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# Widening or convergence, the trajectories of health inequalities induced by childhood SES across the life course: Evidence from China

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ABSTRACT

This study aims to explore the trajectories of health inequalities induced by childhood SES across the life course in China. There are two competing theories on this subject. Cumulative disadvantage theory contends that health gaps induced by childhood SES tend to widen across the life course as adulthood SES compound or multiply the negative effects of early SES disadvantage. Age-neutral theory draws the opposite inference that the physiological decline due to aging offsets the health gaps at older ages. Based on the data of the China Health and Retirement Longitudinal Study (CHARLS) from 2011 to 2018, a two-level mixed-effects model was used to analyze the trajectories of health inequalities induced by childhood SES among Chinese individuals aged 45 and above and further distinguished the age and cohort effects in the overall trajectories. Unlike previous studies that unilaterally supported one of these theories, our findings support both of them. In this study, health gaps induced by childhood SES gradually widened before entering old age, which supports the cumulative disadvantage theory. In contrast, the health gaps in older adults gradually converged with age, thus supporting the age-neutral theory. The age effect shows that in the same birth cohort, health gaps induced by childhood SES first increased and then decreased during the survey time. The cohort effect shows that, at the same age, childhood SES has a greater impact on the health of those with later birth cohorts than on those with earlier birth cohorts. The findings of this study support the importance of policy and practices to reduce health inequalities among adolescents for long-term healthy aging in China.

## 1. Introduction

Health status is an important indicator of human development and social civilization. The health of the Chinese has improved significantly since the 1950s, with average life expectancy rising from an initial 35 to 77.3 in 2019. With China's rapid economic growth and social transformation, health disparities among individuals are also widespread. Generally, health disparities induced by natural biological differences, such as age, genetics and gender are considered reasonable, but health disparities induced by socioeconomic status (such as education, occupation and income) are considered health inequalities that need to be reduced. It has been proven that SES, such as education, occupation and income in adulthood, are associated with multiple indicators of health (Antonovsky, 1967; Fox et al., 1985; Hollingsworth, 1965; Huisman et al., 2003; Marmot & Shipley, 1996; Ross & Wu, 1996). Those with higher education levels, income and prestige tend to enjoy longer and healthier lives (Berkman & Gurland, 1998; Huang & Zhou, 2013). In contrast, a low education level and income undermine people's social activity ability formation and exacerbate health inequalities (Wang & Ma, 2020; Fan et al., 2021; He & Shen, 2021). As an important feature of unbalanced and inadequate development in the health field, health inequalities have become an urgent problem that the government needs to address in China. Against this backdrop, this study aims to explore the origins and trajectories of health inequalities across the life course, which is of great significance in promoting healthy aging in China.

Life course theory indicates that health status is a cumulative result of the life course. Evidence from developed countries suggests that elderly health is not only associated with current SES but is also influenced by early-life activities (Angelini et al., 2018; Emily et al., 2021; Gensowski et al., 2019; Haas S., 2008; O'Rand, 1996; Tetyana & Benedicta, 2014; Yukako et al., 2016). In the framework of life course, health inequalities in adulthood can be traced back to differences in early SES (O'Rand, 1996). At the same time, health status is also the result of the interaction between the macrosocial environment and the individual's

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life course (O'Rand, 1996; Elder, 1974; Zheng & Zeng, 2016). On the one hand, historical change and social transformation have different effects on people at different life stages. On the other hand, the macrosocial environment usually varies in different birth cohorts at the same age (Ryder, 1965; Elder, 1974; Jiao & Bao, 2020). Therefore, health inequalities may vary across age and birth cohorts.

To reduce health inequalities, it is necessary to explore whether the effect of childhood SES on adulthood health is short-term or long-term and whether the trajectories of health inequalities widen or converge across the life course. Different trajectories in health inequalities across the life course have different policy implications. For instance, if health inequalities are gradually widening across the life course, the government needs to provide more social protection for the health of vulnerable older people. Moreover, China has experienced tremendous socioeconomic changes in the past 70 years, and the impact of this change on the trajectories of health inequalities also needs to be explored. Therefore, analyzing the trajectories of health inequalities not only helps policy-makers formulate precise health interventions, but it also reflects the historical change and social transformation in China, to a certain extent.

Theoretically, the trajectories of health inequalities across the life course are far from obvious. There are two competing theories on this subject. On the one hand, the cumulative disadvantage theory indicates that early and sustained hardship accumulate and magnify across the life course and ultimately result in health decline (Barker et al., 2003; O'Rand, Angela, Jenifer, & Hamil-Luker, 2005; Cohen et al., 2010; Shonkoff et al., 2012). Specifically, SES disadvantages in early life tend to have a negative effect on their early health and further affect improvements in health resources, education and future employment (Schafer et al., 2013). As a result, health inequalities also widened in this process. On the other hand, age-neutral theory indicates that health inequalities induced by SES in early life will be reduced across the life course, which is more obvious in the elderly group (House et al., 1994; Christenson & Johnson, 1995). According to health capital and demand theory, health stock depreciates with age. The depreciation rate of health stock also accelerates with age (Grossman, 1972). Therefore, physiological decline with age reduces health disparities induced by early SES. In addition, human physiology has strong adaptability to the external environment, and this adaptability is gradually enhanced across the life course and thereby weakens the effect of early SES disadvantages (Günther et al., 2021).

