42]</td>
<td>29.41 [28.06, 30.63]</td>
<td>5.63 [4.84, 6.32]</td>
<td>.84 [.82, .86]</td>
</tr>
<tr>
<td>Age 65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High childhood SES</td>
<td>17.64 [16.43, 18.79]</td>
<td>13.20 [12.34, 14.41]</td>
<td>4.44 [3.69, 4.94]</td>
<td>.75 [.72, .78]</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 45</td>
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<tr>
<td>Age 65</td>
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</table>
Table 3 and Figure 1 provide estimates of total, disability-free, and ADL-disabled LE at age 45 by the nine SES trajectories explored in our primary analysis (representing all possible permutations of the three early-life SES levels and three later-life SES levels). We find substantial differences across trajectory groups, highlighting the heterogeneity present in China in terms of adult health and longevity. At age 45, the total LE gap between the most advantaged (the high childhood–high adulthood SES trajectory) and least advantaged (the low childhood–low adulthood SES trajectory) is nearly six years for men and more than five years for women. Substantial differences in healthy longevity are also evident between these groups. A man in the least advantaged group is expected to spend only about 75% of this already shorter remaining expectancy life free of ADL limitations, compared with 83% for the most advantaged group. These differences are of a similar scale for women: the low–low group can expect to spend only 64% of remaining life disability free, compared with 75% for the high–high group. Similar patterns are also found in total and disability-free life at age 65 (Table 4). Figures S6–S9 in the online appendix display the age-specific transition probabilities between active life, ADL-disabled life, and death by life course SES trajectory.

The large observed differences in LE and disability-free LE between the high–high and low–low trajectory groups highlight the robust associations between the accumulation of lifetime socioeconomic disadvantage and poorer physical functioning and
mortality outcomes in later life. Similar to the gradients based solely on childhood SES (Table 2), LE gradients across life course trajectories involving medium and low levels of childhood and adulthood SES are relatively small. In the low–low, low–medium, medium–low, and medium–medium trajectory groups, total remaining LE at age 45 averages approximately 31–32 years for men and 34–36 years for women. Comparing across these same groups, individuals in the low–low life course SES pattern experience proportionately more years of disabled life than the low–medium, medium–low, and medium–medium SES trajectory groups. These differences, however, are usually within the 95% confidence intervals.

Even after incorporating adult status, we continue to observe the association between childhood SES and healthy longevity (Table 3). Among men and women who had achieved high status in adulthood, those with low childhood SES have considerably lower total LE compared with those who had high childhood SES (32.3 vs. 36.6 for men, and 35.4 vs. 39.7 for women). The protective effect of high childhood SES can be observed among those with low adulthood status, although to a lesser extent. For both women and men, total LE and disability-free LE for the low–low trajectory trail these measures for the medium–low and high–low groups.
Nonetheless, our findings demonstrate that healthy longevity in China is more strongly patterned by SES in adulthood than by SES in childhood, suggesting that achieved adult status may partially attenuate the scarring effects of poor childhood conditions. We find that those with low childhood SES have substantially higher total LE when their adulthood SES is high versus low (32.3 vs. 30.6 for men, 35.4 vs. 34.4 for women). The SES gradients in LE were larger across levels of adulthood SES conditioned on childhood SES than across levels of childhood SES conditioned on adulthood SES. For example, the difference in years of life for men at age 45 between individuals with low childhood SES but high adulthood SES (32.3) and individuals with low childhood and adulthood SES (30.6) is 1.7. The comparative difference between men at age 45 with high childhood SES but low adulthood SES (31.5) and those with low childhood and adulthood SES (30.6) is 0.9 years.

These gradients are more pronounced for disability-free LE than for total LE, suggesting that socioeconomic conditions during adulthood may play an even larger role in shaping healthy longevity than in shaping total LE. For example, a man with a low childhood SES who attained high SES in adulthood could expect 3.3 more years of disability-free life than a man with low childhood and adulthood SES (26.1 vs. 22.8 disability-free years). This difference is substantially larger than the 1.7-year gap in total LE between these two groups. These patterns hold across most of the gradients studied in these analyses: socioeconomic gradients in disability-free years of life are almost always wider than socioeconomic gradients in total LE.

### Table 4

Microsimulation estimated disability-free, ADL-disabled, and total life expectancy (LE) at age 65 by life course SES trajectory, with 95% confidence intervals in brackets, CHARLS 2011–2015

<table>
<thead>
<tr>
<th>Life Course SES Trajectory (child–adult)</th>
<th>Total LE</th>
<th>Disability-Free LE</th>
<th>ADL-Disabled LE</th>
<th>Proportion Active</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Women</strong></td>
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</table>
In the preceding section, we outlined substantial differences in remaining total LE and healthy LE at ages 45 and 65 depending on the life course SES trajectory of individuals. The microsimulation-based multistate life table approach additionally allows us to investigate LE and disability-free LE among individuals during discrete portions of the life course. From a population health perspective, knowing where in the life course these social disparities arise is key for developing more targeted strategies for ameliorating them. In this section, we investigate whether differences in health arise during the working-age years (age 45–64) or become more substantial toward later life (ages 65–84 or 85+).

