



Article

Does Income Inequality Impair Health? Evidence from Rural China

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Abstract: In the context of the Healthy China strategy and the targeted poverty alleviation policy, based on the survey data of 1710 apple planters in Shandong, Yunnan, Shaanxi, and Gansu provinces, we selected the Probit model and the mediating effect test model to analyze the impact of income inequality on the self-rated health of farmers in this paper. The main results are as follows: First, income inequality within villages and townships had a significant negative impact on self-rated health, with both showing inverted U-shaped relationships, while income inequality within counties had no significant impact on self-rated health. Second, income inequality can impact the health of farmers, in terms of tobacco and alcohol behaviors, social trust, and sense of relative deprivation, where the mediating effect ratio of these three factors combined accounted for 32.4% of the total effect. Furthermore, the effect of income inequality on health was heterogeneous among different income groups, where the negative impact of income inequality on the self-rated health of the high-income group was less than that of the low-income group, indicating that an increase in income inequality serves to aggravate the degree of health inequality. Therefore, the government should adopt differentiated policies to improve the health of farmers. In rural areas with high income inequality, the government should focus on increasing the income of low-income groups, guide them to develop a healthy lifestyle, improve their social trust, and reduce their sense of relative deprivation. In rural areas where incomes are generally low, the government should first guide qualified farmers to become rich, then encourage others to become rich later.

Keywords: farmer; self-rated health; income inequality; mediating effect



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1. Introduction

In 2019, China's per capita gross national income (GNI) reached \$8235.409 [1], higher than the average level of middle-income countries. By World Bank standards, China has entered the ranks of upper-middle-income countries. At the same time, the income inequality in China has been constantly expanding, among which the income inequality within rural areas is rapidly expanding [2] and, even, exceeding the income inequality within urban areas [3]. In fact, rural income inequality in China has a long history. The long-term implementation of the income distribution policy, of giving priority to efficiency, has produced some rich people, however, the poor do not get rich. Instead, the rich get richer and the poor get poorer, resulting in income disparities and a more inflexible class structure with reduced socio-economic mobility. In the long run, these income disparities and social immobility could undermine the continued improvement in the welfare of rural people and impair economic development in a more general sense [4]. Therefore, policy-makers might well consider policies that lead, either directly or indirectly, to decreases in income inequality, including in rural areas. To solve this issue, China has been implementing

accurate poverty alleviation policies in rural areas since 2015, adopting a “one-to-one” approach to allocate responsible cadres to poor households after accurately identifying poor households, in order to achieve the goal of getting rid of poverty and narrowing income inequality.

Simultaneously, health problems, such as obesity and chronic diseases, in rural China are rising, instead of falling. According to a survey of health services in China, the prevalence of chronic diseases among Chinese residents rose from 123.3‰ in 2003 to 245.2‰ in 2013, and in rural residents, rose from 104.7‰ to 227.2‰, doubling in ten years and increasing faster than in urban residents [5]. The prevalence of chronic diseases has two definitions: One is the ratio of the number of patients surveyed to the total number of people surveyed in the first half-year of the survey. The other is the ratio of the number of cases investigated in the first half-year (a person may suffer from one or more diseases, and a maximum of three diseases should be filled in during the investigation) to the total number of persons investigated. The former definition mainly considers the number of people with the disease, no matter how many kinds of diseases a person with a chronic disease has; the latter definition considers, primarily, the need for health services. The prevalence of chronic diseases in this paper was calculated according to the latter definition. The increase in the prevalence of chronic diseases is in contrast with the increase in income, which has aroused widespread concern in the government and academia. To solve this issue, the Politburo has put forward the goal of the “Healthy China 2030 Plan”, while the State Council issued “Suggestions on the implementation of the healthy China Initiative” (2019) and set up the China Health Promotion Action Committee. These measures emphasize that the health of the population is a crucial symbol of national prosperity and the foundation of national development.

Since Leibenstein [6] proposed the logical relation between income and health in 1954, academics have argued about the relationships among poverty, income inequality, and health. However, these studies have mainly been carried out in the United States, and it is still not clear whether the relation between income, income distribution, and health at the individual level is a universal phenomenon [7]. Among them, the most compelling evidence proposes that there is a non-linear relationship between income and health. For example, Deaton and Lubotsky [8], used data from the National Longitudinal Mortality Survey in 1980, providing striking illustrations of the very marked non-linear relationship between income and health. Furthermore, they pointed out that there is no convincing evidence that income inequality has an independent effect on health, after controlling for individual influences on health (including income). Considering this, we take account of the possibility that there exists a non-linear relationship between income and health in this empirical analysis.

On the other hand, numerous studies have also shown that income inequality affects health, with the earliest evidence coming from cross-country comparisons. The literature of this period mainly selected macro indicators, such as life expectancy and mortality [9,10]. However, there exists a “total bias” in the macro-data. Due to the marginal diminishing effect of income growth on health, overall health will decline when income inequality expands. Therefore, studies on income distribution and health have applied micro-data for analysis within a nation in the late 1990s. Some studies have supported the idea that income inequality has a negative impact on health [11,12], while others stated that income inequality has a positive impact on health [13,14]. When Yang [14] studied the relation between income inequality and the health of farmers using household survey panel data of nine provinces in China in 2004 and 2006, he found a threshold for the Gini coefficient. When it is below that threshold, the Gini coefficient can improve health status while, when it is above the threshold, health deteriorates; suggesting an inverted U-shaped relationship between income inequality and health status. Sturm and Gresenz [15] studied data of 60 cities in the United States, and found that there was no relevance between income inequality and self-rated health, physical health, or mental health.

Some studies have also discussed the health effects of the interaction between income inequality and income. Wang [16] used the Order–Logit model and China Health and Nutrition Survey (CHNS) data in 2006 to find that the interaction term coefficient was negative, which means that an increase in income weakens the negative impact of income inequality on health. Zhou and Qi [17] also reached similar conclusions, when using Chinese General Social Survey (CGSS) data in 2005, but emphasized that the interaction term represents limited substantive significance. Feng and Yu [13] studied rural panel data from the CHNS in 1997 and 2000, and concluded that the interaction term has significant positive effects on health.