A large body of empirical studies also show that the trajectories of health inequalities induced by childhood SES across the life course are mixed. On the one hand, some studies found that inequalities in multiple health indicators continue to widen across the life course (Dupre, 2007; Kim & Durden, 2007; Leopold, 2016; Sacker et al., 2005). On the other hand, there is also evidence that health inequalities converge across the life course (House et al., 2005; Zhou & Song, 2017). In addition, the cohort effect of health inequalities is also inconsistent, which is reflected in whether the effect of childhood SES on adulthood health increases or decreases in consecutive birth cohorts (Lynch., 2003; Mirowsky & Ross, 2008; Chen et al., 2010). In recent years, studies on trajectories of health inequalities have gradually emerged in China. For example, Chen et al. (2010) examined the trajectories of health inequalities related to adulthood income and education and identified the cohort effect. Jiao and Bao (2020) analyzed the trajectories of health inequalities related to childhood adversity (starvation experience) from a longer lifespan.

The existing studies have provided important references for this study. However, these studies also have the following limitations. First, these studies present conflicting conclusions on the trajectories of health inequalities across the life course. Second, few of them focus on the origins of health inequalities in adulthood, particularly the trajectories of health inequalities induced by childhood SES. Third, SES indicators commonly used in these studies may not be applicable to the reality in China. For instance, during the planned economy period in China, income cannot reflect an individual's SES because supplies during this period were distributed according to the plan. Fourth, these studies rarely simultaneously explored the age and cohort effects behind the trajectories of health inequalities across the life course.

To fill the gap in previous studies, this study aims to analyze the trajectories of health inequalities induced by childhood SES across the life course. In terms of SES indicators, multidimensional indicators that are in line with the reality in China were used to comprehensively measure childhood SES. Considering the tremendous socioeconomic changes in China and the interaction between the macrosocial environment and individual life course (Elder et al., 2003, p. p3; Shi et al., 2020), age (based on the same birth cohort sample) and cohort effects (based on the same age sample) were also identified within the overall trajectories. In addition, to eliminate the impact of the improvement in adulthood SES on the trajectories of health inequalities, we also controlled for adulthood SES variables in all our models.

## 2. Methods

### 2.1. Data

The data used in this study are derived from the China Health and Retirement Longitudinal Study (CHARLS). These data randomly select approximately 17500 individuals aged 45 and above from 450 villages in 150 counties or districts. The questionnaire includes rich information on respondents' demographic characteristics, health care, childhood experiences, parents' SES, etc. The data was longitudinal tracking data from 2011 to 2018. In addition, CHARLS conducted a life course survey in 2014. Therefore, unbalanced panel data was constructed containing life course information. After excluding observations with missing information on the selected variables, the remaining sample size is 30374 person-years. Among them, 2721 respondents were surveyed 4 times, 3240 respondents were surveyed 3 times, 4156 respondents were surveyed twice and 1458 respondents were surveyed only once.

Dependent variables: This study used self-rated health (SRH) to measure the health status of respondents. SRH has been proven to be a reliable comprehensive indicator in measuring cognitive, morbidity and mortality (Schnittker, 2005). In addition, SRH is easier to obtain and meets the applicability requirements of the model in this study. In the CHARLS questionnaire, the score of SRH ranges from 1 to 5, and the answers are recoded dichotomously into good and bad.

Independent variables: The core independent variable of focus is respondents' childhood SES. Referring to existing studies, respondents' childhood was defined as 0–17 years (Shi et al., 2020). To date, scholars have not provided a clear definition of SES. According to the description and understanding of SES in the previous literature, SES is usually measured by an individual's education level, occupation, and household income. It is worth noting that Chinese society has its own peculiarities. Specifically, most of the respondents in this study experienced childhood during the planned economy period in China. During this period, the government implemented a strict household registration system, which makes it difficult for people to change their household registration status. At the same time, all kinds of material resources were supplied according to the plan and inclined to urban areas. Against this backdrop, the type of household registration and material living conditions of the family have become important manifestations of SES. In this study, parents' education levels, occupation types, household registration, household water resources, household electricity and household cooking fuel during respondents' childhood were selected to measure childhood SES. Respondents whose parents were educated and engaged in nonagricultural occupations, had urban household registration and enjoyed better material living conditions during their childhood can be considered as a high SES group in childhood.

To facilitate the estimation of the results the principal component analysis (PCA) method was used to fit the above childhood SES indicators into the childhood SES index. The sample was then divided into high and low SES groups based on the childhood SES index. In addition, the sample was divided into 6 birth cohorts according to the corresponding historical period of Chinese society and a continuous variable was generated.

Control variables: Referring to previous studies on the influencing factors of health (Dupre, 2007; Chen et al., 2010; Shi et al., 2020; Jiao & Bao, 2020), a series of control variables were added from four aspects. The first is respondents' demographic characteristics, including gender, marriage, and the number of siblings (a continuous variable). The second is parents' health status during respondents' childhood, including whether the biological mother died prematurely, whether the mother was bedridden for a long time, had a severe physical or mental disability. The third is respondents' SES in adulthood, including the years of education (a continuous variable), current household income level (using the logarithm of the average monthly household consumption as a proxy) and current household registration status. The fourth contains medical insurance, the year respondents entered the survey and whether the respondents died during the survey.