**Partial LEs and Disability-Free LE by Life Course SES**

In the preceding section, we outlined substantial differences in remaining total LE and healthy LE at ages 45 and 65 depending on the life course SES trajectory of individuals. The microsimulation-based multistate life table approach additionally allows us to investigate LE and disability-free LE among individuals during discrete portions of the life course. From a population health perspective, knowing where in the life course these social disparities arise is key for developing more targeted strategies for ameliorating them. In this section, we investigate whether differences in health arise during the working-age years (age 45–64) or become more substantial toward later life (ages 65–84 or 85+).

**Figure 2** and Tables S2 and S3 in the online appendix present partial LEs and partial disability-free LE in the CHARLS sample for ages 45–64, 65–84, and 85+. For both men and women, differences in partial LEs at ages 45–64 are small across SES trajectories: we find only a 0.9-year difference in men’s partial LE between the low–low and  

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**Fig. 2** Estimated partial life expectancy (LE) and disability-free LE at ages 45–64, 65–84, and 85+ by life course SES trajectory, CHARLS 2011–2015. The differently shaded areas represent the distribution of the LE across life with and without ADL disability. The black vertical lines denote the 95% confidence interval around each point estimate, and the percentage figures in the lower bars denote the percentage of partial life expectancy spent disability free. The bars do not necessarily reflect the ordering of these life-years by health states, given that individuals in our analysis can recover and relapse between health states. ADL = activities of daily living.
high–high trajectories and a 0.7-year difference for women. Differences in disability-free life during these years are somewhat larger, at 2.1 years between the high–high and low–low SES trajectory for men and 2.5 years for women. Disparities in disability-free life during these years are somewhat larger, at 2.1 years between the high–high and low–low SES trajectory for men and 2.5 years for women. Disparities by life course SES trajectory expand substantially at older ages, with a clear gradient present in partial LE and disability-free LE at ages 65–84 (Figure 2). Similar to the findings for LE at ages 45 and 65, the high–high and medium–high groups are clearly advantaged in terms of both partial LE and partial disability-free LE. These advantages persist for those aged 85+, although the gradients are smaller and not universally significant at these oldest-old ages. These findings suggest that, in China, SES trajectories have the most impact in shaping healthy longevity at older ages: social gradients emerge strongly at ages 65+ but show somewhat less differentiation at late middle ages, 45–64.

Alternative Parameterizations of Health States and Life Course SES

Here, we turn to two supplemental analyses: an exploration of a more detailed state space incorporating lower order physical limitations and an alternative parameterization of life course SES using a relative measure of SES change.

Our primary analyses use a simple three-state model (with available states of active, ADL disabled, and dead). Tables S4 and S5 in the online appendix provide the results of an analysis on a four-state model including an additional state of “physically limited” between active and disabled, defined as self-reported difficulty with one or more of the following five activities: walking 100 meters; getting up from a chair; climbing several flights of stairs; stooping, kneeling, and crouching; or lifting and carrying 5 kilograms. These physical limitations represent impairments in common daily activities, albeit at a level that is less severe than an ADL disability. We find that at age 45, men can expect to live approximately 40% to 50% of their remaining years free of ADL disability and physical limitations, compared with 20% to 30% for women. Time spent with physical limitations is also less clearly patterned by life course SES. However, given that our analyses stratify the sample into nine trajectories of life course SES, the confidence intervals around our estimates expand substantially with the more complex four-state model. We therefore prioritize the simpler three-state model as our primary outcome.

We additionally tested the robustness of our results to an alternative measure of life course SES. This alternative parameterization of life course SES focuses on the magnitude and direction of individuals’ SES change over the life course, as opposed to their life course movement between tertiles of SES at the population level. We defined an upward trajectory as an increase of greater than 0.5 standard deviations between childhood SES and adulthood SES; a stable trajectory as a change of between −0.5 and 0.5 standard deviations between childhood SES and adulthood SES; and a downward trajectory as a decline of more than −0.5 standard deviations between childhood SES and adulthood SES. We then explored differences in healthy longevity between these different trajectories, stratified by childhood SES group; Tables S6 and S7 (online appendix) present the results of these analyses. The overall patterning by this alternative measure of life course SES trajectory is consistent with our primary results. Total LE and disability-free LE are lower for individuals maintaining a similar level of SES across the life course or experiencing a decline between childhood and
adulthood. However, both LE and disability-free LE are markedly higher for individuals with an upward SES trajectory, regardless of their level of childhood SES. Conversely, individuals with a downward trajectory in life course SES, even among those starting with high childhood SES, saw fewer years of total LE and active LE at age 45.