Relevant empirical studies mainly come from the United States, Europe, and other developed countries and, so, their conclusions may not be applicable to developing countries, such as China. To be specific, the findings may be influenced by regional differences in income levels, consumption habits, and medical services. Therefore, research into the relationship between income inequality and health in China is helpful to improve the theory, in this regard. In China, some researchers have distinguished different groups of people, such as urban residents and rural residents, to discuss the impact of health inequality on health. Using CHNS data in 2006 and China Family Panel Studies (CFPS) data in 2016, for example, Chen [18] and Zhang [19] both found that income inequality had no significant impact on the health of urban residents, but had a significant negative impact on rural residents. Qi [20] used micro panel data of nine provinces in China and found that the relationships between income inequality and health were different between urban and rural areas. Among them, income inequality had a significant positive impact on the health of urban residents. However, it had a significant negative impact on the health of rural residents.

In summary, the existing studies have some aspects to be improved: First, most of the subjects covered both urban and rural residents, ignoring the differences between them, resulting in an increase in data variance and heteroscedasticity. Second, in the study of farmer-related health issues, the research subjects were mainly rice, wheat, and other grain planters, while there is little research focused on farmers who produce high-value agricultural products, such as apple planters. Their production process is characterized as labor-intensive, technology-intensive, and capital-intensive, which has higher requirements on their physical health. Therefore, we take apple planters as an example in this paper, as typical and representative subjects to study the relationship between income inequality and the health of farmers who grow high-value crops. Third, due to the neglect of the right-biased distribution of health, the estimation results using traditional regression technology are biased.

The paper includes following topics: How does income inequality affect the health of farmers? Are there any differences in the impacts of different regional levels of income inequality on health? Is there any difference in the impact of income inequality on the health of different income groups? To solve these problems, we use Order–Probit, Binary Probit, mediating effect test models, and survey data of 1710 farmers in the main apple-producing provinces of Shandong, Yunnan, Shaanxi, and Gansu, in order to analyze the impact of and clarify the relationship between income inequality and the self-rated health of farmers.

2. Theoretical Analysis and Research Hypothesis

There are three theories regarding the impact of income inequality on health: One is the absolute income theory, which suggests that income inequality does not affect health. The other two are the income inequality hypothesis and the neighborhood effect, both of which consider income inequality to have an impact on health. In this section, we comprehensively review these three theories.

2.1. Absolute Income Hypothesis

Preston [21] and Gravelle [22] proposed the absolute income theory, arguing that income is the key factor affecting health and, as long as the income effect is controlled, income inequality will not affect health. The specific model of income effect is as follows:

$$h_i = f(y_i), \text{ and } f' > 0, f'' < 0, \quad (1)$$

where h_i and y_i represent the health and income of individual i , respectively. It is assumed that the first derivative of the function is positive (i.e., the function is monotonically increasing) and its second derivative is negative. Namely, the slope of the tangent decreases with an increase in income, and it is a concave function. Imagine a situation where there are only two members of a society: One is rich, and the other is poor. As shown in Figure 1, the initial income of the poor individual is Y_{P0} , the initial income of the rich individual is Y_{R0} , and the initial average health of the society is H_0 . When the rich individual transfers part of their income to the poor individual, their income decreases to Y_{R1} . At this time, the income of the poor individual increases to Y_{P1} , and the corresponding average social health is H_1 , which is greater than their initial health H_0 . Subramanian et al. [23] refer to the diminishing marginal effect of income on health as the “concave relation”. The reason for this rise in average health is that transferred wealth improves the health of the poor individual more than it damages the health of the rich individual.

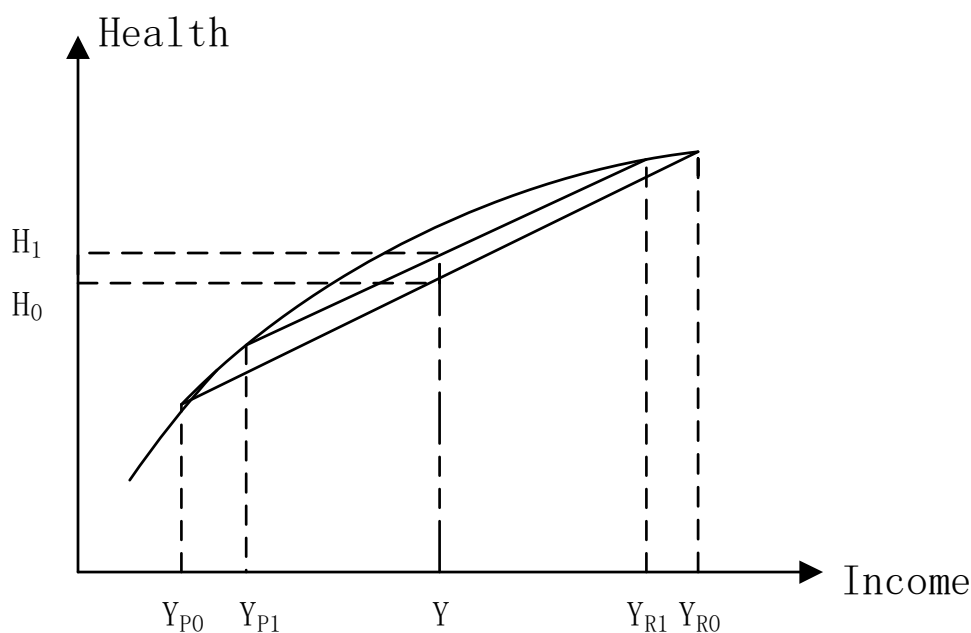


Figure 1. Absolute income theory.

Based on this, Hypothesis 1 (H1) is proposed in this paper.

Hypothesis 1 (H1). When the “concave relation” of income is controlled, income inequality will not affect health.

2.2. Income Inequality Hypothesis

Wilkinson [24] pointed out that income inequality itself has a direct impact on health, regardless of how high the income is; namely, the existence of the “pollution effect”. It is worth noting that the interaction between income inequality and income may have implications for health. According to this interaction, the Wilkinson hypothesis [21] can be divided into strong and weak hypotheses: The former hypothesis sees no difference in the impact of income inequality on the health of low- and high-income groups. In other

words, income inequality has the same effect on health, no matter if the individuals are rich or poor (see Figure 2). As the Gini coefficient increases, the income-health curve IH_0 moves down to IH_s , as a whole, with the health of the rich individual falling from H_{R0} to H_{RS} and the health of the poor individual falling from H_{P0} to H_{PS} , meaning the health of the poor and rich individuals deteriorate equally. The latter hypothesis argues that income inequality is more harmful to the health of low-income groups, as high-income groups are more aggressive in crowding out medical resources, leading to an insufficient supply of local public medical resources and worsening the health of the poor. In addition, compared with high-income groups, low-income groups are more likely to feel frustrated and depressed psychologically. This indicates that the income-health curve IH_0 moves down to IH_W . The health damage of the rich individual ($H_{R0}-H_{RW}$) will be less than that of the poor individual ($H_{P0}-H_{PW}$) when income inequality increases.

