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Relative deprivation and health revisited: New evidence from middle-aged and older adults in rural China

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ABSTRACT

The critical role of income in individual health is not only reflected in the direct effect of income but also derived from the relative income levels within cohorts. This study first constructs relative deprivation indicators to measure the relative income levels of rural households by taking village-level households as the reference group. Using the data from the four waves of the China Health and Retirement Longitudinal Study (2011–2018), we apply a panel event study approach to detect the impact of relative deprivation on the health status of rural middle-aged and older adults. The estimation results show the significantly negative and persistent effects of deterioration in relative deprivation on the physical and mental health outcomes of these adults. In rural China, the impact of relative deprivation on individual health shows significant age and wealth differences, but no significant gender differences are observed. Meanwhile, local collective culture plays important roles. The findings have important implications for the government to improve public health policies and promote healthy aging.

1. Introduction

At present, China has entered into an aging society, and the degree of aging is deepening. According to the National Bureau of Statistics, the number of elderly adults aged 65 and above was about 176 million at the end of 2019, accounting for 12.6% of the total population. The old-age dependency ratio reached 17.8% and even exceeded 20% in some areas.[1] As life expectancy is increasing, how to achieve high-quality longevity is a major concern for the whole society. *The China Geriatric Health Research Report*, first released in 2018, emphasizes the need to pay equal attention to the physical and mental health and good social adaptation of the old. It points out that achieving and promoting healthy aging are necessary paths for China to cope with the rapid growth of aging trend. Urban–rural population migration has further aggravated population aging in rural areas (Cai & Wang, 2005). Compared with urban areas, the health status of rural middle-aged and older adults is more worrying due to the relatively lagging economic development, inadequate social security system, and the lack of medical resources in rural areas (Lei, Sun, Strauss, Zhang, & Zhao, 2014).

Along with the continuous rapid economic growth of China, the total wealth of society has been increasing. However, the problems

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[1] By the end of 2019, seven provinces/cities in Shandong, Sichuan, Chongqing, Shanghai, Liaoning, Jiangsu, and Anhui had old age dependency ratios exceeding 20% (National Bureau of Statistics of China, 2020).

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caused by uneven distribution have become prominent. The differentiation of income and wealth affects the macroeconomic trend and has an essential impact on personal development. China's persistently high-income disparity also has noticeable urban–rural differences, primarily manifested in income inequality that is more serious in rural areas than in urban areas (Wang, Wan, & Yang, 2014). According to the estimation of Li, Yue, Terry, and Sato (2019), the income gap within urban and rural areas widened between 2007 and 2013, whereas the Gini coefficient of the income gap within rural areas increased from 0.37 to 0.41, which is larger than the income gap within urban areas. In acquaintance societies in rural areas, farmers pay particular attention to interpersonal interactions, and social relationships exhibit solid interactive characteristics. Thus, examining the impact of relative income on health outcomes on the basis of social networks is important for the well-being of middle-aged and older adults in rural China.

Although the relationship between income and health is an important topic widely discussed in health economics, several studies have focused on the relationship between absolute income and individual health (Eibner, Sturn, Fau-Gresenz, & Gresenz, 2004; Grossman, 2000). A paucity of research exploring the effect of relative income on health is observed. The income levels of individuals relative to their peers and other groups in society also play an essential role in health (Wildman, 2003a, 2003b). According to existing studies, literature has explored the impact of deteriorating income distribution on individual health from the perspective of group income inequality, and the findings mainly support a negative relationship between income disparity and health (Li & Zhu, 2006; Pickett & Wilkinson, 2015). However, widely used indicators, such as the Gini coefficient, measure income inequality from a group perspective and thus cannot identify the relative income of different individuals, let alone identify the differences in the impact of income disparity on different individuals. Another related literature measures the relative income levels of people at the individual level by adopting relative deprivation theory (RDT) (Balsa, French, & Regan, 2014; Eibner & Evans, 2005). This theory assumes that individuals tend to compare themselves to a reference group of people with relatively high incomes. As a result, the differences in individuals' income rankings within-group cause the income deprivation to vary individually. This measure of relative deprivation captures additional information at the micro level and is helpful in identifying the health effects of individuals' relative income levels (Lhila & Simon, 2010).

In this study, relative deprivation indicators are constructed using the village where the rural middle-aged adults are located as the reference group. It examines the effect of relative income on the health of rural middle-aged and older adults. Our results reveal the significantly negative impact of deterioration in relative deprivation on the health status of middle-aged and older adults. This finding is consistent when using different health measures and relative deprivation indicators, extending the reference group to the city level or adopting subjective relative deprivation measures. The finding is also robust with respect to first-difference and within estimators. Given the heterogeneity of rural residents, this study analyzes the sample of middle-aged and older adults according to the following elements: age, gender, household income level, and collectivist culture to examine the differences in the effect of relative deprivation on the health status of individuals with different characteristics.

The contributions of this study are as follows: first, on the basis of the closely-knit rural society, we explore the impact of relative deprivation on individual health; we also point out the comparison within the social network, in which the middle-aged and elderly groups are located, on their health. Hence, new ideas are provided for the formulation of public health policies. Second, we adopt a panel event study design to better capture the dynamics of the effects of relative deprivation on health outcomes, including both deterioration and improvement in relative deprivation. Using data from the four waves of the China Health and Retirement Longitudinal Study (CHARLS), we control for the multidimensional fixed effects to eliminate the potential effect of time-invariant unobserved individual heterogeneity. Specifically, the possible external shocks in rural areas are considered to further control for interactive fixed effects, to mitigate the effects of time-variant unobservable factors at the village level, and to improve the accuracy of the estimation results.

The remainder of the paper is structured as follows. Section 2 reviews relevant literature and composes the theoretical framework of the paper. Section 3 sets up the econometric model and introduces the selection and measurement of relevant variables. Section 4 clarifies the data sources and further conducts descriptive statistical analysis. Section 5 presents the estimation results and discussion. Section 6 provides a brief conclusion.

2. Literature review and theoretical framework

Relative deprivation is a state of deprivation, in which individuals find themselves at an economic disadvantage by comparing themselves to others. RDT argues that people tend to make upward social comparisons, that is, to compare themselves with individuals who are better off than those who are worse off (Runciman, 1966). By definition, relative deprivation is a deprivation level based on social comparisons. Unlike the absolute income hypothesis,[2] even individuals with high incomes are affected by comparisons with higher income individuals or groups (Eibner et al., 2004). At the same time, relative deprivation is different from group income inequality, as portrayed by indicators such as the Gini coefficient. The former captures the overall variation in incomes within a group, where all individuals face the same inequality level, whereas relative deprivation is the relative level of individuals with respect to others in the group; the sense of deprivation varies from person to person (Kawachi, Subramanian, & Almeida-Filho, 2002; Lhila & Simon, 2010).

Specifically, relative deprivation measures fall into two broad categories: objective and subjective methods. Yitzhaki (1979) initially proposed the objective indicator-based measures of relative deprivation. These measures are based on Runciman's (1966)

[2] The absolute income hypothesis suggests that absolute income is strongly associated with individual health (Frijters et al., 2005).

theory for indicator construction and proven to be closely related to the Gini coefficient, which is widely used in the field of economics. In subsequent empirical studies, scholars have also attempted to adapt and optimize the measures proposed by their predecessors (Deaton, 2001; Wildman, 2003b). Given that relative deprivation is based on social comparisons, choosing a reference group is another thorny issue in testing RDT (Bossert & D'Ambrosio, 2006; Wolff, Subramanian, Acevedo-Garcia, Weber, & Kawachi, 2010). Sociological studies have shown that people compare themselves with individuals within their social circle or close to their social network. Previous studies mainly classified reference groups on the basis of sociodemographic characteristics, such as age, race, education level, and place of residence. Several studies have compared groups on the basis of the same geographical characteristics, such as country, region, and village (Eibner & Evans, 2005; Knight, Song, & Gunatilaka, 2009; Mellor & Milyo, 2003). In addition, some scholars have established subjective relative deprivation indicators from respondents' subjective feelings and evaluations (Mishra & Carleton, 2015).