### 2.2. Analytic approach

This study employed two-level mixed-effects models to analyze the trajectories of health inequalities induced by childhood SES and to identify age and cohort effects within it. Unbalanced panel data are essentially hierarchical structured data. In unbalanced panel data, the same individual may be repeatedly observed in different periods, and the frequency of being observed may vary randomly. As a result, repeated observations of the same individual are nested within individual study subjects, and the data present multilevel structural characteristics. However, multilevel structural data suffer from intragroup correlation in which the same individual's characteristics at different survey times are correlated. Traditional analysis methods, such as ordinary least squares (OLS), cannot be applied to multilevel structural data analysis in that these methods rely on the assumptions of mutual independence and variance homogeneity of samples. Different from traditional analysis methods, a multilevel mixed-effects model includes both fixed and random effects and can properly address intra-individual homogeneity and inter-individual heterogeneity problems. Another strength of the multilevel mixed-effects model is that respondents who have only been surveyed once also contribute to the total sample, and a large sample size is also beneficial for the accuracy of the estimation results (Hox et al., 2010).

Five two-level mixed-effects models were executed to examine the trajectories of health inequalities induced by childhood SES. Model 1 shows the relationships between age, birth cohorts and the health of middle-aged and elderly individuals. In Model 2, childhood SES was added to estimate the effect of childhood SES on the health of middle-aged and elderly individuals. The next model added the interaction item of childhood SES and age to explore whether the health effects of childhood SES vary by age across the life course. To explore whether the health effects of childhood SES vary by birth cohort, the interaction item of childhood SES and birth cohort were added in the fourth model. On the basis of the above, a test of whether the health effects of childhood SES vary by both age and birth cohort across the life course were further conducted in our final model.

## 3. Results

### 3.1. Descriptive statistics

Table 1 presents descriptive statistics for all variables of the total samples in this study. A total of 45.9% of respondents rated their health as good, and 31.8% of them had high childhood SES. The average age of the total sample was 60 years old. The sample distribution of each birth cohort is also nearly similar. The sample comprised slightly more females (53.9%) than males. A total of 88.6% of the respondents had a spouse. The average number of siblings was approximately 4. The proportion of the sample covered by medical insurance exceeded 94%. The overall health of respondents' parents was better during the respondents' childhood. However, the proportion of biological parents who died prematurely was relatively high. In terms of respondents'

**Table 1**
Definition and statistical description of variables.

| Variables | Variable definition | Mean/ Percent | Standard deviation |
|---|---|---|---|
| Dependent variable | | | |
| SRH | Good:1 = excellent or good or fair; Bad:0 = bad or very bad | 0.459 | 0.498 |
| Independent variable | | | |
| Mother's education level | 1 = primary school and above 0 = illiterate | 0.132 | 0.338 |
| Father's education level | 1 = primary school and above; 0 = illiterate | 0.441 | 0.497 |
| Mother's occupation type | 1 = non-agricultural work; 0 = agricultural work | 0.065 | 0.247 |
| Father's occupation type | 1 = non-agricultural work; 0 = agricultural work | 0.175 | 0.380 |
| Household registration | 1 = urban; 0 = rural | 0.071 | 0.256 |
| Household drinking water sources | 1 = clean tap water; 0 = others | 0.069 | 0.254 |
| Household electricity | 1 = with electricity; 0 = without electricity | 0.352 | 0.477 |
| Household cooking fuel | 1 = coal, electricity or natural gas; 0 = others | 0.213 | 0.409 |
| Childhood SES | High:1 = childhood SES index above average; Low:0 = others | 0.318 | 0.466 |
| Age | Survey year minus birth year | 59.967 | 9.160 |
| Birth cohort | 0 = 1919–1936; 1 = 1937–1948; 2 = 1949–1954; 3 = 1955–1961; 4 = 1962–1966; 5 = 1967–1973 | 2.671 | 1.374 |
| Control variables | | | |
| Gender | 1 = male; 0 = female | 0.471 | 0.499 |
| Marriage | 1 = married or co-habiting, 0 = others | 0.886 | 0.318 |
| The number of siblings | Total number of siblings | 4.373 | 2.044 |
| Medical insurance | 1 = with medical insurance; 0 = others | 0.947 | 0.223 |
| Biological mother died prematurely | 1 = yes; 0 = no | 0.299 | 0.458 |
| Mother bedridden for a long time | 1 = yes; 0 = no | 0.131 | 0.338 |
| Mother has a severe physical disability | 1 = yes; 0 = no | 0.028 | 0.164 |
| Mother has a severe mental disease | 1 = yes; 0 = no | 0.028 | 0.164 |
| Biological father died prematurely | 1 = yes; 0 = no | 0.267 | 0.442 |
| Father bedridden for a long time | 1 = yes; 0 = no | 0.086 | 0.281 |
| Father has a severe physical disability | 1 = yes; 0 = no | 0.028 | 0.165 |
| Father has a severe mental disease | 1 = yes; 0 = no | 0.016 | 0.126 |
| The year entered the survey | 0 = 2011; 1 = 2013; 2 = 2015; 3 = 2018 | 0.294 | 0.638 |
| Whether died during the survey | 1 = yes; 0 = no | 0.006 | 0.074 |
| Education level in adulthood | Years of education | 5.465 | 4.119 |
| Current household income level | The logarithm of average monthly household expenditure | 5.924 | 1.770 |
| Current household registration status | 1 = urban; 0 = rural | 0.193 | 0.394 |

adulthood SES, the length of education of respondents was approximately 5.47 years. The average logarithm of respondents' current household income was 5.924. Currently, only 19.3% of the samples have urban household registration.