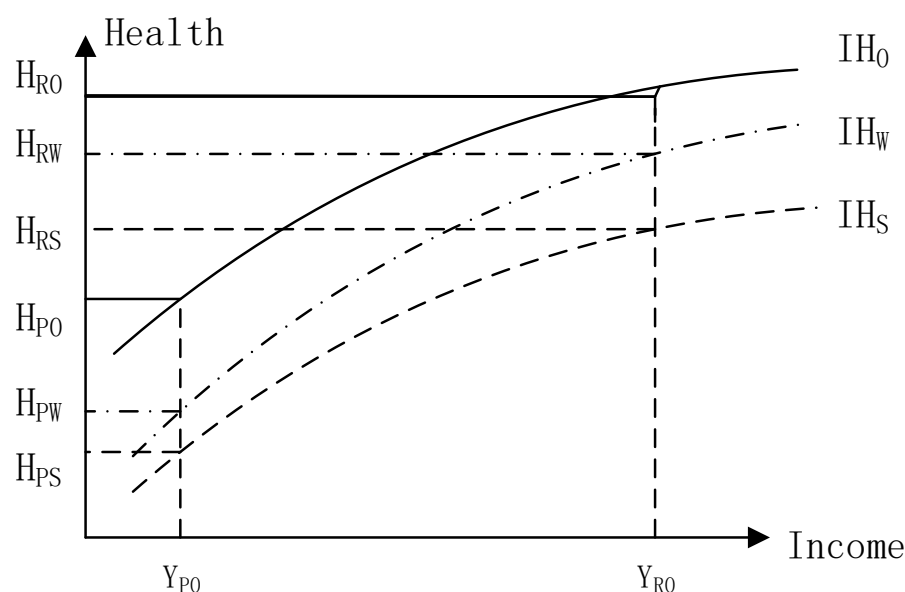


Figure 2. Income inequality hypothesis.

Based on this, Hypotheses 2 (H2) and 3 (H3) are proposed in this paper.

Hypothesis 2 (H2). When the “concave relation” of income is controlled, increasing income inequality has a negative impact on the health of farmers.

Hypothesis 3 (H3). The impact of income inequality on the health of different income groups of farmers is heterogeneous.

2.3. Neighborhood Effect

Defining a “community” or “neighborhood” is a challenging and controversial task. In Western societies, many studies use administrative definitions, such as census district, electoral district, or zip code [25]. Community usually refers to a social group with certain common psychological factors, based on a certain geographical area. This group has at least three elements: A population group with a geographical boundary, one or more common activities or service centers, and a sense of geography or some collective consciousness and behavior [26]. Regarding the size of the community, it is generally believed that the most basic community is a village, followed by townships and counties. The neighborhood effect refers to the fact that the community environment directly or indirectly affects the way of thinking and behavior of residents, thus affecting their health [27]. Generally, the neighborhood effect is classified in terms of the built environment and social environment. The built environment can be summarized as urban land-use patterns under different

scales, the walkability index [28], park green space, and food store accessibility. The social environment is embodied in the neighborhood code of conduct and values, social capital and community cohesion, income inequality, crime and order, and so on [29]. From the perspective of the neighborhood effect, income inequality directly or indirectly affects health behavior and health status. To be specific, when living in communities with a large income inequality, vulnerable residents have less access to resources, such as medical services, and are more likely to feel stressed and deprived, thus increasing their consumption of tobacco and alcohol. Health damage is caused by the long-term effects of these daily stresses [30,31]. Second, income inequality between the larger community is often accompanied by a lack of social capital and community cohesion. As important indicators of social capital and community cohesion, social relations enable people to obtain emotional affiliations and identity, thus helping to alleviate their psychological problems, such as loneliness, social alienation, and depression [32]. Neighborhoods with high social capital can solve community problems and create a healthy living environment for residents by organizing collective activities; for example, to make it more convenient for physical exercise [33].

In conclusion, income inequality affects health in four main ways:

1. Public medical services—On one hand, income inequality can affect health by increasing public medical expenditure. Specifically, if income inequality is accompanied by an increase in government tax revenue, then the government's public spending capacity will increase, and public health expenditure may increase. It is worth noting that increased income inequality will encourage high-income groups to improve their health needs, thereby encouraging medical institutions to introduce more advanced medical technologies. Moreover, the "spillover effect" of medical technology introduction and the technology itself will lead to a general improvement of health [34]. On the other hand, income inequality may have a negative impact on medical expenditure. The increase in income inequality can lead to a differentiation of medical service demand and behavior between high- and low-income people. High-income groups tend to get better services from provincial- and county-level medical institutions. In contrast, low-income groups tend to receive health services from local community medical institutions, which leads to an underestimation of public goods and a reduction in public expenditure [22].
2. Social relations—Widening income inequality may worsen health by eroding social capital. The inherent logic is that the expansion of income inequality weakens social cohesion [35], which leads to a loss of social support and social connections, resulting in a lack of social-emotional support in coping with health risks, thus further worsening health [11].
3. Relative deprivation—In the process of increasing income inequality, people may experience a sense of relative deprivation [36]. If income inequality is too high and social strata are seriously divided, low-income groups may have a sense of relative deprivation, due to their low status. Numerous studies have shown that this sense of deprivation not only deprives them life opportunities, but also harms their mental health [37].
4. Tobacco and alcohol behaviors—Individuals living in bad social relationships and long-term negative emotions are more likely to experience stress and, thus, develop unhealthy behaviors such as smoking and drinking, which eventually damage their mental and physical health [38].