Although literature has explored the relationship between relative deprivation and individual health, existing studies have not reached consistent conclusions (Leigh & Jencks, 2007; Ling, 2009; Mellor & Milyo, 2003; Mishra & Carleton, 2015; Wilkinson, 1997). Most studies support a negative effect of relative deprivation on individual health outcomes. However, some scholars have yet to find strong evidence to support the negative association between relative deprivation and individual health. Specifically, Eibner and Evans (2005) found a significant relationship among relative deprivation and mortality, self-rated health (SRH), and health risk behaviors; meanwhile, Mellor and Milyo (2003) and Leigh and Jencks (2007) failed to find a significant negative effect of relative deprivation on health. Many studies have focused on income inequality and its impact on health in the context of China; however, only few have analyzed the potential mechanism through which the effect of relative deprivation on health may be found (Bakkeli, 2016; Chen, 2015; Chen & Meltzer, 2008; Jin & Tam, 2015; Li & Zhu, 2006). Chen and Meltzer (2008) studied the impact of relative income on individual health on the basis of urban and rural residents in China. They found that low relative income may increase the incidence of obesity and hypertension among a sample of rural Chinese residents but not among their urban counterparts. Lyu and Sun (2020) focused on older adults in China and revealed that great feelings of relative economic deprivation are associated with low levels of cognitive function. Moreover, relative economic status adversely affects psychological health.

Psychosocial stress is regarded as an important mechanism of action for relative deprivation to affect individual health. Psychosocial stimulation generated through social comparisons can have an impact on individual health (Wilkinson, 1997). The effect of psychosocial stress on individual health may act through multiple channels. On the one hand, the accumulation of negative emotions, such as long-term psychological imbalance, may lead to illnesses that have direct negative impacts on physical and mental health (Lhila & Simon, 2010). On the other hand, in response to psychosocial stimulation, individuals tend to change their health behaviors by increasing risky behaviors to find ways to release stress, such as poor eating habits, smoking, problem drinking, and physical inactivity. Ultimately, these health-compromising behaviors are harmful to individual health (Balsa et al., 2014; Eibner & Evans, 2005). In addition, some theories analyze the potential impact of income stratification on individual health from the perspective of social relationships (Berkman, Glass, Brissette, & Seeman, 2000; Kawachi et al., 2002; Li & Zhu, 2006). The rejection and jealousy of high-income people based on social comparisons may increase intra-group barriers and weaken interpersonal trust, which affects social behaviors, such as interpersonal interactions. Both are detrimental to individual health.

In general, existing literature focuses on the direct effect of relative deprivation on individual health but lacks in-depth analysis. However, our conclusions may diverge from those of previous studies partly due to the problems associated with their identification strategies, which we aim to address in our work. More specifically, tests based on cross-sectional data ignore the potential impact of unobservable individual heterogeneity on the estimation results. Endogeneity issues must be well addressed. This study adopts a panel event study design to identify the effect of relative income on health outcomes among middle-aged and older adults in rural China, including both deterioration and improvement in relative deprivation.

3. Empirical strategy

3.1. Endogeneity

The key challenge comes from the possible reverse causality between health status and income level (Grossman, 2000; Ling, 2009). An individual's income level affects his or her health investment and thus health level; conversely, an individual's health status affects his or her labor capacity and labor efficiency and thus the corresponding income. Therefore, the empirical estimation must consider the health endowment of the middle-aged and elderly group; otherwise, it may lead to biased estimates of the effect of relative deprivation on their health. In addition, the income levels and health status of middle-aged and older adults may be simultaneously affected by unobservable factors, such as social norms and access to healthcare, which may also lead to estimation bias (Balsa et al., 2014). Moreover, the occurrence of external shocks and extreme events, such as natural disasters, may affect the income and health status of the middle-aged and elderly cohorts simultaneously, leading to the problem of omitted variables.

In this study, we utilize a couple of strategies to mitigate the endogeneity impact on the estimations by improving the model setting and controlling for confounding variables. First, we adopt a panel event study design, which is borne out of older difference-in-differences or two-way fixed effects models (Clarke & Tapia-Schythe, 2021). This method is suitable for exploring the effect of changes in relative deprivation on health, where the occurrence of the event is staggered.

Moreover, multidimensional fixed effects are included to control unobserved individual heterogeneity. The model first controls for individual and time fixed effects, namely, two-way fixed effects model, to remove the effects of unobservable factors that do not vary over time but vary by individual and those that do not vary by individual but vary over time. Two other possibilities for estimation bias are found due to time-vary unobservables at individual levels: (a) changes in the external environment that affect individual health, such as cultural climate, social security policies, natural disasters, and other unexpected shocks; and (b) changes in omitted variables

induced by relative income, which may also affect individual health, such as health knowledge and awareness. Considering that Chinese rural networks are densely connected in the acquaintance society, the same natural and human environment guarantees that the omitted time-varying unobservables are highly likely shared by individuals within villages (Liu, Eriksson, & Yi, 2021). Hence, interaction terms between village-level and year dummies are further controlled in this study to mitigate potential biases caused by time-varying unobservables. These interaction terms represent unobservable common shocks and their heterogeneity on cross sections (Bai, 2009).

In addition, chronic diseases are mostly triggered by long-term factors, such as genes, dietary habits, and living environments, which probably not be affected by household income in the short term. Therefore, the number of chronic diseases is used as a proxy variable for the health endowment of each middle-aged and older adult in this study. At the same time, individual and household characteristics affecting health status are controlled for to minimize the influence of unobservable heterogeneity on the estimation results. A discussion of estimation methods is presented in detail in the next section.

3.2. Econometric model

We adopt a panel event study approach. Following Dobkin, Finkelstein, Kluender, and Notowidigdo (2018), we use both nonparametric and parametric event models to estimate the effect of relative deprivation on the health status of rural middle-aged and older adults. These two models differ in their setting of the baseline period. Specifically, the former uses one wave before the event as the baseline period, which helps us visualize the pre- and post-treatment trends, whereas the latter uses all periods *ex ante* as the baseline period, which allows us to precisely estimate the event of interest (Cotti, Nesson, & Tefft, 2019; Dobkin et al., 2018; Schmidheiny & Siegloch, 2020).

3.2.1. Define an event

Event is usually defined as a policy of interest to be studied, and many scholars have estimated the impact of exposure to some quasi-experimental policy by using a panel event study design (Clarke & Tapia-Schythe, 2021; Schmidheiny & Siegloch, 2020). By contrast, we focus on relative income and its impact on health outcomes, which is a continuous variable. As abovementioned, we use relative deprivation, specifically the Deaton indicator, to measure relative income at the individual level. Given that this indicator is a continuous variable ranging from 0 to 1 (see Section 3.3.2 for details), we take the following approach to define a considerable change in relative deprivation as *an event*. We will also conduct a series of robustness checks.

We initially calculate the changes in the Deaton indicator between adjacent waves via first-differencing, and the percentage of individuals showing the greatest change are treated as having an event shock. Among various deviations, we use 25% as the threshold in the baseline estimation. Given that the selection of criteria determines whether an individual is affected by the shock, we define different percentages to examine the robustness of our results. Furthermore, the change in relative deprivation includes two aspects: (1) deterioration in relative deprivation (increase in the value of the indicator, upper 25%); and (2) improvement in relative deprivation (decrease in the value of the indicator, lower 25%). We analyze the impact of changes in both directions.[3]

3.2.2. Nonparametric event study

Nonparametric event study allows us to see the dynamic effects on health outcomes by comparing each wave with the baseline period (Dobkin et al., 2018). We treat one wave prior to the event as the baseline period. This method effectively checks the trend before the occurrence of an event. We set up the model as follows:

$$H_{ict} = \alpha + \sum_{j=-3}^{-2} \beta_j b_{ict}^j + \sum_{j=0}^{2} \beta_j b_{ict}^j + \theta X_{ict} + T_t + u_{ic} + \delta_c T_t + \varepsilon_{ict}, \tag{1}$$

for t=2011, 2013, 2015, and 2018, where b_{ict}^j=1[$t = Event_i + j$] is a binary variable indicating that each individual is a given number of periods away from the *event*, among which 1[•] is an indicative function; β_j is the dynamic treatment effect j periods before ($j < 0$) or after ($j \geq 0$) the event, the baseline (omitted) period is one wave prior to the *event*, where $j = -1$;[4] H_{ict} denotes the number of health outcomes of individual i in village c in year t; X_{ict} denotes individual and household characteristics, including age, marital status, education level, employment status, health status in the base period, household size, and household per capita income; T_t denotes time fixed effects; u_{ic} refers to individual fixed effects; $\delta_c T_t$ is the interaction term between village-level and year dummies, that is, the interaction fixed effects; ε_{ict} is the idiosyncratic error term.

