Asian Social Science; Vol. 19, No. 2; 2023
ISSN 1911-2017 E-ISSN 1911-2025
Published by Canadian Center of Science and Education

The Impact of Income Inequality on Health of Chinese Residents — Decomposition Based on Individual Effect and Macro Effect

Songtao Wang[1], Minqian Luo[1], & Bin Li[1]

[1] Shantou University Business School, Shantou, China

Correspondence: Songtao Wang, Shantou University Business School, 243 Da Xue Road, Shantou, Guangdong, China. Tel: 86-134-1191-6965. E-mail: stwang@stu.edu.cn

Received: December 15, 2022 Accepted: January 21, 2023 Online Published: February 15, 2023

doi:10.5539/ass.v19n2p15 URL: https://doi.org/10.5539/ass.v19n2p15

Abstract

This paper reviews the mechanism of income inequality affecting residents' health, and proposes a new measurement method to decompose the micro mechanism and macro effect of income inequality affecting residents' health. Based on the provincial data onto 1990, 2000 and 2010, an empirical analysis using the multi-period mixed cross-sectional data (Pool Data) model shows that income inequality has a significant negative impact on health in China. The method constructed in this paper is used to decompose the contribution rate of macro effect and individual effect. The results show that the negative impact of macro effect accounts for 27.7%, while the impact of micro effect accounts for 72.3%. With the continuous improvement on GDP per capital in China, the impact of macro effect of income gaps between life expectancy is getting smaller and smaller. The macro effect contribution rate decreases year by year. Therefore, on the one hand, it is necessary to reduce income inequality, but also to take targeted measures to reduce the negative impact of income inequality on individual health.

Keywords: Income inequality, Life expectancy, Macroscopic effect, Individual effect

1. Introduction and Literature Review

As one of the components of workers' human capital, health is important not only for its inherent intrinsic value, but also for a series of instrumental values such as promoting economic growth (Cuesta, 2015; Ren et al., 2017), improve labor productivity (Wang et al., 2005), increase personal income (Cao et al., 2018). It is precisely because of the positive role of health in promoting various social fields that health has become the focus of attention from all walks of life. Many scholars have studied the influencing factors of health, among which income inequality is an important branch. Since the reform and opening up, China's economy has developed rapidly, with an average annual growth rate of 9.5%, and people's living standards have been greatly improved. At the same time, along with the rapid economic development, the income gap of Chinese residents keeps widening, with the Gini coefficient increasing from 0.16 in 1978 to 0.474 in 2018, indicating that China is at a relatively high level of income inequality.

China has been focusing on economic construction, paying too much attention to GDP growth and not enough attention to income inequality. Income inequality will not only affect the macro aggregate demand, and then affect the economic growth itself, but also affect the health of residents and the development of society. Therefore, it is of great practical significance to study the impact of income inequality on average life expectancy of citizens of China and serves as an important warning for improving the policy guidance of "Healthy China" strategy.

The research on the relationship between income inequality and health was carried out earlier by foreign scholars. In earlier studies, studies on the relationship between income inequality and health were mostly conducted using cross-country data. Most empirical studies using cross-country data show that income inequality has a significant negative effect on health at the macro data level. For example, Rodgers (1979) selected 56 countries with unequal wealth as samples to study the relationship between income inequality and health. Income inequality is measured by Gini coefficient, and health status is measured by life expectancy at birth, life expectancy at age 5 and infant mortality. The results showed that income inequality had a significant negative impact on the overall health of the population. With the development of research, many scholars began to question the comparability of transnational data. They argue that the health of a country's inhabitant is influenced by its diet, medical services, and lifestyle, and that the research scope of studies about the relationship between income inequality and health should be narrowed down. Therefore, scholars began to use a country's cross-regional data onto empirical research. Wang (2007) by using Chinese provincial the cross sections data in 2000, establish regression model, analyzes the relationship between income inequality and population health, the results show that the income gap (the ratio of the income of urban and rural residents in the area measurement) enlargement of regional population health in China in regional average life expectancy by a negative impact. Certainly, some studies have found no significant association between income inequality and health after controlling for regional education level, race, and other explanatory variables associated with income inequality (Ross et al., 2000; Deaton & Darren, 2003).