Therefore, Hypothesis 4 (H4), the last hypothesis of this paper, is proposed:

Hypothesis 4 (H4). *Income inequality may have effects mediated by health services, social relations, relative deprivation, and tobacco and alcohol behaviors.*

3. Materials and Methods

3.1. Data Sources

For this paper, we used data from a field survey of apple planters in Shandong, Yunnan, Shaanxi, and Gansu provinces from June to August 2018 conducted by The Apple Industrial Economics Research Office of China Modern Agricultural Industry System. Among these provinces, Shandong belongs to the apple dominance area around Bohai Bay, Yunnan belongs to the characteristic apple-producing area in the Cool Plateau of southwest China, and Shaanxi and Gansu belong to the apple dominance areas in the Loess Plateau. The samples cover the eastern and western regions of China (as shown in Figure 3). The survey adopted a combination of typical sampling and stratified sampling. The sample province was obtained through stratified sampling, while the sample county was determined by the typical sampling method, based on the information concentration degree and the apple industry development concentration degree. Then, 4 to 6 sample villages were selected in the sample counties, and 20 to 25 apple households were randomly selected as the respondents for each village. The questionnaire covered the information of the resident population members of sample households, and face-to-face interviews were used in the research process. A total of 860 sample apple households were investigated, involving 2701 permanent residents, including 1730 farmers who were engaged in apple production at home. The research was aimed at permanent resident apple planters. In order to ensure the representativeness of the samples, 1710 valid samples were obtained after eliminating samples with missing values, outliers, and inconsistencies.

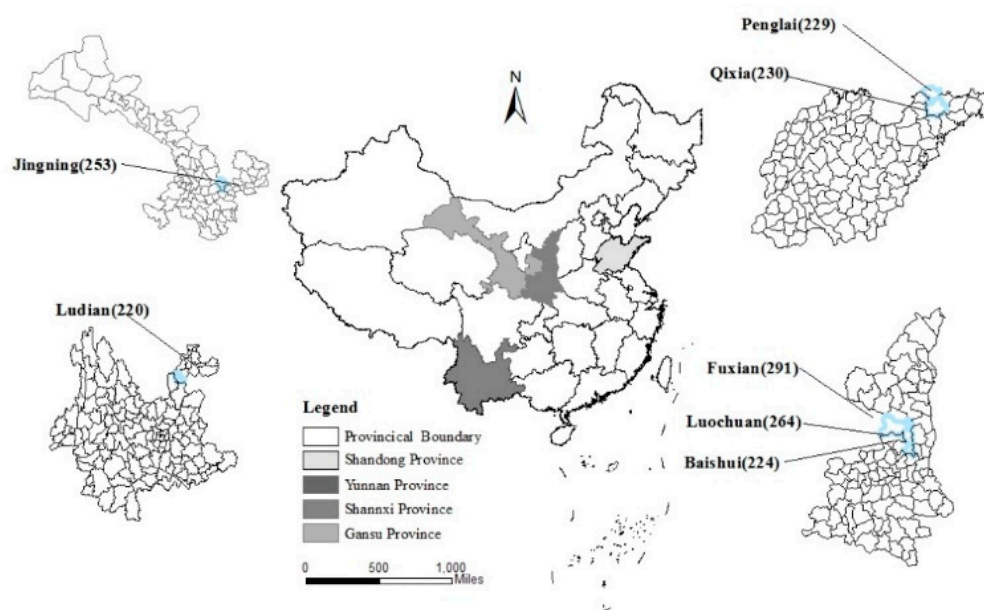


Figure 3. Sample distribution map.

3.2. Measures

3.2.1. Dependent Variable

In this paper, health perceptions—that is, self-rated health—was used to represent the health status of respondents. Based on the health demand model of Grossman [39], the concept and principle of self-rated health have been widely applied. Although some researchers have questioned the subjectivity of self-rated health, studies have shown that it can effectively reflect the health differences of different groups, to a certain extent, and that it is a reliable, comprehensive, and effective measurement method [40]. The self-rated health score in this questionnaire ranged from 1 to 4. The higher the score, the better the farmer's self-rated health. Specifically, "very unhealthy" was associated with a score of 1, "not very healthy" is a score of 2, "relatively healthy" is a score of 3, and "very healthy" is

a score of 4. Considering that the original self-rated health was not normally distributed, resulting in the deviation of the estimated results, we constructed three self-rated health indicators, referring to the method of Zhou et al. (shown in Table 1) [12]. On this basis, the Shapiro–Francis W test was conducted on “self-rated health 2” and “self-rated health 3”; the results showed that the P values were both greater than 0.05, indicating that they were subject to normal distributions. Considering the simplification of subsequent empirical operations, we took the regression results of “self-rated health 3” as the criterion, while the other two were taken as robustness tests.

Table 1. Definition of health indicators.

	Self-Rated Health 1	Self-Rated Health 2	Self-Rated Health 3
Very healthy	4	3	1
Relatively healthy	3	2	
Not very healthy	2		0
Very unhealthy	1	1	

3.2.2. Independent Variable

The existing literature has adopted many methods to measure income inequality, including the Gini coefficient, Thiel index, coefficient of variation, and Dalton index, among which the Gini coefficient method has been especially widely used. It refers to the proportion of total household income used for an unequal distribution. Its value can only be between 0 and 1: A value of 0 represents the absolute equality of income distribution among residents (i.e., full equality of income among people without any difference), while a value of 1 means that the income distribution among residents is absolutely uneven, which means a person of one unit occupies 100% of the income. The smaller the Gini coefficient is, the more equal the income distribution is. A value of 0.4 is commonly used internationally as the warning line for the income inequality between the rich and poor. Therefore, we calculated the Gini coefficient to measure income inequality. Concretely, the Gini coefficient within villages was adopted as the key independent variable, while the Gini coefficients within townships and counties were used for the robustness test.

3.2.3. Intermediary Variable

The mediating effect analysis in this paper was divided into four paths: First, medical expenditure was selected to represent health services, and its logarithm was taken. The second was social relations. We assessed social trust by asking “Can most people be trusted or do you have to be careful?”. An answer of 1 meant that most people can be trusted, while 0 meant the opposite (binary variable). The third was the sense of relative deprivation. Referencing the research of Karvonen and Rahkonen [41], the sense of relative deprivation was obtained by asking “where is your economic status in the village?”. The score ranged from 1 to 10, with 10 representing the highest status in the village and 1 the lowest status. The fourth was tobacco and alcohol behaviors (binary variable). Either of these behaviors was assigned a score of 1, while neither smoking nor drinking was assigned a score of 0.