### 3.2. The effect of childhood SES on health in middle and old age

A mixed-effects regression analysis was conducted to explore the trajectories of health inequalities induced by childhood SES across the life course. First, the relationship the relationship between age, birth cohorts and the health of middle-aged and elderly individuals were explored in Model 1 in Table 2. The results show that age and health are not a linear relationship across the life course. At the same time, the birth cohort has a significant positive effect on the health of middle-aged and elderly individuals. Those born later have better health outcomes in that they are relatively younger than those born earlier. In Model 2, we added the childhood SES variable. The coefficient of childhood SES is 0.160 and is statistically significant. From the coefficient of childhood SES, it can be seen that the effect of childhood SES is still significant until middle and old age. To analyze whether the health effect of childhood SES varies by age, the interaction term of childhood SES and age in Model 3 was added. In Model 3, the coefficient of the interaction term of childhood SES and age is small and not statistically significant. After adding the interaction terms of childhood and birth cohort on the basis of Model 3, the coefficients of all interaction terms are significant. To more intuitively test whether the effect of childhood SES on the health of middle-aged and elderly individuals is simultaneously moderated by age and birth cohort, the interaction terms of childhood SES and age and

**Table 2**
Mixed-effects regression for childhood SES and adulthood health.

| Fixed effects | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Gender | 0.090*** | 0.099*** | 0.099*** | 0.099*** | 0.101*** |
| | ( 0.030 ) | ( 0.030 ) | ( 0.031 ) | ( 0.030 ) | ( 0.030 ) |
| Marriage | 0.020 | 0.018 | 0.018 | 0.020 | 0.025 |
| | ( 0.046 ) | ( 0.046 ) | ( 0.046 ) | ( 0.046 ) | ( 0.046 ) |
| The number of siblings | −0.021*** | −0.018*** | −0.018*** | −0.018** | −0.018*** |
| | ( 0.007 ) | ( 0.007 ) | ( 0.007 ) | ( 0.007 ) | ( 0.007 ) |
| Medical insurance | 0.304*** | 0.304*** | 0.305*** | 0.303*** | 0.303*** |
| | ( 0.059 ) | ( 0.060 ) | ( 0.060 ) | ( 0.060 ) | ( 0.060 ) |
| Biological mother died prematurely | −0.116*** | −0.117*** | −0.117*** | −0.115*** | −0.115*** |
| | ( 0.032 ) | ( 0.032 ) | ( 0.032 ) | ( 0.032 ) | ( 0.032 ) |
| Mother bedridden for a long time | −0.265*** | −0.262*** | −0.262*** | −0.262*** | −0.264*** |
| | ( 0.044 ) | ( 0.044 ) | ( 0.044 ) | ( 0.045 ) | ( 0.045 ) |
| Mother has a severe physical disability | −0.334*** | −0.334*** | −0.333*** | −0.326*** | −0.325*** |
| | ( 0.091 ) | ( 0.091 ) | ( 0.091 ) | ( 0.091 ) | ( 0.092 ) |
| Mother has a severe mental disease | −0.216** | −0.214** | −0.214** | −0.216** | −0.220** |
| | ( 0.101 ) | ( 0.101 ) | ( 0.101 ) | ( 0.101 ) | ( 0.101 ) |
| Biological father died prematurely | −0.022 | −0.021 | −0.021 | −0.021 | −0.021 |
| | ( 0.032 ) | ( 0.032 ) | ( 0.032 ) | ( 0.032 ) | ( 0.032 ) |
| Father bedridden for a long time | −0.288*** | −0.277*** | −0.277*** | −0.276*** | −0.277*** |
| | ( 0.053 ) | ( 0.053 ) | ( 0.053 ) | ( 0.053 ) | ( 0.053 ) |
| Father has a severe physical disability | −0.235*** | −0.237*** | −0.237*** | −0.237*** | −0.237*** |
| | ( 0.089 ) | ( 0.089 ) | ( 0.089 ) | ( 0.089 ) | ( 0.089 ) |
| Father has a severe mental disease | −0.097 | −0.102 | −0.101 | −0.090 | −0.092 |
| | ( 0.131 ) | ( 0.131 ) | ( 0.131 ) | ( 0.131 ) | ( 0.131 ) |
| The year entered the survey | 0.194*** | 0.189*** | 0.188*** | 0.174*** | 0.191*** |
| | ( 0.025 ) | ( 0.025 ) | ( 0.025 ) | ( 0.026 ) | ( 0.026 ) |
| Whether died during the survey | −0.352* | −0.352* | −0.352* | −0.361* | −0.369* |
| | ( 0.192 ) | ( 0.192 ) | ( 0.191 ) | ( 0.192 ) | ( 0.192 ) |
| Education level in adulthood | 0.033*** | 0.030*** | 0.030*** | 0.029*** | 0.029*** |
| | ( 0.004 ) | ( 0.004 ) | ( 0.004 ) | ( 0.004 ) | ( 0.004 ) |
| Current household income level | −0.002 | −0.003 | −0.003 | −0.004 | −0.004 |
| | ( 0.008 ) | ( 0.008 ) | ( 0.008 ) | ( 0.008 ) | ( 0.008 ) |
| Current household registration status | 0.149*** | 0.105*** | 0.106*** | 0.113*** | 0.110*** |
| | ( 0.039 ) | ( 0.040 ) | ( 0.040 ) | ( 0.040 ) | ( 0.040 ) |
| Age | 0.281*** | 0.285*** | 0.286*** | 0.265*** | 0.215*** |
| | ( 0.021 ) | ( 0.021 ) | ( 0.021 ) | ( 0.021 ) | ( 0.024 ) |
| Age squared | −0.001*** | −0.001*** | −0.001*** | −0.001*** | −0.001*** |
| | ( 0.000 ) | ( 0.000 ) | ( 0.000 ) | ( 0.000 ) | ( 0.000 ) |
| Birth cohort | 0.803*** | 0.794*** | 0.794*** | 0.694*** | 0.663*** |
| | ( 0.031 ) | ( 0.031 ) | ( 0.031 ) | ( 0.035 ) | ( 0.036 ) |
| Childhood high SES | / | 0.160*** | 0.158*** | 0.141*** | 0.265*** |
| | / | ( 0.034 ) | ( 0.034 ) | ( 0.034 ) | ( 0.045 ) |
| Childhood high SES x Age | / | / | −0.001 | 0.046*** | 0.062*** |
| | / | / | ( 0.003 ) | ( 0.009 ) | ( 0.010 ) |
| Childhood high SES x Birth cohort | / | / | / | 0.336*** | 0.445*** |
| | / | / | / | ( 0.059 ) | ( 0.065 ) |
| Childhood high SES x Age x Birth cohort | / | / | / | / | 0.011*** |
| | / | / | / | / | ( 0.003 ) |
| Random effects | | | | | |
| Variance ( intercept ) | 0.455*** | 0.453*** | 0.453 | 0.457 | 0.461 |
| | ( 0.038 ) | ( 0.038 ) | ( 0.038 ) | ( 0.038 ) | ( 0.039 ) |
| Goodness of fit | | | | | |
| Freedom degree | 22 | 23 | 24 | 25 | 26 |
| Log likelihood | −20007.683 | −19996.274 | −19996.214 | −19980.099 | −19970.659 |
| AIC | 40059.37 | 40038.55 | 40040.43 | 40010.20 | 39993.32 |
| BIC | 40242.44 | 40229.94 | 40240.14 | 40218.23 | 40209.67 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard error in parentheses. Age and birth cohort variables were centered.