3.2.3. Parametric event study

To obtain accurate estimated coefficients that can be directly compared in the current event and after the event, we specify the following model:

$$H_{ict} = \alpha + \sum_{j=0}^{2} \gamma_j b_{ict}^j + \theta X_{ict} + T_t + u_{ic} + \delta_c T_t + \varepsilon_{ict}, \tag{2}$$

[3] Obviously, those individuals who have experienced both deterioration and improvement events in the database can contaminate the estimated effect. Therefore, we remove those observations from the estimation sample.

[4] Given that the *event* is defined based on the first-differenced values between two adjacent periods, the final observation window is from three periods before the *event* to two periods after the *event*, where $j \in [-3, 2]$

The only difference here is that all waves before the event ($j < 0$) are set as the baseline period. Therefore, the estimated coefficients describe the impact of the event. These coefficients include the effects at the current, one, and two waves after the deterioration in relative deprivation as well as the average effects over two waves. Unsurprisingly, the coefficients of time-invariant variables, such as gender, cannot be identified and are therefore omitted from both estimation methods. We further use relative deprivation indicators directly and then report the first-difference and within estimators in the robustness checks. The model specification is set up in a similar way as Eq. (1).

3.3. Variable measurement

3.3.1. Health measures

The physical and mental health of middle-aged and older adults are analyzed and measured by physical action and depression scores, respectively. First, physical action score includes two components: the activity of daily living (ADL) and movement limitation. ADL is mainly used to characterize individuals' daily living activities, including the 11 necessary skills[5] for maintaining basic life. Movement limitation indicators have seven questions and focus on relatively high physical quality.[6] In terms of variable values, a point system exists to construct physical action indicators. The points vary according to the corresponding options for ADL and movement limitations. The rules of points for each option are as follows: "no difficulty" accumulates 3 points, "have difficulty but can still do it" accumulates 2 points, "have difficulty and need help" accumulates 1 point, and "cannot do it" accumulates 0 point. Therefore, the higher the score it obtains, the more physically active and healthy the middle-aged and elderly respondents are. Second, a 10-question version of the Center for Epidemiologic Studies-Depression is used in CHARLS to measure mental health status. The respondents are asked about whether they faced psychological problems in the most recent week. In negative emotional statements, such as "I was bothered by things that do not usually bother me," the least frequent of the four options is scored as 3; the most frequent is scored as 0. The aggregate point for these questions, namely, depression score, is used as a mental health variable. Apparently, a high value of depression score implies good mental health.

In terms of the multidimensional nature of individual health, SRH, cognitive capacity, and life satisfaction are used to test the robustness of the empirical results. SRH is an overall evaluation of individuals' current health condition, including five options of "excellent," "very good," "good," "fair," and "poor." It is assigned a score from 5 to 1 on the basis of the evaluation from high to low, with higher scores indicating better SRH. Cognitive capacity is measured by the number of 10 simple words memorized in a short period. In general, the more the total number of words remembered per unit of time, the higher the cognitive level of middle-aged and older adults. Life satisfaction is an assessment of life-as-a-whole. CHARLS provides five options for the life satisfaction question: "completely satisfied," "very satisfied," "somewhat satisfied," "not very satisfied," and "not at all satisfied."

3.3.2. Relative deprivation

The key explanatory variable in this study is the relative deprivation of rural middle-aged and older adults, which is based primarily on their household income compared with reference groups. Yitzhaki and Deaton indicators are widely used for measuring relative deprivation in existing studies (e.g., Balsa et al., 2014; Eibner & Evans, 2005). Among them, the Yitzhaki indicator is concisely defined and easy to construct. However, it is sensitive to changes in the sample size of the reference group and the income level. When comparing individuals from different reference groups or cross-period comparisons, it may face specific problems. For this reason, Deaton (2001) adjusted and optimized the Yitzhaki indicator by standardizing it with the mean value of the reference group. Compared with the Yitzhaki indicator, the Deaton indicator is not sensitive to changes in income levels. The standardized values range from 0 to 1, making it suitable for comparing relative deprivation across different reference groups. Thus, this study mainly adopts the Deaton indicator to measure the relative deprivation of rural middle-aged and older adults. The following are the specific definitions of the two indicators.

Assuming that the sample size in the reference group is n and the income levels y of all individuals in the reference group are sorted in ascending order, $y_1 \le y_2 \le \ldots \le y_n$. The Yitzhaki indicator defines the relative deprivation YRD_i of individual i as follows:

$$YRD_i = \int_{y_i}^{y_n} [1 - F(y)]\,dy = \frac{1}{n}\sum_{j=i+1}^{n} (y_j - y_i), \forall y_j > y_i, \text{and } i = 1, \ldots, n, \tag{3}$$

where y_n is the highest income in the reference group, $F(y)$ is the cumulative distribution function of income,[7] and $1 - F(y)$ is the probability that individual i's income is higher than y.

Assuming that the mean value of income in the reference group is μ, the relative deprivation DRD_i of individual i, as defined by the Deaton indicator, is

$$DRD_i = \frac{1}{\mu}\int_{y_i}^{y_n} [1 - F(y)]\,dy = \frac{1}{n\mu}\sum_{j=i+1}^{n} (y_j - y_i), \forall y_j > y_i, \text{and } i = 1, \ldots, n. \tag{4}$$

[5] Dressing, bathing and showering, eating, getting into and out of bed, using the toilet, doing household chores, shopping for groceries, managing money, and taking medicines.

[6] Movement limitations include long-distance walk, weight-bearing, stooping, and kneeling or crouching.

[7] The distribution function of income has no special set form.

Table 1
Summary Statistics.

Variables	Unit	Observations	Mean	SD
Health measures				
Physical action score	Point	21,283	48.06	7.85
Depression score	Point	19,910	20.60	6.69
SRH	1 = Poor, …, 5 = Excellent	20,647	2.04	0.84
Cognition test score	Point	18,184	3.58	1.89
Life satisfaction	1 = Not at all satisfied, …, 5 = Completely satisfied	19,123	3.20	0.80
Relative deprivation				
DRD	0–1	21,283	0.55	0.29
DRD (city-level)	0–1	21,283	0.59	0.28
Subjective RD (compared with relatives)	1 = Much better, …, 5 = Much worse	8,883	3.54	0.85
Subjective RD (compared with neighbors)	1 = Much better, …, 5 = Much worse	8,885	3.51	0.82
Individual and household characteristics				
Age	Year	21,283	61.48	10.06
Male	1 = Male; 0 = Female	21,283	0.48	0.50
Education in years	Year	21,283	4.42	4.02
Married	1 = Married; 0 = Others	21,283	0.86	0.35
Dummy variable for work last year	1 = Yes; 0 = No	21,283	0.74	0.44
Number of chronic diseases	Number	21,283	1.46	1.53
Number of household members	Number	21,283	2.93	1.56
Household per capita income	Ten Thousand yuan	21,283	0.85	1.24

As previously mentioned, selecting a reference group is a crucial part of defining the relative deprivation of individuals (Bossert & D'Ambrosio, 2006; Deaton, 2003). Numerous studies have revealed that rural areas in China have a strong "demonstration effect," which is highlighted by the fact that individuals' decision-making behavior is influenced by other residents in the village (Mangyo & Park, 2011). Therefore, taking the per capita income levels of other middle-aged and elderly households in their village as the reference group, we construct the relative deprivation indicator of each respondent. Among the respondents, the lower the per capita income of the middle-aged and elderly households is, the higher their income deprivation is, and vice versa.