3.2.4. Control Variables

Referring to the previous literature, the control variables designed in this paper were individual characteristics, family characteristics, and regional dummy variables.

Individual characteristic variables included gender, age, education, political status, and working time. Among them, political identity was represented by whether they were a party member or village cadre. If yes, it had a value of 1; otherwise, it was 0. Working time was measured by the average months of work in a year. The longer the working time, the greater the labor intensity. An enormous amount of literature has proved that working time has a significant negative effect on health [42].

Family characteristic variables included household size, household income per capita, land, access to credit, and ownership of car. According to the absolute income theory, the

model is incorporated into the square term of per capita income [21,22], and the logarithm of both per capita income (“income” for short) and per capita income squared terms (“income squared” for short) were used. Land reflects the labor intensity and economic level. Specifically, the larger the area, the higher the labor intensity and the more likely to damage health; but, at the same time, the larger the area, the higher the agricultural income, which can promote health through the income effect, such that the overall direction of the impact of land on health is uncertain. Access to credit was divided into private credit and formal credit. If the farmer had borrowed money in the past five years, it had a score of 1. On the contrary, if the farmer had not borrowed any money, the score was 0. Access to credit and ownership of a car reflect the wealth of households.

The regional dummy variable controlled the provincial geographic location factor by introducing a provincial dummy variable, among which Yunnan province was the control group. Tables 2 and 3 show descriptive statistics for all variables.

Table 2. Descriptive statistics of self-rated health.

Variable	Option	Frequency	Percentage (%)
Self-rated health 1	4 = Very healthy	652	38.13
	3 = Relatively healthy	743	43.45
	2 = Not very healthy	281	16.43
	1 = Very unhealthy	34	1.99
Self-rated health 2	3 = Very healthy	652	38.25
	2 = Relatively healthy	743	43.51
	1 = else	315	18.25
Self-rated health 3	2 = Very healthy	652	61.87
	1 = else	1058	38.13

Table 3. Descriptive statistics.

Variable	Mean	Std. Dev	Min	Max
Dependent variable				
Self-rated health 1	3.177	0.771	1	4
Self-rated health 2	2.200	0.725	1	3
Self-rated health 3	0.381	0.486	0	1
Independent variables				
Village Gini coefficient	0.343	0.080	0.233	0.575
Township Gini coefficient	0.364	0.069	0.258	0.557
County Gini coefficient	0.427	0.033	0.398	0.485
Individual characteristic variables				
Gender (Male = 1; Female = 0)	0.523	0.500	0	1
Age	50.007	10.027	20	76
Education (year)	7.563	3.384	0	16
Political identity (Yes = 1; No = 0)	0.084	0.277	0	1
Working time (Months/year)	7.888	2.585	5	12
Family characteristic variable				
Household size	3.284	1.447	1	8
Income (ln)	3.884	1.573	1.051	12.101
Land (mu)	7.443	4.950	1	60
Private credit (Yes = 1; No = 0)	0.499	0.500	0	1
Formal credit (Yes = 1; No = 0)	0.284	0.451	0	1
Ownership of a car (Yes = 1; No = 0)	0.305	0.461	0	1
Regional dummy variable				
Shaanxi (Yes = 1; No = 0)	0.455	0.498	0	1
Shandong (Yes = 1; No = 0)	0.268	0.443	0	1
Gansu (Yes = 1; No = 0)	0.148	0.355	0	1

Table 3. Cont.

Variable	Mean	Std. Dev	Min	Max
Intermediary variable				
Health care expenditure (ln)	6.677	1.430	2.526	12.206
Social trust (Yes = 1; No = 0)	0.620	0.486	0	1
Relative deprivation	5.433	1.772	1	10
Tobacco and alcohol (Yes = 1; No = 0)	0.443	0.497	0	1

3.3. Model Specification

3.3.1. Probit and Order-Probit Models

For Hypotheses H1 and H2, the model equation is:

$$H_i = \alpha_{i0} + \alpha_{i1}Q + \alpha_{i2}I + \alpha_{i3}I^2 + \alpha_{i4}X + \varepsilon_i, \quad (2)$$

where $i = 1, 2, 3$; H_1 is “Self-rated health 1”; H_2 is “self-rated health 2”; H_3 is “self-rated health 3”; Q , I , and X are the income inequality, income, and other control variables, respectively; and ε is the error term. Equation (2) is also the benchmark model for this article. When $i = 1$ or 2 , H_i is an ordered multi-classification variable, and the Order-Probit model was adopted. When $i = 3$, H_i is a binary variable, and the Binary-Probit model was used. For Hypothesis 3 (H3), the interactive term of income and income inequality was added to the benchmark model.

3.3.2. Mediating Effect Test

In this paper, the Bootstrap method proposed by Wen and Ye [43] was used to establish the regression models of independent variable versus dependent variable, independent variable versus intermediary variable, independent variable versus dependent variable, and intermediary variable versus dependent variable, respectively, as shown below:

$$Y = cX + e_1, \quad (3)$$

$$M = aX + e_2, \quad (4)$$

$$Y = c'X + bM + e_3, \quad (5)$$

where X stands for income inequality, M stands for the intermediary variable, and Y stands for the health of farmers. The test process was divided into four steps [44], as shown in Figure 4. The first step was to test the regression coefficient c ; if significant, we continued to the second step; otherwise, the analysis was stopped. In the second step, the coefficients a and b were tested in turn. If both were significant, the impact of income inequality on the health of farmers was at least partially realized through the intermediary variable M ; then, we proceeded to the third step. If at least one of them was not significant, then we went to step four. The third step was to test the coefficient c' . If c' is not significant, it indicates that Y is a complete mediating process, which means that the effect of income inequality on the health of farmers was totally influenced by the mediating variable M . Otherwise, it indicates that Y is a partially mediating process, which means only part of Y is affected by the mediating variable M . Finally, the fourth step was a Sobel test. If it is significant, it means that the mediating effect of M is significant; otherwise, it is not significant. After this, the testing was complete.