birth cohort were added. According to the Akaike information criterion (AIC) and Bayesian information criterion (BIC) values of each model, it was found that the goodness of fit of Model 5 was significantly better than that of the other models. The findings in Model 5 indicate that the effect of childhood SES on the health of middle-aged and elderly individuals varies significantly by age and birth cohort. Therefore, the health effect of childhood SES not only persists into middle and old age but also varies by age and birth cohort.

### 3.3. The overall trajectories of health inequalities induced by childhood SES across the life course

In this study, the size of the health effect of childhood SES indicates the degree of health inequalities. Although findings in the above models show that health inequalities induced by childhood SES exist, these findings fail to directly reveal specific trajectories of health inequalities. In this section, the trajectories of health inequalities induced by childhood SES across the life course are graphically presented based on Model 5.

From Fig. 1, it can be seen that the health effect of childhood SES presents an inverted U-shape in middle and old age. Specifically, the effect of childhood SES on health shows a gradual upward trend between 45 and 60 years old, then the effect gradually weakens after 60 and approaches zero by age 95. Correspondingly, health inequalities induced by childhood SES gradually widen before 60 years of age, which supports the cumulative disadvantage theory. This inequity gradually converges after 60 years of age, supporting the age-neutral effect theory. As a result, 60 years old is a turning point of the trajectories of health inequalities induced by childhood SES across the life course. This finding also confirms that cumulative disadvantage and age-neutral effects play a role in different life stages, rather than one single effect across the life course. In addition, it is worth noting that the finding in Fig. 1 only shows the overall trajectories of health inequalities based on the total samples, while it includes differences in both age and birth cohorts. Against this backdrop, it is necessary to identify the age and cohort effects in the trajectories of health inequalities across the life course.