To test the robustness of the results for alternating the definitions of the reference group, we extend the reference group from the village-level comparison to the city-level comparison, constructing an additional reference group: rural middle-aged and older adults in the same prefecture-level city. We also construct two groups of subjective relative deprivation indicators on the basis of respondents' subjective evaluations of their living standards.[8]

3.3.3. Control variables

This study draws on relevant literature in the field of health economics to control for factors affecting the health status of rural middle-aged and older adults (Lei et al., 2014; Strauss et al., 2010; Yi, Liu, & Xu, 2019). Specifically, individual characteristics include age, marital status, education in years, work status, and number of chronic diseases. A close relationship is observed between individual health endowment and current health status. Chronic diseases are caused mainly by long-term factors, such as genes or dietary habits and living environments, and are usually not influenced by current income levels. Hence, the number of chronic diseases is selected as a proxy variable for the health endowment of each respondent. Household characteristics include the number of household members and household income per capita.[9] In addition, individual and time fixed effects are controlled to eliminate unobservable individual heterogeneity and the influence of external factors, such as annual macro policies, on the health status of middle-aged and older adults. Table 1 provides the details of all variables used in this study.

4. Data and descriptive statistical analysis

4.1. Data sources

The data used here were obtained from CHARLS, particularly data for 2011, 2013, 2015, and 2018. The CHARLS national baseline

[8] Respondents are asked to rate their own living standards compared with others, namely, relatives or neighbors in their village. The ratings include: "much better (1 point)," "a little better (2 points)," "about the same (3 points)," "a little worse (4 points)," and "much worse (5 points)." The lower the respondent's evaluation of his or her own life, the higher the level of subjective relative deprivation. The final value of subjective relative deprivation ranges from 1 to 5. Subjective relative deprivation indicators are only available for two waves, 2011 and 2013.

[9] Household income includes the wage, transfer, agricultural, and business incomes of all household members. To avoid the interference of income outliers, household per capita income was winsorized in this study.

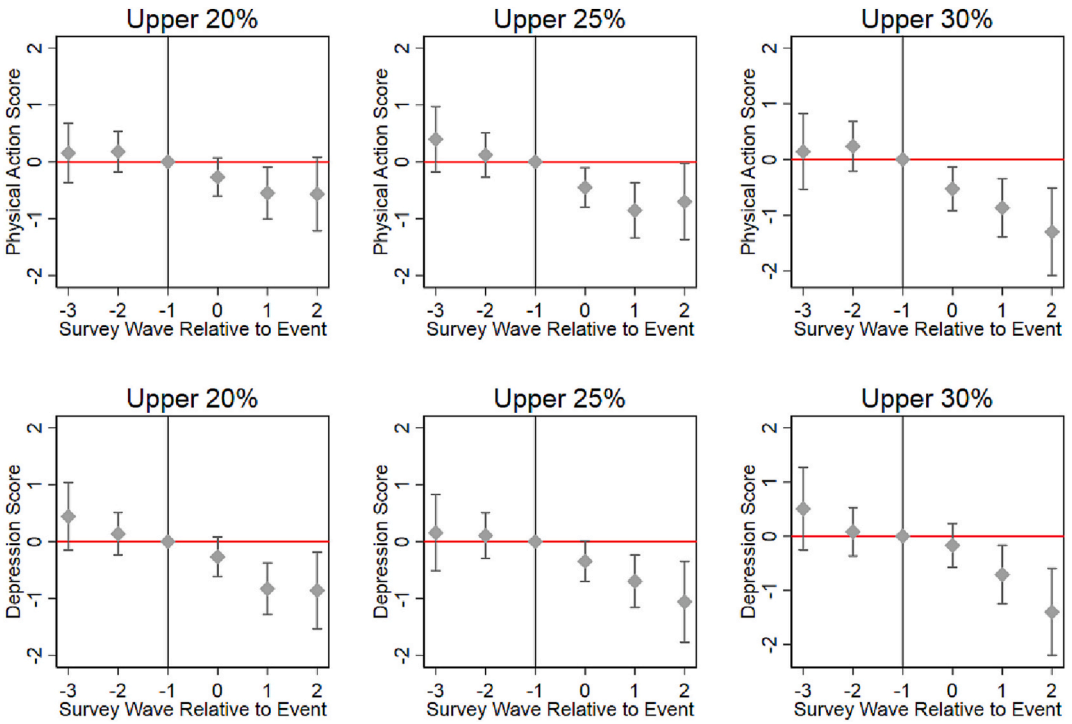

Fig. 1. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, Deterioration in Relative Deprivation).
Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the deterioration in relative deprivation as indicated by the solid vertical line in the plot.

survey was conducted in 2011, with a follow-up survey performed every two years, targeting middle-aged and older Chinese adults[10]. A multistage, random cluster process was used to draw the samples that can be treated as representative of the middle-aged and older Chinese population. The questionnaire covered detailed information on demographic and sociological characteristics, health status and functioning, physical measurements, work, retirement and pensions, income, consumption and assets, and basic community conditions (Zhao, Hu, Smith, Strauss, & Yang, 2014). The analysis was conducted among adults aged 40 years or older in rural areas. The final samples involved in the regressions differed slightly due to the missing values of different health indicators, as presented in Table 1.

4.2. *Descriptive statistical analysis*

Table 1 illustrates the summary statistics for the main variables. First, from the individual characteristics of the middle-aged and older adults in the sample, the overall average age was 61, with 48% of men and 52% of women. Their average education level was low, at the elementary school level and below (4.4 years). In terms of marital status, 86% of the middle-aged and older adults were married and living with their spouses. In comparison, the remaining middle-aged and older adults were separated, divorced or widowed. Approximately 74% of them were working last year, whereas 26% were not working or had retired. The family size of the sample middle-aged and older adults was around 3, and the per capita annual household income was about RMB 8500.[11] In terms of health outcomes, the average number of chronic diseases was 1.5, indicating that rural middle-aged and older adults suffered from at least one chronic disease on average, and their health condition was unoptimistic. The mean value of SRH was approximately 2, close to the rating of "fair," whereas that of life satisfaction was close to the assessment of "somewhat satisfied."

[10] The target population of CHARLS is to survey middle-aged and elderly who are 45 years old and above. However, respondents' spouses may be younger than 45 years old in the database.
[11] Using the Consumer Price Index for rural residents from the *China Statistical Yearbook*, this study adjusts the per capita household income in 2013, 2015, and 2018 to the price level of 2011.

Table 2
Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Parametric Event Study, Deterioration in Relative Income).

	Physical action score		Depression score	
	(1)	(2)	(3)	(4)
Upper 25%				
Current wave	−0.501***		−0.377**	
	(0.178)		(0.178)	
One wave after	−0.867***		−0.712***	
	(0.248)		(0.234)	
Two waves after	−0.699**		−1.066***	
	(0.343)		(0.363)	
Average effect		−0.594***		−0.465***
		(0.176)		(0.171)
Control variables				
Age	1.395***	1.398***	−0.148	−0.138
	(0.129)	(0.128)	(0.116)	(0.116)
Square of age	−0.011***	−0.011***	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Education in years	0.051	0.051	0.024	0.024
	(0.036)	(0.036)	(0.040)	(0.040)
Married	0.499	0.499	1.978***	1.980***
	(0.339)	(0.340)	(0.326)	(0.326)
Dummy variable for work last year	1.719***	1.722***	0.500***	0.503***
	(0.149)	(0.149)	(0.136)	(0.136)
Number of chronic diseases	−0.659***	−0.661***	−0.284***	−0.286***
	(0.060)	(0.060)	(0.054)	(0.054)
Number of household members	−0.081**	−0.080**	0.058	0.061
	(0.037)	(0.037)	(0.038)	(0.038)
Household per capita income	−0.070	−0.068	−0.049	−0.042
	(0.048)	(0.048)	(0.050)	(0.050)
Constant	4.375	4.302	24.478***	24.122***
	(4.689)	(4.678)	(4.162)	(4.149)
Individual FE	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES
Interactive FE	YES	YES	YES	YES
Observations	21,283	21,283	19,910	19,910

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses are clustered at the household level.