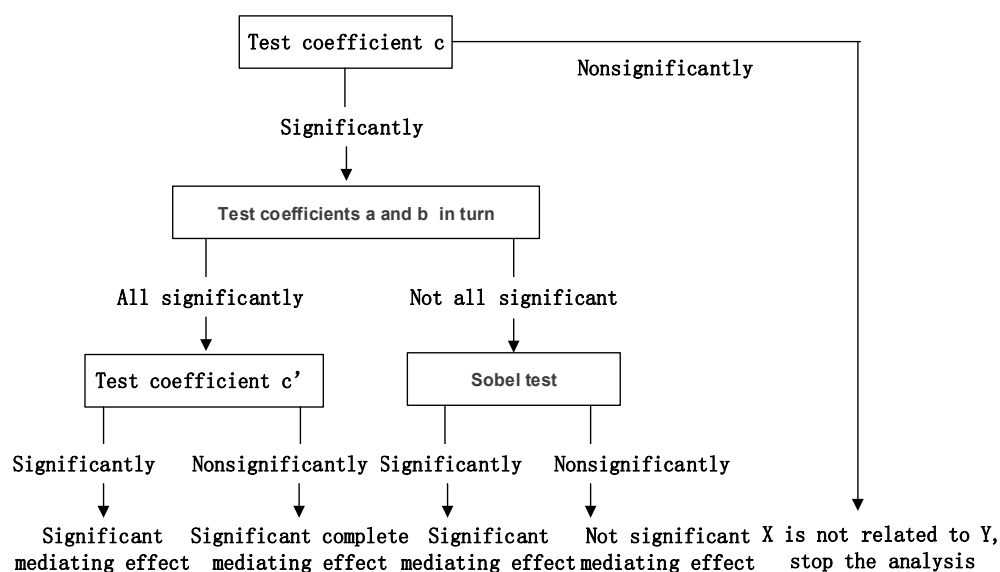


Figure 4. Mediating effect test procedure.

4. Results

4.1. The Effect of Income Inequality on Self-Rated Health of Farmers

As shown in Table 4, an increase in income significantly improved the self-rated health of farmers, where the relationship between them had an inverted U-shape, rather than being linear. In the fourth column, it can be seen that the critical point of the inverted U-shaped function was equal to 8103 yuan, which is slightly larger than the average income of the sample, indicating that most of the sample farmers had income to the left side of the inverted U-shaped curve, such that an increase in income could improve their health; this may be as an increase in income would cause farmers to increase their health investment and nutrition intake [45]. When the income is higher than the critical value, an increase in income will reduce the self-rated health of farmers. The possible reason for this may be that farmers consume too much food, with overnutrition leading to obesity, hypertension, and other health problems [46].

The Gini coefficient could significantly reduce the self-rated health of farmers. When the Gini coefficient squared term is added (see the last column), it was found that the relationship between them had an inverted U-shape. The critical point was at the Gini coefficient of 0.319, slightly lower than the international warning line of 0.4 and lower than the average Gini coefficient of the sample villages, indicating that most of the sample villages were on the right side of the inverted U-shaped curve. The economic implication is that when the Gini coefficient is less than the critical value of 0.319, the expansion of income inequality will improve the self-rated health of farmers. A possible reason for this could be that when income inequality is low, people see the hope of upward mobility, treat life more positively, and, therefore, have better subjective health. When the Gini coefficient is greater than 0.319, income inequality leads to psychological disadvantages and health deterioration in low-income groups. For example, if the income inequality is too large, it will dampen personal motivation and people will feel that they cannot catch up with others, thus giving up on themselves and possibly even forming some bad habits, such as drinking to drown their sorrows. Therefore, Hypothesis H1 was rejected, while Hypothesis H2 was assumed to be validated in this paper.

In terms of individual characteristic variables, according to the benchmark model (see the fifth column), gender and working time had no significant effect on self-rated health. Age had a negative effect on health, which is consistent with the assumption that the depreciation coefficient increases with age in the Grossman health demand model [47]. Education and political identity had a significant positive effect on health, in which edu-

cation can often improve the efficiency of health production by influencing the degree of attention to health and the choice of a healthy lifestyle [48]. Additionally, village cadres and party members generally have a higher education level and excellent ability, thus affecting their self-rated health.

Table 4. The effect of income inequality on self-rated health of farmers.

Variable	Self-Rated Health 1	Self-Rated Health 2	Self-Rated Health 3		
Village Gini coefficient	−2.426 *** (0.365)	−2.394 *** (0.377)	−2.162 *** (0.467)	13.465 *** (3.919)	
Village Gini coefficient squared				−21.102 *** (5.283)	
Gender	0.094 (0.058)	0.094 (0.059)	0.061 (0.068)	0.051 (0.069)	0.049 (0.069)
Age	−0.039 *** (0.003)	−0.041 *** (0.003)	−0.046 *** (0.004)	−0.045 *** (0.004)	−0.046 *** (0.004)
Education	0.025 *** (0.009)	0.026 *** (0.010)	0.026 * (0.012)	0.030 *** (0.012)	0.032 *** (0.012)
Political identity	0.274 *** (0.106)	0.280 *** (0.108)	0.256 ** (0.121)	0.281 ** (0.122)	0.295 ** (0.123)
Working time	−0.004 (0.011)	−0.010 (0.011)	−0.015 (0.013)	−0.017 (0.013)	−0.019 (0.014)
Household size	0.512 *** (0.075)	0.505 *** (0.077)	0.518 *** (0.089)	0.446 *** (0.091)	0.477 *** (0.093)
Income	0.883 *** (0.153)	0.852 *** (0.159)	0.882 *** (0.186)	0.734 *** (0.190)	0.777 *** (0.192)
Income squared	−0.052 *** (0.011)	−0.049 *** (0.012)	−0.049 *** (0.014)	−0.039 *** (0.014)	−0.041 *** (0.014)
Land	0.000 (0.007)	0.001 (0.007)	−0.013 * (0.008)	−0.008 (0.008)	−0.004 (0.008)
Private credit	−0.145 ** (0.060)	−0.134 ** (0.061)	−0.170 ** (0.071)	−0.174 ** (0.072)	−0.153 ** (0.072)
Formal credit	−0.050 ** (0.068)	−0.069 ** (0.070)	−0.004 (0.082)	−0.027 (0.083)	−0.053 (0.084)
Ownership of a car	0.250 *** (0.068)	0.234 *** (0.068)	0.185 * (0.077)	0.176 * (0.077)	0.164 (0.078)
Shaanxi	0.184 * (0.097)	0.195 ** (0.099)	0.279 ** (0.117)	0.196 (0.120)	0.065 (0.125)
Shandong	0.673 *** (0.113)	0.679 *** (0.115)	0.642 *** (0.136)	0.611 *** (0.138)	0.514 *** (0.141)
Gansu	−0.232 ** (0.109)	−0.228 ** (0.112)	−0.164 (0.138)	−0.205 (0.142)	−0.174 (0.145)
Constant term			−2.624 *** (0.752)	−1.268 (0.869)	−4.155 *** (1.092)
Number of Obs.	1710	1710	1710	1710	1710
R ²	0.1256	0.1303	0.1342	0.1439	0.1513

Note: ***, **, and * represent significance levels of 1%, 5%, and 10% (double tails), respectively. The values in brackets are robust standard errors.