### 3.4. The age effect of health inequalities induced by childhood SES

To explore the age effect of health inequalities induced by childhood SES across the life course, the trajectories of health effects of childhood SES were analyzed in the same birth cohort during the surveyed period based on Model 5. From Fig. 2, it can be seen that the effect of childhood SES on adulthood health tends to first increase and then decrease with

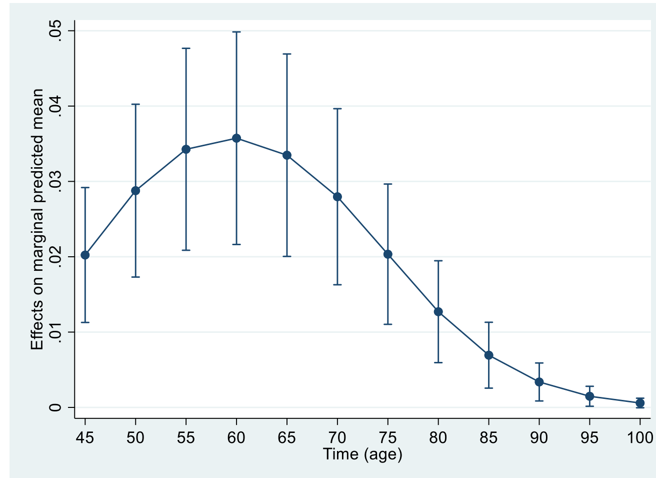


**Fig. 2.** Overall trajectories of health inequities induced by childhood SES across the life course.

age in most birth cohorts. In the 1960 birth cohort, the health effects of childhood SES are greatest, which is consistent with the trajectory inflection point of 60 years old in Fig. 1. For the 1970 birth cohort, the health effects of childhood SES tended to decline slightly with age but remained at a high level compared with other cohort groups. Overall, the trajectories of health inequalities induced by childhood SES also present an inverted U shape with age in the same birth cohort. In other words, before a significant decrease in physiological functioning, personal health is greatly affected by childhood SES, and health inequalities between groups have gradually increased. However, the accelerated physiological decline with age further reduces health inequalities since it offsets the effect of childhood SES on current health.

### 3.5. The cohort effect of health inequalities induced by childhood SES

To explore the cohort effect of health inequalities induced by childhood SES across the life course, the effect of childhood SES on adulthood health was analyzed at the same age from different birth cohorts according to Model 5. To include the birth year of the sample as far as possible in the birth cohort grouped in this study, samples aged 50, 60, 70 and 80 were selected. The results in Fig. 3 show that the health effects of childhood SES increase as the birth cohort approaches at each age group. In other words, the marginal effect of childhood SES on the