5. Results and discussions

5.1. Baseline results

5.1.1. Deterioration in relative deprivation

Fig. 1 shows that the deterioration in relative deprivation significantly reduces the health status of middle-aged and older adults both physically and mentally. The coefficients are not statistically significant from 0 during the pre-treatment period, thereby suggesting that the treatment and control groups share the same trend prior to the deterioration event, which verifies the hypothesis of the parallel trend assumption. Compared with the baseline period (−1 wave), the health outcomes significantly decline in the current wave when the deterioration event occurred, and these effects persist in the two subsequent waves. These results are consistent across different event thresholds (20%, 25%, and 30%) as shown in Fig. 1. Without loss of generality, 25% is recognized as the baseline definition in Section 5.

Due to the model specification, Fig. 1 cannot provide a straightforward illustration of the coefficients of the nonparametric event study. Therefore, we further report the regression results based on parametric estimations, including the effects at current, one, and two waves after the deterioration event as well as the average effects over two waves. Table 2 shows the parametric estimates. The impact on the health outcomes of middle-aged and older adults is immediate and persists in the subsequent periods. Columns (1) and (2) show that a deteriorating shock in relative deprivation decreases the physical action scores by 0.5 points for an individual in the current wave yet keeps the other conditions unchanged. This impact persists and becomes stronger in one and two waves after the deterioration event, with the physical action scores being lower by 0.9 and 0.7 points, respectively. On average, the physical action scores have decreased by 0.6 points two waves after deterioration. Columns (3) and (4) report similar effects on mental health. The coefficients suggest that a decline in depression scores is significantly associated with deterioration in relative deprivation by 0.4 points in the current wave and by 0.7 and 1.1 points in one and two waves after the event, respectively.

In terms of control variables, middle-aged and older adults accompanied by spouses have better health outcomes than their

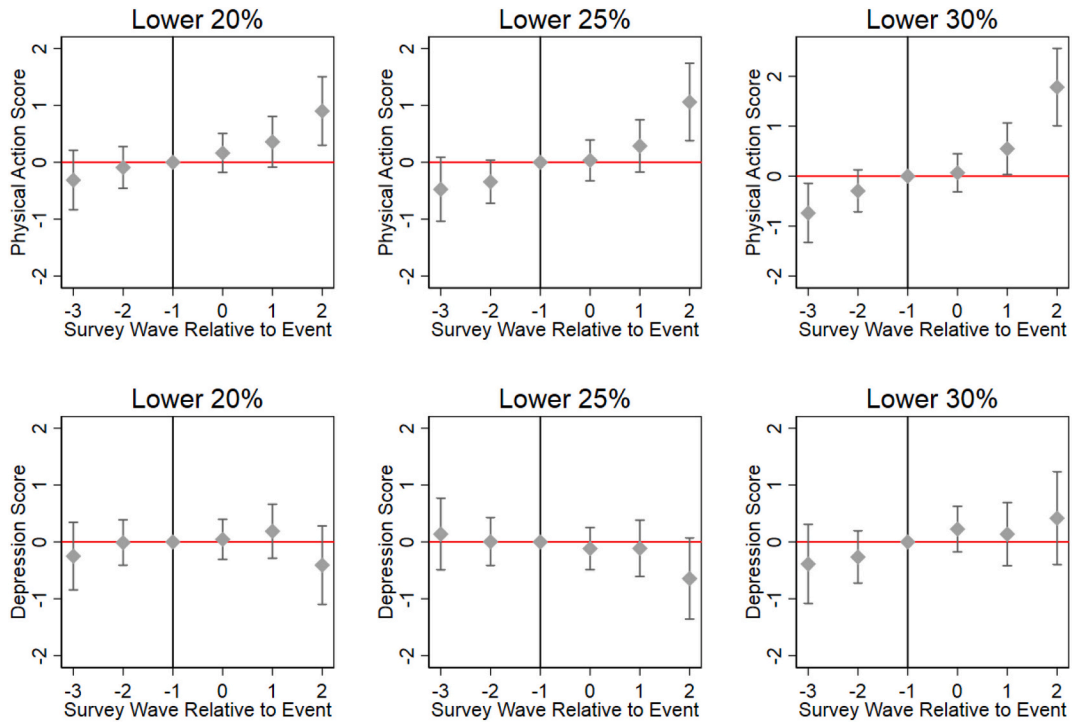

Fig. 2. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, Improvement in Relative Deprivation).
Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the improvement in relative deprivation as indicated by the solid vertical line in the plot.

separated, divorced or widowed counterparts. As a proxy variable of health endowment, the more chronic diseases the middle-aged and older adults have, the worse their health status is, consistent with the expectation of this study. The coefficients of per capita household income are insignificant[12], possibly because relative deprivation is an indicator constructed on the basis of household income. To ensure that the identification of relative deprivation is based on the premise of controlling for absolute income, we still put the relative deprivation and the per capita household income into the empirical model for the estimation. We also attempt to include only per capita household income in the empirical model for reference. The coefficient of per capita household income is positive, indicating that the increase of absolute household income can improve the health status of middle-aged and older adults, which is consistent with the findings in previous studies (Ettner, 1996; Frijters, Haisken-DeNew, & Shields, 2005).

5.1.2. Improvement in relative deprivation

We further investigate the effects of improvement in relative deprivation on health outcomes among middle-aged and older adults. Fig. 2 illustrates the results. We only find statistically significant effects on physical action scores after two waves of the improvement event. Unlike the deterioration event, we find no statistical and substantive evidence of a response on depression scores. Table 3 reports similar results. The improvement in relative deprivation slightly increases the physical action score in the current and one wave after the event by 0.1 and 0.3 points, respectively. Although the physical action scores increase by 1.1 points after two waves, the average effects of the improvement event are not statistically significant. The result that the deterioration event has a statistically significant effect on health outcomes whereas the improvement event does not have such significant effect may suggest that the impact of changes in relative income is asymmetrical.

The coefficients of the nonparametric event study with a more extreme event definition (15% and 35%) show similar results as the baseline estimation. Therefore, the selection of criteria is not a concern in this study. To further rule out the endogeneity of the control variables, we use lagged chronic diseases as a proxy for health endowment. The results are visualized in Figs. A1 and A2 in Appendix A.

5.2. Robustness checks

5.2.1. Different health measures

Considering the multidimensional nature of health, we adopt several health-related indicators for robustness checks, namely, SRH,

[12] Similar results have been found in Salti (2010), when absolute income and relative deprivation are included in models.

Table 3
Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Parametric Event Study, Improvement in Relative Income).

	Physical action score		Depression score	
	(1)	(2)	(3)	(4)
Lower 25%				
Current wave	0.146		−0.124	
	(0.182)		(0.183)	
One wave after	0.344		−0.111	
	(0.235)		(0.251)	
Two waves after	1.083***		−0.640*	
	(0.347)		(0.363)	
Average effect		0.222		−0.134
		(0.178)		(0.180)
Control variables				
Age	1.375***	1.375***	−0.162	−0.158
	(0.128)	(0.128)	(0.115)	(0.115)
Square of age	−0.011***	−0.011***	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Education in years	0.049	0.052	0.025	0.024
	(0.036)	(0.036)	(0.040)	(0.040)
Married	0.512	0.510	1.991***	1.989***
	(0.340)	(0.341)	(0.327)	(0.327)
Dummy variable for work last year	1.727***	1.727***	0.513***	0.513***
	(0.149)	(0.149)	(0.136)	(0.136)
Number of chronic diseases	−0.664***	−0.660***	−0.282***	−0.284***
	(0.060)	(0.060)	(0.054)	(0.054)
Number of household members	−0.078**	−0.077**	0.065*	0.064*
	(0.037)	(0.037)	(0.038)	(0.038)
Household per capita income	−0.018	−0.015	0.041	0.038
	(0.045)	(0.046)	(0.048)	(0.048)
Constant	4.841	4.810	24.735***	24.621***
	(4.678)	(4.687)	(4.142)	(4.139)
Individual FE	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES
Interactive FE	YES	YES	YES	YES
Observations	21,283	21,283	19,910	19,910

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses are clustered at the household level.

cognitive capacity, and life satisfaction.