**Discussion**

We examine the relationship between lifetime SES and healthy longevity using national-level longitudinal survey data from China. Our results show that healthy longevity in China is patterned by SES in both childhood and adulthood. Although we find that SES throughout adulthood plays a substantial role in shaping healthy longevity in China, the associations between childhood SES and LE and disability-free LE remain after adulthood SES is incorporated. This study is not designed to evaluate the specific pathways by which early-life conditions impact health longevity, but these findings are suggestive of both imprint and pathway processes linking early-life SES to late-life functioning and mortality. Adult SES plays a substantial role in shaping healthy longevity in China, and the association between early-life SES and healthy longevity is partly through socioeconomic achievement processes. At the same time, older Chinese adults with low early-life SES were more likely to have been exposed to sustained calorie deficits, infectious diseases, and family disruptions due to parental loss during childhood (Mu and Zhang 2011). These exposures may have permanent physiological scarring effects that adversely impact late-life functioning and mortality.

The most striking disparities in LE and disability-free LE are found between those with persistent high SES in early life and adulthood and those with low SES throughout life. This pattern suggests that the accumulation of advantage/disadvantage across the life course may have profound effects on healthy longevity in China. Our findings further demonstrate a consistent pattern of social mobility on healthy longevity. Focusing on those with high and low socioeconomic conditions, we find that those who experience upward social mobility from childhood to adulthood have the highest LE and disability-free LE than any other group except those with high lifetime SES. This finding is consistent with Luo and Waite’s (2005) analysis of the effect of social mobility on health and survival among older Americans.

The age patterns of social gradients in healthy longevity in China differ substantially from the observed patterns in high-income societies. Studies in the United States and the United Kingdom that used both cross-sectional and longitudinal data suggest that the onset of health problems is postponed until late in life among persons with higher SES status in adulthood, whereas health declines in lower SES population groups are prevalent by middle ages owing to exposure to a greater range of risk factors, including risky health behaviors, lack of social supports, and life course stressors (Crimmins 2005; Crimmins et al. 2009; House et al. 1994; Marmot and Shipley 1996). In contrast, we find that those who are poor in China do not seem to age earlier.

These contrasting findings may be attributable to several factors. Chinese adults with higher SES are more likely to have less healthy diets and lifestyles, partly because these choices are perceived as privileges (Chen et al. 2010). Urban dwellers in China have elevated biological risks for cardiovascular diseases and other chronic conditions compared with their rural peers, largely owing to stress exposure, sedentary
working styles, and reduced physical activities (Wang and Stokes 2020; Zhang and Crimmins 2019). In contrast, dwellers in China’s poorer, rural regions may enjoy better living environments with better air quality and less noise pollution that could, to some extent, facilitate their physical activities and help maintain physical functioning (Gu and Zeng 2004). These differences emerge strongly in middle ages and converge at older ages (Wang and Stokes 2020). Among higher SES groups, less healthy lifestyles—particularly reduced physical activities—may have weakened the protective effects of high SES on functioning and mortality during working ages, resulting in the lack of observed disparities in healthy longevity at these ages. Nonetheless, higher SES confers better education, greater access to health services, and more abundant economic resources. These advantages may become vitally important at older ages, especially in the context of escalating medical costs and widening inequality in access to health care in reform-era China.

Although our preceding discussion highlights potential mechanisms for the age patterns we observe in LE and disability-free LE, a number of cohort trends may have also influenced our results. For example, individuals aged 45–64 include cohorts exposed (in utero or during early life) to China’s Great Famine (1959–1961). Differential mortality selection by early-life SES may have contributed to the observed lack of disparities in LE in ages 45–64, given that individuals who survived these extreme adversities in childhood may possess genetic traits that enhance survival and health in later life (Mu and Zhang 2011). The Great Famine is only one example of the extreme social and political upheaval that the cohorts in this study experienced in early life. Older cohorts in our study were born into the conflict between the Nationalists and the Communists during the 1920s and 1930s, the Second Sino-Japanese War, and the Chinese Civil War—all of which may have led to mortality selection pressures that were unequal across the SES gradient.

In contrast, throughout the Mao era (1949–1976), the Chinese state attempted to invert traditional notions of social classification. Those who traditionally belonged to lower socioeconomic strata were assigned high political status; landlords, rich peasants, capitalist intellectuals, and their family members were labeled “class enemies” and were subjected to often violent persecution in various political campaigns during this period (Rodzinski 2017). This classification likely dampened the potential advantage of high childhood SES in these cohorts.