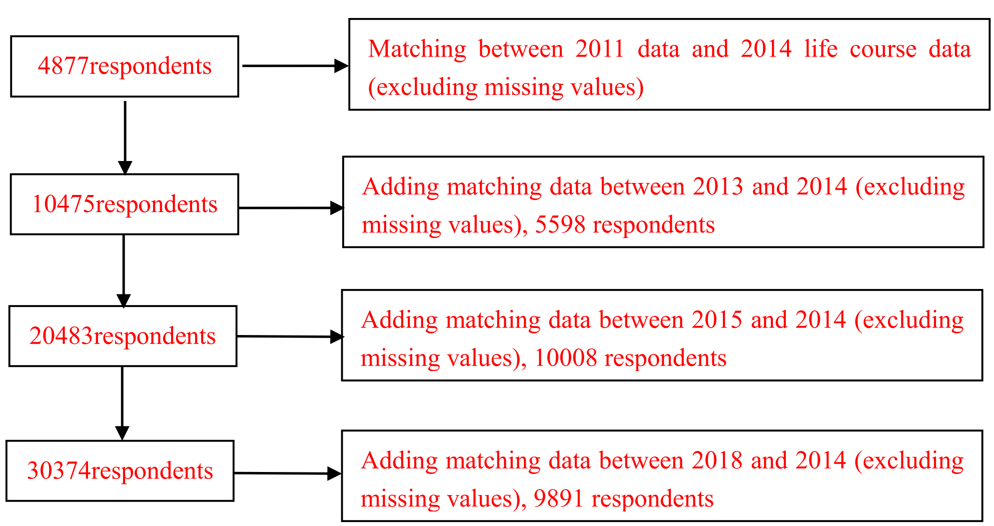


**Fig. 1.** Flow chart on how the final analytical sample was derived.

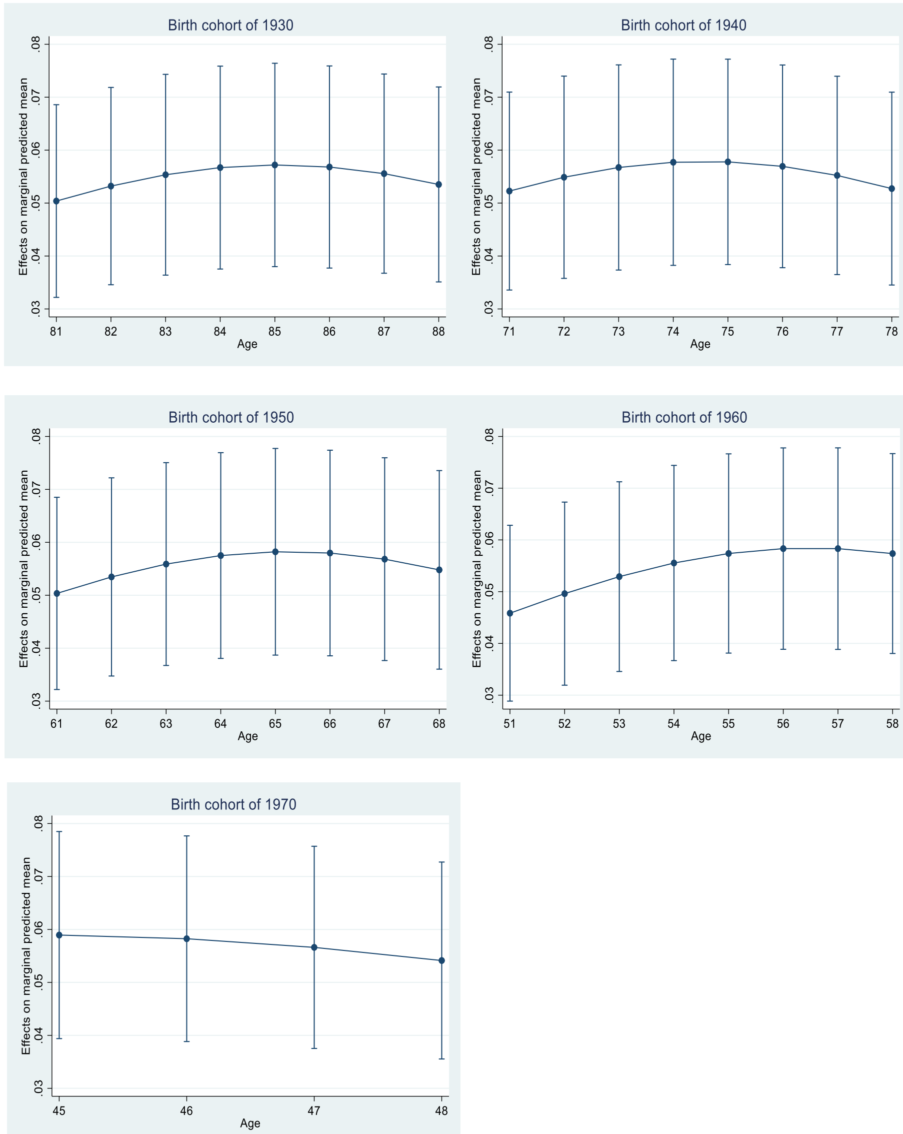


**Fig. 3.** The age effect of health inequities in the same birth cohort.

health of later-born cohorts is relatively higher than that of earlier-born cohorts at the same age, which provides further evidence that health inequalities are more pronounced in the later birth cohorts (see Fig. 4).

## 4. Discussion

Health inequalities have become an important feature of unbalanced and inadequate development in the health field and bring barriers to healthy aging in China. To reduce health inequalities, it is necessary to explore their origins and trajectories across the life course. In the framework of cumulative disadvantage and age-neutral theory, using CHARLS data from 2011 to 2018, this study analyzed the content from three aspects. First, whether childhood SES has a significant effect on the health of middle-aged and elderly people and whether this effect varies by age and birth cohorts were analyzed. Second, the overall trajectories of health inequalities induced by childhood SES across the life course are graphically presented by using a joint model involving the interaction of age and cross-cohort effects. Third, the age and cohort effects among the overall trajectories of health inequalities were identified.

In conclusion, the results of this study did not fully support the cumulative disadvantage theory or the age-neutral theory. Although it was found that childhood SES still has a significant effect on health when the respondents entered old age, the overall health effect of childhood SES presented an inverted U-shaped relationship with time. Specifically, health gaps induced by childhood SES gradually increased before age 60, supporting the notion of cumulative disadvantage. This gap gradually decreased after age 60, supporting the notion of age neutrality. The age effect shows that, in the same birth cohort, health gaps also first increased and then decreased during the survey time. The cohort effect shows that, at the same age, health gaps were more pronounced in successive birth cohorts.

The trajectory before the age of 60 was in line with the studies from some developed countries. A notable difference, however, emerged in old age. Studies from the United States and the United Kingdom reported that health gaps widened with older age (Sacker et al., 2005; Dupre, 2007; Kim & Durden, 2007). At the same time, evidence from Sweden showed that the rise in health inequalities was limited to earlier and middle stages of the life course, while health gaps remained constant after the age of 55 (Leopold, 2016). However, in this study, health inequalities induced by childhood SES showed a convergence state after the age of 60.

The disparities in findings in old age between this study and previous studies can be explained from two aspects. One is that most previous studies have analyzed the trajectories of health inequalities induced by