The estimation results in Fig. 3 indicate the significant effect of deterioration in relative deprivation on the SRH and subjective evaluation of life satisfaction of rural middle-aged and older adults. Similarly, we find no substantive effects of the improvement event on either SRH and life satisfaction among middle-aged and older adults. In terms of cognitive capacity, those residents who experience an improvement event obtain slightly higher cognition test scores. Consistent with the baseline results, the deterioration in relative deprivation has more profound effects on the health outcomes of individuals compared with an improvement event.

5.2.2. *Different relative deprivation indicators*

To ensure the robustness of the above results, we directly use different relative deprivation indicators as key explanatory variables without constructing *an event* under alternative empirical strategies (see Table 4). In Panel A, we use the Deaton indicator, and the estimates[13] of DRD share a similar relationship with health outcomes, as listed in baseline results. Then, we attempt to change the reference group of rural middle-aged and older adults. Public services and policy implementations are mainly coordinated at city levels in China. Hence, the social comparison scope is extended from the village level to the city level. The estimates of Panel B show that irrespective of the reference group definition, relative deprivation indicators share significant negative impacts on health outcomes. The magnitudes of the coefficients are slightly greater in absolute value due to the change in the reference group. On the basis of respondents' subjective evaluations of living standards, the estimates of Panels C and D reveal that subjective relative deprivation has significantly adverse effects on their health, regardless of using relatives or neighbors in their village as a reference measure, which is in line with previous studies (Mishra & Carleton, 2015).

5.2.3. *Different estimation methods*

In addition to first-difference estimation, we further apply within estimation under the assumption that idiosyncratic errors are

[13] In this section, we apply the first-difference estimation, which relies on weak exogeneity assumptions that permit future values of the covariates to be correlated with the error term, especially when there exists feedback from the idiosyncratic shock today to a covariate tomorrow (Cameron & Trivedi, 2010; Wooldridge, 2015).

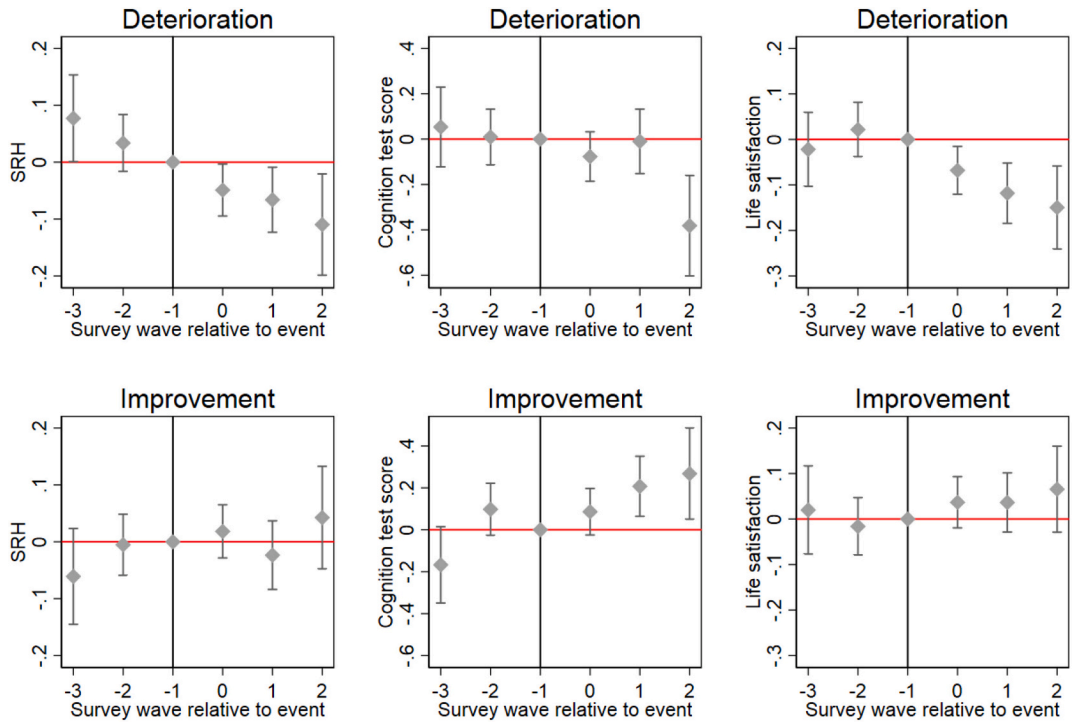

Fig. 3. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, with Different Health Measures).

Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the changes in relative deprivation as indicated by the solid vertical line in the plot.

serially uncorrected, under which within estimators are more efficient than first-difference estimators[14]. From columns (3)–(4) of Table 4, relative deprivation has a negative impact on the health status of middle-aged and older adults in rural China. Specifically, a 1-unit increase in relative deprivation is associated with an 0.6-point decrease in both physical action and depression scores, which is slightly greater in magnitudes than first-difference estimators in columns (1)–(2). Overall, both first-difference and within estimators are consistent with the baseline results. Hence, we believe that our results are robust with respect to estimation strategies.

Our findings can be further understood by comparing them with those of previous studies, especially those conducted in China. First, previous studies show the varying magnitudes of the relationship between relative income and health outcomes, which depend on the definition of the reference group (Lhila & Simon, 2010). Our results are similar in magnitude with those of Li and Zhu (2006), who also used households in the same community as the reference group to generate the relative deprivation indicators[15]. Comparatively, the relative deprivation indicators used by Ling (2009) were hinged at the provincial level, thereby leading to a larger coefficient estimate. Second, in terms of estimation methods, both Li and Zhu (2006) and Ling (2009) used between-variation across individuals by conducting a pooled cross-section analysis. In this section, we adopt a panel data-based method for causal inference and only use the within-variation over time for each individual. Therefore, the estimation method may also explain the differences in the coefficient magnitudes. Given that the abovementioned studies have used the same database from the China Health and Nutrition Survey, we argue that the data itself are not mainly responsible for the mixed results. Instead, properly selecting the health variables, defining the reference group when constructing relative income, and using identification methods are critical to estimate the adverse effect of relative deprivation on health outcomes.

5.3. *Heterogeneity analysis*

The analysis for different population characteristics can help identify the differences among various groups and help in the target selection of health intervention policies. We classify middle-aged and older adults according to age, gender, household income level, and collectivist culture to further explore the heterogeneity (see Figs. 4 and 5). Only the deterioration event is estimated in this section

[14] Following Liu et al. (2021), we exclude all singleton samples in the analysis.

[15] However, due to the small variation across individuals in the dependent variable, the findings of Li and Zhu (2006) do not support the relative income hypothesis. Specifically, Li and Zhu (2006) used SRH status as the dependent variable (1 = excellent or good; 0 = fail or poor), which may not have sufficient variation across individuals in a cross-section analysis (73% of the sample has a value of 1, whereas only 27% has 0).

Table 4
Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Panel-data Methods, with Different Relative Deprivation Indicators and Estimation Methods).

	First-difference estimators		Within estimators	
	Physical action score	Depression score	Physical action score	Depression score
	(1)	(2)	(3)	(4)
Panel A: Deaton indicator				
DRD (community-level)	−0.538***	−0.442**	−0.594***	−0.578***
	(0.205)	(0.226)	(0.200)	(0.209)
Observations	30,017	27,648	41,998	38,993
Panel B: Deaton indicator				
DRD (city-level)	−0.639***	−0.630**	−0.754***	−0.719***
	(0.227)	(0.252)	(0.221)	(0.234)
Observations	30,017	27,648	41,998	38,993
Panel C: Subjective relative deprivation indicator				
Subjective RD (compared with relatives)	−0.449***	−0.551***	−0.454***	−0.540***
	(0.070)	(0.075)	(0.070)	(0.075)
Observations	7904	7825	15,808	15,650
Panel D: Subjective relative deprivation indicator				
Subjective RD (compared with neighbors)	−0.533***	−0.559***	−0.531***	−0.561***
	(0.074)	(0.078)	(0.074)	(0.078)
Observations	7909	7830	15,818	15,660
Individual FE	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES
Interactive FE	YES	YES	YES	YES

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses are clustered at the household level. All regressions include marital status, work status, number of chronic diseases, household size and household per capita income. Sample loss due to constructing *an event* is avoided via the direct use of different relative deprivation indicators as key explanatory variables. We also conducted regressions using the same sample with the event study method, and the results remained consistent.

given that the improvement in relative deprivation has no significant effects as mentioned above.