In terms of family characteristic variables, household size had a positive impact on health, possibly because larger families have more social capital and stronger emergency response capacity; for example, family members have easier access to care and medical expenses when they are ill. There may be an optimal value for the impact of household size on health. The effect of land on health was not significant, which may be the result of the negative effect of labor intensity counteracting the positive effect. Access to credit and ownership of a car are indicative of household wealth. The higher the wealth, the looser the investment constraint on health and, so, the better the health.

Compared with Yunnan, Shandong had significantly better health, in terms of regional dummy variables, which may be due to its higher economic level and healthier eating habits (e.g., higher seafood intake). Gansu's health was worse, by comparison, but not significantly.

“Self-rated health 1”, “self-rated health 2”, and “self-rated health 3” were used as the regression results of dependent variables, respectively. The results all showed that

income inequality had a significant negative effect on health after controlling for the income “concave relation”, indicating that the research conclusion is robust.

4.2. Mediating Effect Analysis

According to the mediating effect test procedure in the previous section, we analyzed the health care expenditure, social trust, relative deprivation, and tobacco and alcohol behavior. The results showed that social trust, relative deprivation, and tobacco and alcohol behaviors passed the mediating test (as shown in Table 5). However, when testing for health care expenditure, the coefficients *a* and *b* were not significant in the second step test procedure and failed to pass the Sobel test. Thus, health care expenditure does not play a mediating role between income inequality and health; however, this does not mean that income inequality does not affect the use of health services, such as whether to see a doctor when sick, or the choice between a regular or informal hospital. Unfortunately, we cannot conduct a comprehensive mediating effect analysis of health services behaviors in this paper, due to data limitations.

Table 5. Intermediary test of income inequality and self-rated health.

Variable	Health Care Expenditure	Self-Rated Health 3	Variable	Social Trust	Self-Rated Health 3
Village Gini coefficient	−0.274 (0.457)	−2.168 *** (0.467)	Village Gini coefficient	−1.473 *** (0.430)	−2.066 *** (0.469)
Health care expenditure		−0.016 (0.023)	Social trust		0.153 ** (0.075)
Variable	Relative Deprivation	Self-Rated Health 3	Variable	Tobacco and Alcohol	Self-Rated Health 3
Village Gini coefficient	−1.493 *** (0.534)	−2.041 *** (0.469)	Village Gini coefficient	1.516 ** (0.615)	−2.119 *** (0.468)
Relative deprivation		0.077 *** (0.020)	Tobacco and alcohol		−0.240 ** (0.118)

Note: *** and ** represent significance levels of 1% and 5% (double tails), respectively. The values in brackets are robust standard errors.

The mediating effects of social trust, relative deprivation, and tobacco and alcohol behaviors were further calculated. The calculation results are shown in Table 6. Among them, tobacco and alcohol behaviors had the largest mediating effect on income inequality and health, accounting for 16.8%. The second was social trust, with the mediating effect accounting for 10.4%, while the sense of relative deprivation was the lowest, accounting for 5.3%. The three factors accounted for 32.5% of the indirect effect of income inequality on health. Therefore, there are still some factors to be studied.

Table 6. Proportion of mediating effect.

Variable	Total Effect (c)	Mediating Effect (ab)	Mediating Effect/Total Effect (%)
Social trust	−2.162	−0.225	10.4
Relative deprivation	−2.162	−0.115	5.3
Tobacco and alcohol	−2.162	−0.364	16.8

4.3. Heterogeneity Analysis

We wished to further discuss whether there were inter-group differences in the impact of income inequality on self-rated health and, so, we further added the interaction term of income and income inequality to the model (as shown in Table 7). Compared with Table 4, the R^2 value increased with the addition of interaction term, indicating that the interpretation of the expanded model is enhanced. The results show that the income coefficient was greater than 0, the Gini coefficient was less than 0, and the interaction

coefficient was greater than 0, indicating that income reduced the negative impact of income inequality on health. In other words, with an increase in income inequality, the tangent slope of the relation between income and health becomes larger and larger, which means that the interaction between income and income inequality is an important factor in health inequality.

Table 7. The interaction of income and income inequality on health.

Variable	Self-Rated Health 1	Self-Rated Health 2	Self-Rated Health 3
Village Gini coefficient	−5.867 *** (0.899)	−5.572 *** (0.937)	−5.388 *** (1.188)
Income	0.515 *** (0.178)	0.528 *** (0.183)	0.429 ** (0.218)
Income squared	−0.048 *** (0.012)	−0.047 *** (0.012)	−0.039 *** (0.015)
Income × Village Gini coefficient	0.936 *** (0.223)	0.860 *** (0.232)	0.848 *** (0.283)
Control variable	controlled	controlled	controlled
Number of obs.	1710	1710	1710
R ²	0.1303	0.1342	0.1480

Note: *** and ** represent significance levels of 1% and 5% (double tails), respectively. The values in brackets are robust standard errors.

4.4. Robustness Test

According to the test method of heterogeneity analysis, the samples were grouped according to income and regressed. Then, the coefficient significance and economic significance of explanatory variables in each group were compared. Specifically, the income was sorted from low to high, and the samples are divided into three groups—low-income, middle-income, and high-income—according to 0.33 and 0.65 quantiles [49]. The results of each group are shown in Table 8.

Table 8. Income subgroup test results.