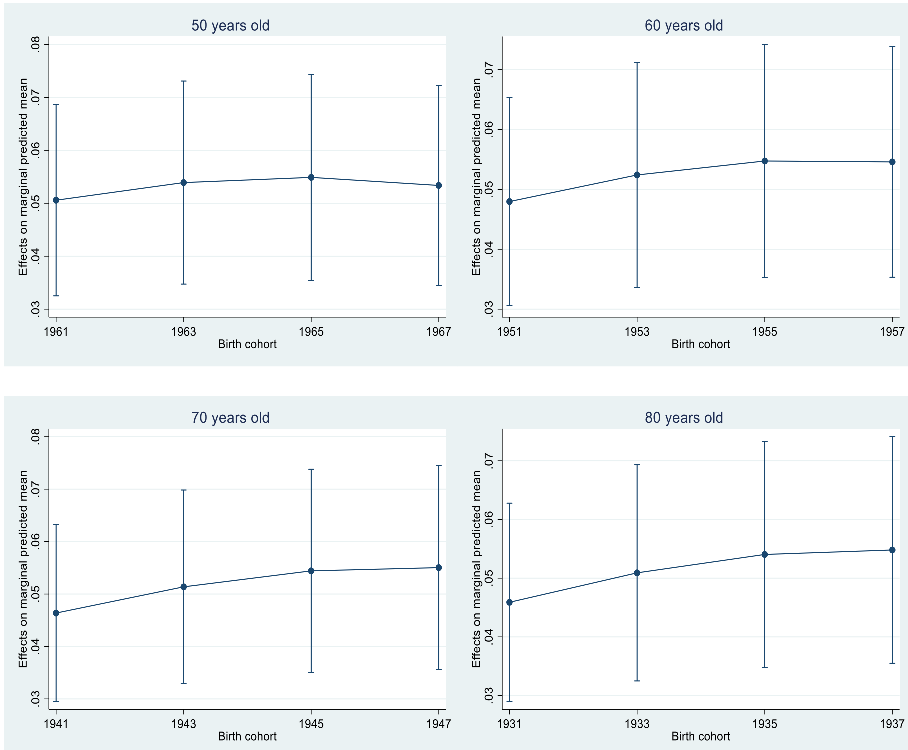


**Fig. 4.** The cohort effect of health inequities at the same age.

adulthood SES without considering their common origins, that is, childhood SES. Childhood SES affects both adulthood SES and adulthood health. Although improvements in adulthood SES will partially offset the adverse effect of childhood SES disadvantages on adulthood health, this adverse effect will persist throughout the life course. Therefore, only exploring the health inequalities caused by adulthood SES will underestimate the extent of health inequalities across the life course.

An alternative interpretation is that self-selection driven by death may lead to the convergence of health gaps in old age. In other words, childhood SES disadvantage will impose a negative impact on health. If people with poor health die prematurely with age, then the elderly in the survey are relatively healthy people who left after death selection. In this case, health gaps were less pronounced in later life, and the actual health decline induced by childhood SES may be underestimated (Leopold, 2016; Lynch, 2003; Zheng & Zeng, 2016). To control estimation bias due to death selection, referring to previous studies (Beckett, 2000; Herd, 2006), the variable of whether respondents died during the longitudinal survey to the model was added. Therefore, self-selection driven by death did not play a major role in this study.

A major benefit of the data used in this study is that it allowed for detailed cross-cohort analysis. The birth cohort generally reflects the position of the individual in social history. Therefore, a detailed cross-cohort analysis also reflects the trends of social history. In this study, it was found that childhood SES had a greater impact on the health of later-born groups, indicating that health inequalities induced by childhood SES were more pronounced in successive birth cohorts. The findings of the cross-cohort analysis are consistent with the conclusions of previous studies from developed countries (Leopold, 2016; Lynch, 2003; Mirowsky & Ross, 2008). In addition, this finding also directs attention to the special historical processes and social institutional arrangements in China. To prevent and control infectious diseases and epidemics, China launched a Patriotic Health Movement in the 1950s. Health gaps induced by childhood SES in the elderly were also reduced by the Patriotic Health Movement during this period. At the same time, the disease spectrum has also shifted from acute infectious diseases to chronic non-communicable diseases in China (Omran., 1971). Compared with biological factors, socioeconomic factors play a major role in chronic disease. With the reform and opening up in China, the disparities in people's SES have further widened. As a result, the health status of those born later is more affected by SES, and the health inequalities induced by childhood SES are also widening among them.

The findings of this study are of great significance for healthy aging. Given that the health effects of childhood SES persist into old age and that health inequalities in adulthood have taken root in peoples' early life. Interventions for healthy aging cannot be limited to elderly individuals. At the same time, the health status of the later birth cohorts is more affected by childhood SES. In this case, effective interventions on health starting from childhood are necessary to achieve healthy aging. Social policy compensation for SES disadvantages can improve people's early health and affect their labor market returns in the long term, thus improving their health status in middle and old age. Therefore, the government can provide disadvantaged adolescents with material resources to maintain and improve their health through social policies. In addition to material resources, the government also needs to guarantee disadvantaged adolescents' educational opportunities and improve their education level.

It is important to bear in mind that this study has some limitations. First, the trajectories of health inequalities with age in the same birth cohort were limited by time horizon since the tracking time of the CHARLS data is relatively short. Second, there might be recall bias for childhood SES in that life course information comes from retrospective data. In addition, improvement in adulthood SES can also compensate for the long-term adverse health effects of early life disadvantage, which may also narrow the health gaps in old age (Jiao & Bao, 2020). However, we added respondents' adulthood SES to all models in this study to control for its effect on the results as much as possible.

## Ethics approval

This study was exempt from human subjects' approval.

## Statement of ethics approval

Ethics approval is not required since this study used public available secondary dataset that contains de-identifiable information.

## Credit author statement

CYC conceptualized the study, directed the data analysis, and wrote most of the manuscript. ZYX performed the statistical analysis, wrote portions of the draft, and supervised the manuscript.

## Data availability

Data will be made available on request.

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