In terms of age subgroups, relative deprivation shares a negative relationship with the health status of middle-aged (aged between 40 and 60 years) and elderly people (greater than or equal to 60 years old) in rural China. However, the decline in health outcomes among the elderly group is obviously larger than that among the middle-aged group as shown in Fig. 4. For the gender subgroups, we find no statistically significant differences between the male and female respondents, thereby confirming the absence of gender differences.

In Fig. 5, the sample is divided into low- and high-income groups on the basis of the median per capita income (4480 yuan/year) of rural households. Compared with the high-income group, the low-income group is more significantly affected by the deterioration event and hence suffers from great adverse health effects at the relative income level. In addition, collectivism is argued to be positively correlated with the degree of social comparisons in literature (Gorodnichenko & Roland, 2012; White & Lehman, 2005). Individuals in a collectivist culture more likely seek social comparisons than those in independent cultures, especially making upward comparisons. Hence, this study attempts to group the sample according to the local collective culture within villages. CHARLS has information about whether each village has a large surname[16], which is used as a proxy for the local collectivist culture. From Fig. 5, the negative effects on health outcomes is pronounced in villages with large surnames, suggesting that sociocultural environment has important implications for social comparisons among middle-aged and older adults. However, we should also be careful in interpreting the results because of the relatively small subsample sizes of villages without large surnames[17].

6. Conclusion

On the basis of the four waves of the CHARLS follow-up survey, we adopt a panel event study approach to explore the effect of relative income, as measured by relative deprivation indicators, on the health of middle-aged and elderly people in rural China. Our results highlight the significant impact of deterioration in relative deprivation on the health of these adults. These findings are supported by different health measures and relative deprivation indicators and are robust to both first-difference and within estimators. Our heterogeneity analysis indicates that the elderly group is more significantly affected by relative deprivation than its middle-aged counterparts. However, no significant gender differences are observed. In terms of household income, low-income respondents are

[16] The percentage of local persons who have the same surname is above 20%.
[17] The number of middle-aged and older adults who live in villages with and without large surnames is 17,182 and 3985, respectively.

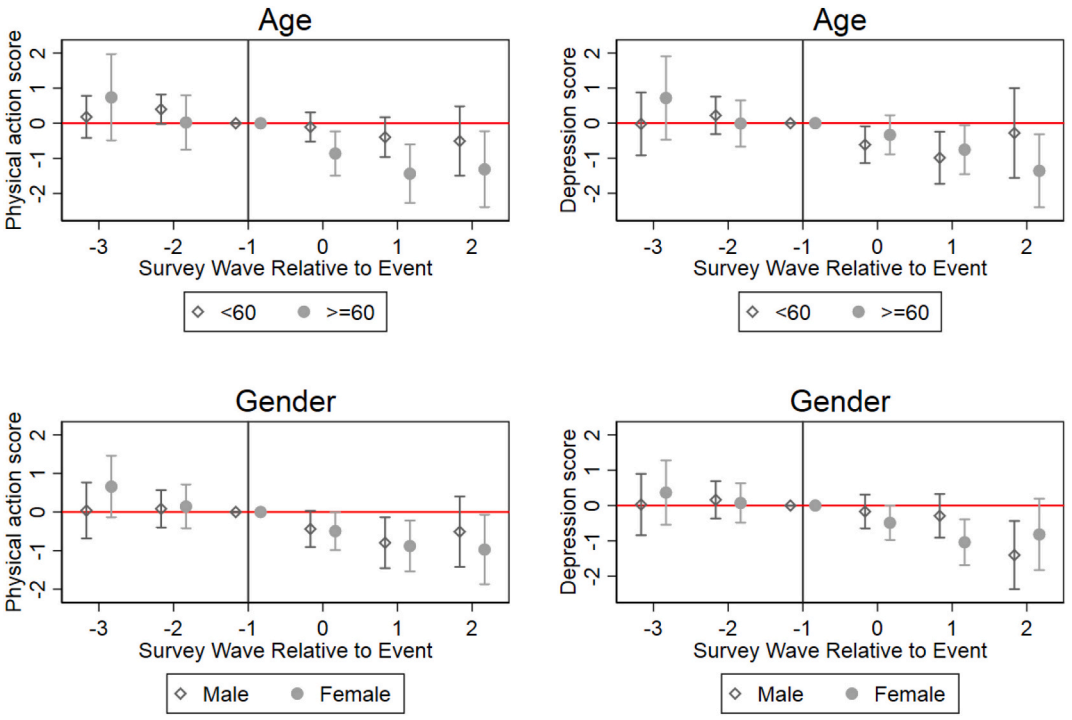

Fig. 4. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, with Different Subsamples). Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the deterioration in relative deprivation as indicated by the solid vertical line in the plot.

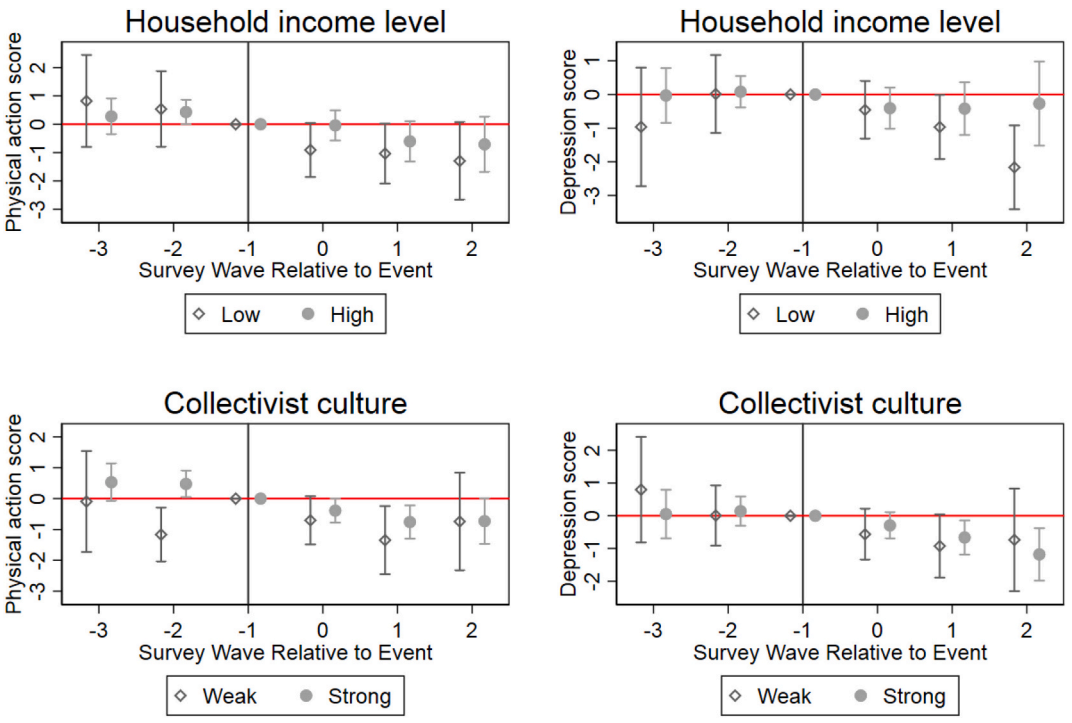

Fig. 5. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, with Different Subsamples). Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the deterioration in relative deprivation as indicated by the solid vertical line in the plot.

significantly affected by relative deprivation in comparison with high-income counterparts. Relative deprivation is pronounced for middle-aged and older adults who live in a village with a collectivist culture, where people tend to seek upward social comparisons.