We also acknowledge that the overall socioeconomic gradients were relatively small during early life for the Chinese cohorts under study. The magnitude of SES and wealth disparities between the richest and poorest was constrained by China’s overall low levels of wealth and development through the early and mid-1900s. In contrast, rapid economic development during the reform era led to rising levels of wealth and inequality across Chinese society, resulting in the substantial adult SES gradient in the contemporary population. This disparity in the overall magnitude of childhood and adulthood SES gradient is, in part, what motivated our use of relative measures of life course SES. Despite the smaller SES gradient, we find meaningful variation in childhood conditions and demonstrate that this variation in relative childhood status is linked with differential outcomes in late-life functioning and mortality. In the context of low levels of socioeconomic development in China during the first half of the twentieth century, better living conditions as achieved through, for example, residence in urban areas or relatively wealthier regions and having parents who are more educated
may greatly reduce individuals’ chances of suffering from nutritional deprivation and enhance their chances of survival. Nonetheless, our findings on the relative importance of adult SES for shaping healthy longevity in China may be partially attributable to widening inequality in reform-era China, resulting in a much wider spectrum of overall SES conditions in recent years. China’s unique history means that our results may not easily generalize to other contexts with differing histories of development, and these patterns may indeed change over time within China in the coming decades.

Limitations

This study has several limitations. ADL disability is a simplified measure of functional health, and as such, our analyses may overlook lower order physical limitations. Our analyses follow a first-order Markov chain and are thus not dependent on state duration—that is, transition probabilities are not adjusted by duration in a given state. Individuals who experience a disability transition between waves of data collection are assumed to experience only a single transition during the period between surveys, which likely overlooks shorter term transitions between disability statuses. These overlooked transitions are known to downwardly bias estimates of transition probabilities, although the net effect on health expectancy estimates is generally small with interwave intervals of two or fewer years (Gill et al. 2005; Wolf and Gill 2009). The Markov assumption that no unobserved transitions occur before death is a particularly problematic one: it somewhat unrealistically assumes that individuals who were observed as disability free and die before the next wave experienced no disability before death (Zeng et al. 2004), which could downwardly bias our disability-free LE estimates. Similar to other life table–based measures, our disability-free LE estimates are based on a synthetic cohort approach, which inherently assumes that transition rates are stationary over time. Hence, our results do not account for any shifts in the prevalence of ADL limitations that may have occurred over the study period. As discussed in the Methods section, our measure of adult SES assumes that SES in later life is relatively stable—an assumption that could be violated if there are large swings in wealth or other SES measures in later life.

Healthy longevity is not a simple function of life course SES, and other factors are very likely to influence both healthy longevity and an individual’s propensity to experience a change in relative SES over the life course. Factors such as differences in life course stressors, diseases, and health behaviors (Oksuzyan et al. 2010), as well as access to and quality of health care services (Zhang et al. 2017), could also impact LE and disability-free LE at older ages. Our analyses focus on the extent of observed social gradations in healthy longevity. We do not make causal claims about how SES at different portions of the life course impacts later-life health.

In recent decades, policymakers in China have dedicated significant resources to improving older adults’ socioeconomic conditions, health, and well-being. Recent health care reforms have specifically targeted equity of access as a key tenet (Yip et al. 2012), and the country’s health care system has also made substantial strides in reducing the disabling effects of major diseases (Sousa et al. 2009; Yang et al. 2013). Despite these efforts, however, income and wealth inequality in China continued to widen from the 1990s to 2008 and remained high after 2008 by international standards (Li
and Sicular 2014). These policy measures might not be adequate to address deepening inequality in reform-era China, which is fundamentally attributable to the country’s urban-biased development strategies (Wang et al. 2013). Similarly, recent health reforms have not sufficiently narrowed the substantial rural–urban gap in access to health care resources. Considerable rural–urban differences remain in the cost and accessibility of medical treatment and preventative care in China (Meng and Xu 2014; Zhang et al. 2017).

Conclusions

Despite China’s major policy changes that explicitly prioritized equity in income and health care in recent decades, our findings suggest that dramatic health inequalities among older Chinese adults remain. Substantial gaps in LE and disability-free LE exist between individuals with more and less advantaged life course SES trajectories. Socioeconomic conditions in adulthood play an especially important role in shaping healthy longevity among China’s older population. However, we find that these social disparities are relatively small during working ages (45–64) and emerge most strongly at older adult ages (65–84). These findings suggest that more targeted strategies for improving health at these key ages could substantially alleviate health inequality throughout the population.

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