Variable	Low-Income Group	Middle-Income Group	High-Income Group
Village Gini coefficient	−4.417 *** (0.932)	−2.433 ** (0.961)	−0.196 (0.855)
Control variable	controlled	controlled	controlled
Number of obs.	563	544	603
R ²	0.1973	0.1215	0.1245

Note: *** and ** represent significance levels of 1% and 5% (double tails), respectively. The values in brackets are robust standard errors.

By comparing and analyzing the regression results of low-income, middle-income, and high-income groups, we can see that income inequality of different income groups had different effects on the self-rated health of farmers, where the difference was statistically significant. When income is low, the impact of income inequality on self-rated health is significant at the 1% level. When income is in the middle level, the inhibitory effect of income inequality on self-rated health is significant at 5% level. When income increases further, the inhibitory effect of income inequality on self-rated health is no longer significant. Moreover, with an increase in income, the coefficient of income inequality decreased gradually, indicating less harm to health. These results illustrate that the influence of the interaction between income and income inequality on the self-rated health of farmers was relatively stable.

In addition to grouping regressions, robustness tests can also select different indicators to measure independent variables for regression. Specifically speaking, we selected the Gini coefficient within townships and counties to replace the Gini coefficient within villages for regression; the results are shown in Table 9. When the Gini coefficient within townships was taken as the independent variable, the income, the square term of income, the Gini coefficient, and the interaction term were all significant at the 5% level, and the coefficient

was less than that of the Gini coefficient within villages. The influence of the Gini coefficient within counties on self-rated health was still negative, but was no longer significant, while its interaction term was significant at the 10% level. The reason for this may be that the scope of activities of the sample farmers were mainly in villages and townships, such that they were more likely to perceive income inequality within villages and townships, thus affecting their psychology and behavior. In contrast, income inequality at the county level was less relevant, indicating that people tend to compare themselves with those around them.

Table 9. Different indicators of income inequality test results.

Variable	Township Gini Coefficient	County Gini Coefficient
Gini coefficient	−5.279 *** (1.368)	−4.298 (5.676)
Income	0.496 ** (0.232)	0.412 (0.323)
Income squared	−0.040 *** (0.014)	−0.052 *** (0.015)
Income × Gini coefficient	0.682 ** (0.339)	1.213 * (0.677)
Control variable	controlled	controlled
Number of obs.	1710	1710
R ²	0.1471	0.1356

Note: ***, **, and * represent significance levels of 1%, 5%, and 10% (double tails), respectively. The values in brackets are robust standard errors.

5. Discussion

In this cross-sectional analysis in China, we showed that income inequality has a stronger association with self-rated health, and the following four conclusions can be drawn: (1) Income had a significant positive impact on the self-rated health of farmers, showing an inverted U-shape, where the average income of the sample fell on the left side of the curve. Economic constraints weaken the ability of low-income people to invest in health, which directly strengthens the low-level cycle between health and poverty. (2) Income inequality had a significant negative effect on the self-rated health of farmers, also showing an inverted U-shape. The average income inequality of the sample fell on the right side of the curve, indicating that there was high income inequality within the sample rural areas. (3) Social trust, relative deprivation, and tobacco and alcohol behaviors played intermediary roles in the impact of income inequality on health, accounting for 32.4% of the indirect effect in total, which indicates that psychological cognition and behavior preference are the direct factors affecting health status. (4) The interaction between income and income inequality had a significant impact on health; specifically, increasing income weakens the negative impact of income inequality on health, which means that income inequality increases the health inequality of different income groups. As a result, health inequality between the rich and the poor was seen to be increasing.

According to the research results of this paper, the policy implications are as follows: (1) From the perspective of income, the overall income level of rural areas in China is still low and, so, increasing the income of farmers is still the most effective method to improve their health. Policy-makers might well consider policies that accelerate the reform of the income distribution, in order to raise the income level of low-income rural residents, and to increase transfer payments, such as special financial funds for poverty alleviation and medical security, such that low-income groups can receive adequate nutrition from food and quality medical services. (2) From the perspective of income inequality, low income inequality areas are usually those with lower overall income [50]; therefore, appropriately increasing income inequality by supporting and guiding some people to become rich first is suggested, such that the people can have hope for upward mobility and adopt a positive attitude towards life, thus improving their health. For rural areas with high income inequality, reducing it should be a priority. (3) The government and relevant social organizations can guide farmers to actively participate in collective cultural and recreational activities and enrich the social relationship resources of vulnerable groups,

thus reducing their sense of relative deprivation. (4) The government can strengthen the health knowledge education of farmers, in order for them to realize the harm of smoking and drinking to their health, such that they consciously resist such unhealthy behaviors. (5) Increasing income inequality was found to strengthen the impact of income on health, suggesting that the government should focus on the “two high” areas: High-income and high income inequality areas. In such areas, the health damage of low-income farmers is the most serious.

A negative effect of income inequality on health was observed in our study, unlike in some previous studies, such as that of Deaton and Lubotsky [8]. Several explanations can be proposed for this disparity. First, the magnitude of income inequality in China has increased rapidly since the reform and opening-up in 1978, such that it can now be more strongly perceived. Second, the units of aggregation used in the previous study (i.e., prefectures) may be too homogeneous for income inequality to exert an effect independent of individual income. We decided to use the village as the primary unit of aggregation, as the activities of farmers are mainly within this range. Finally, the relationship between income inequality and health may not be universal but, instead, may depend on location-specific social and political characteristics and cultural norms, as demonstrated by a study from Taiwan that has provided evidence of changes in association between income inequality and health, depending on the stage of economic development and social transformation [51].

Subject to data and other factors, this study had certain limitations. For example, there may be a lag effect on the impact of income inequality on health; however, we could not empirically analyze the existence of the lag effect, due to the limitation of cross-section data, which can be improved in future studies. Another further line of study from this paper is to compare the impact of the urban–rural income inequality on health. For example, there was no significant effect on the health of farmers at the county level, but different results may be obtained, given that the urban residents have a wider range of activities due to developed transportation and other reasons. Second, the relation between income inequality and health may be influenced by cultural norms and region-specific dietary habits. Future studies can study the relationship between income inequality and health in a more comprehensive way, by comparing different regions. It is worth noting that the discussion of income inequality and health in this paper is only one dimension of many social inequalities. In fact, inequalities such as wealth, political power, cultural assets, social assets, and human capital may also be important in affecting health outcomes.

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