In the context of an aging society, an in-depth analysis of the effect of relative deprivation on the health outcomes of the elderly people has profound policy implications, which ensure the welfare level of elderly people in rural areas and promote healthy and active aging. On the basis of our findings, we suggest further improving the rural pension insurance system, moderately increasing the pension level within the financial affordability, enhancing the protection role of pensions, and supplementing the financial subsidies for the elderly in special hardship.

This study has several limitations. First, CHARLS is a nationally representative survey of Chinese people aged 40 years and older. However, those households without middle-aged and older adults are not included in the sample and are therefore excluded from the calculation of the relative deprivation in this study. Our results need to be further validated by using data that cover all rural Chinese residents. Second, CHARLS currently publishes data in four waves spanning from 2011 to 2018. We presume that longitudinal analyses can reveal additional variations in relative income given that households and individuals may respond differently in the long term.

Declaration of Competing Interest

None.

Data availability

Publicly available datasets were analyzed in this study. This data can be found here: China Health and Retirement Longitudinal Study (CHARLS) http://charls.pku.edu.cn/.

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Appendix A. Appendix

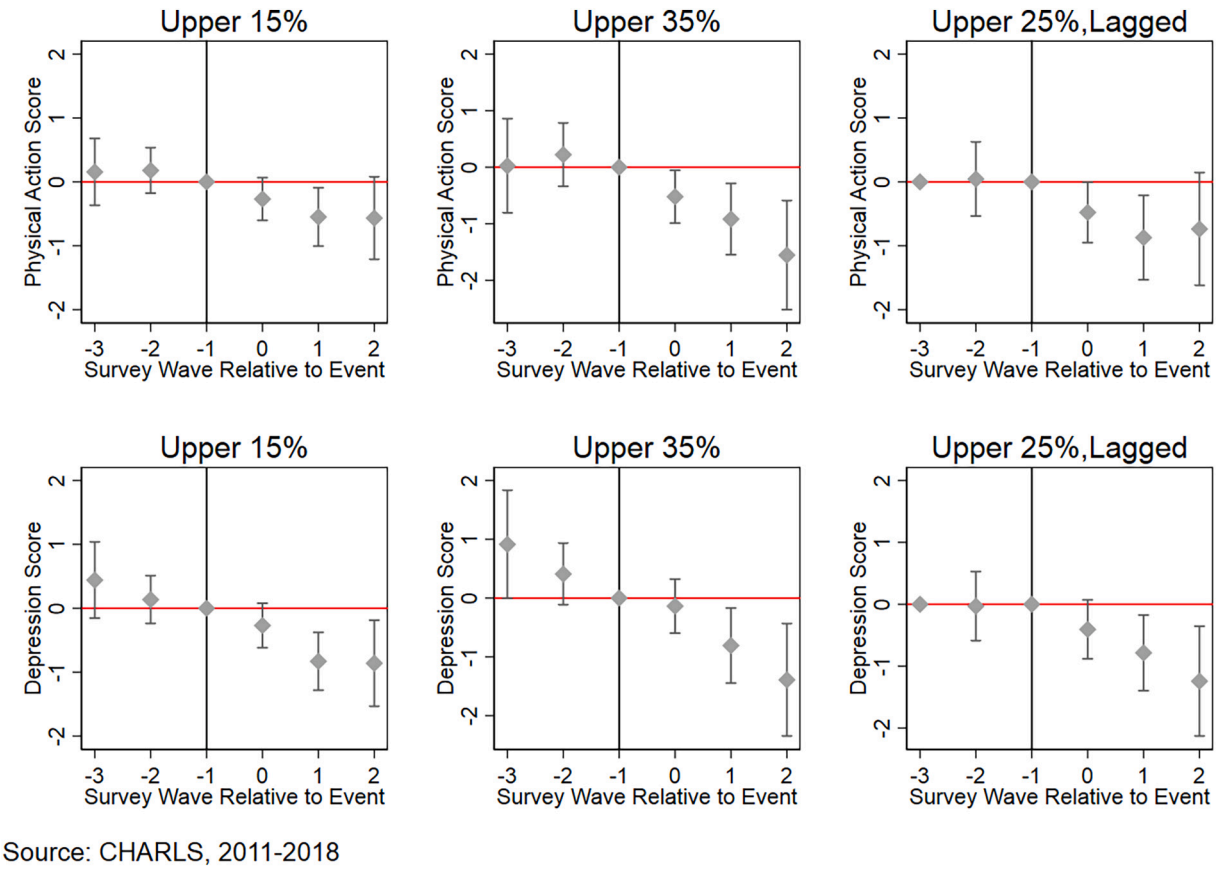

Fig. A1. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, Deterioration in Relative Deprivation).

Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the deterioration in relative deprivation as indicated by the solid vertical line in the plot.

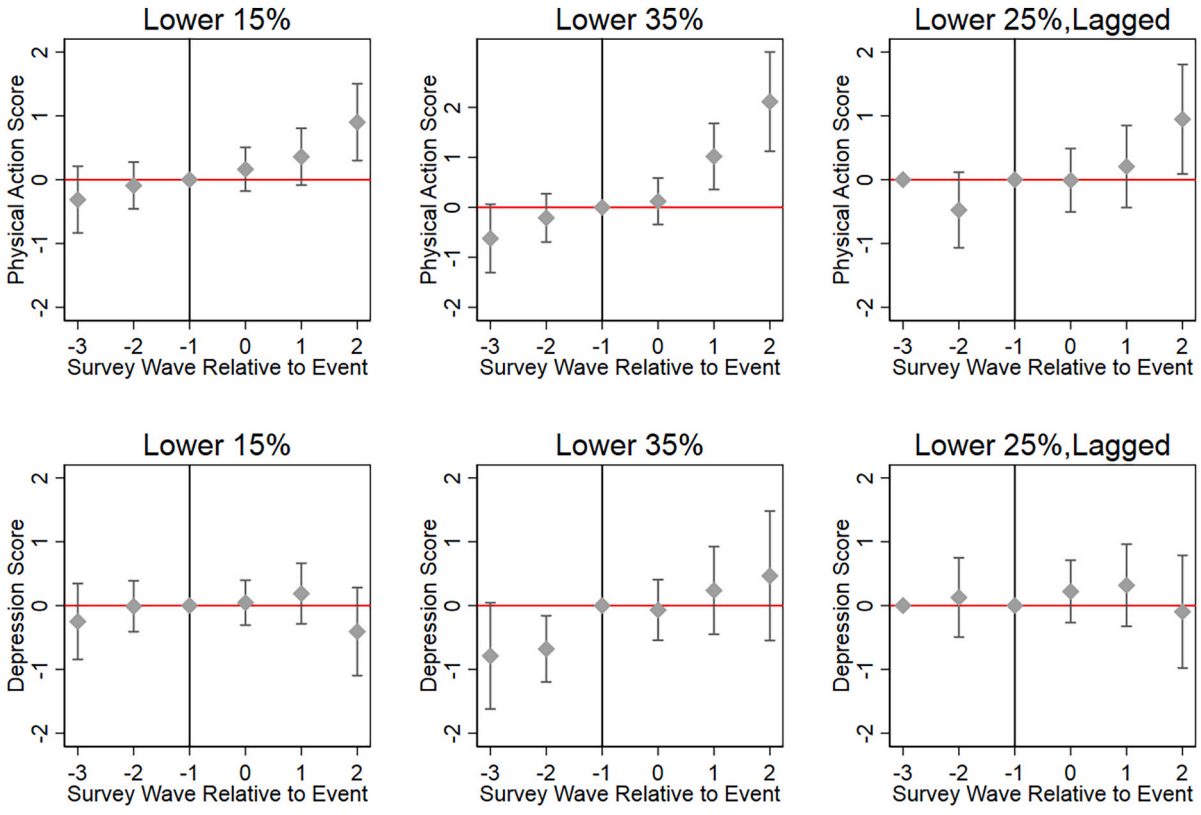

Fig. A2. Effects of Relative Deprivation on the Health of Middle-Aged and Older Adults (Nonparametric Event Study, Improvement in Relative Deprivation).

Notes: Point estimates are displayed along with their 95% confidence intervals as described in Eq. (1). The baseline (omitted) period is one wave prior to the improvement in relative deprivation as indicated by the solid vertical line in the plot.

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