In recent years, with the increasing availability of individual survey data, the academic community has begun to shift from using transnational or trans-regional data to using individual data to study the relationship between income inequality and health. Ren et al. (2016) used CGSS2010 cross-sectional data to study the impact of personal income and income deprivation on self-rated health and mental health. It is found that under Ordered Logistic model and semi-parametric model, individual income deprivation has significant adverse effects on self-rated health and mental health of urban and rural residents. Similarly, due to different research characteristics such as estimation method, time span and regional scope, research conclusions are also slightly different. For example, Ma et al. (2011) made an empirical regression on health level by using the income gap in the lagging period and found that the impact of income gaps on health was "inverted U-shaped". When the income inequality was high, the impact of income inequality on health was negative.

It is now widely accepted that income inequality affects human health, and there is a wealth of research on the relationship between income inequality and health. At the macro level, life expectancy and mortality were used to measure health, while Gini coefficient was used to measure income inequality. However, since the marginal contribution of income to health is decreasing, when the level of income inequality increases, the overall data will show a decline in health, which leads to the question of "aggregates bias" of macro data. That is, it is difficult to distinguish whether the impact of income inequality on health is caused by the marginal diminishing effect of absolute income or by income inequality itself (Feng & Yu, 2007; Sun & Zhou, 2009; Huang et al., 2019). However, existing researches on the relationship between income inequality and health by using micro-individual data also have two limitations: one is that individual health is not measured by objective indicators, and subjective indicators such as "self-evaluation of health" are usually used. Differences in individual self-evaluation may lead to estimation bias (Qi, 2006; Wang, 2007; Wu & Zhang, 2020); Second, most scholars still use Gini coefficient to analyze its impact on individual health, but because of the Gini coefficient is a group, it will cause to measure the Gini coefficient of income inequality is still a community (macro) level, even if the control of the individual income, in fact for the same community, the Gini coefficient is still the same. Thus, it hides the different impacts of income inequality on individuals in the community and forces individuals with different incomes to have the same sense of inequality, which will also lead to estimation bias.

Therefore, compared with existing literature, the value of this paper lies in: First, by building a function that contains the Gini coefficient of average health (life expectancy),, the average income inequality on health, life expectancy is decomposed into the influence of income gap of individual life changes directly affect and the macroeconomic effects of income gap influence on life expectancy, it can solve the use of macro data produced by the "overall bias" problem; Secondly, using the census data of 1990, 2000 and 2010 and the statistical data of each province in the corresponding years, the Gini coefficient at the provincial level is used to explain the health (life expectancy) at the provincial level, so as to avoid the bias caused by the Gini coefficient. Third, use the objective indicator of life expectancy to measure health, avoiding the estimation bias caused by the use of subjective indicators.

2. Analysis of the Theoretical Mechanism of Income Inequality Affecting Health

The experience of existing literature indicates that income inequality may influence individual health through the following ways.

2.1 The Macro Effects of Income Inequality on Health

An increase in individual income can improve health through improvements in food, medical care and so on. The positive effects of income on health, both at the individual and national levels, are well supported by research. S. Preston (1975) earlier studies found that people living in rich countries is healthier than those living in poor countries; Lynch & Kaplan (2000) also showed that higher income is always associated with good health. With the improvement of an individual's economic and social status, his or her health will also be improved. A study by J.Lynch et al. (2004) found a significant correlation between per capital GDP and life expectancy. The theory that Income influences health is called the Absolute Income Hypothesis. "Absolute income hypothesis" holds that people with higher absolute income have better health status, but the positive impact of income on health decreases with the increase of income, that is, the relationship between health and income is concave (Rodger, 1979). According to the study of Wagstaff & Doorslaer (2000), the individual health function H =f(y) satisfies the following conditions: F '(y)>0, f "(y)<0, y is income, and His life expectancy.

Subramania et al. (2004) called this marginal diminishing effect of income on health "concavity effect". If life expectancy is used as a measure of individual health, then the marginal effect of income is very regressive, because life expectancy is always limited, and when income is high enough, additional income has very little effect on life expectancy. Concavity of income and health, means that the relationship between the two is non-linear, then different income distribution will be overall health level of the national (statistically) effect, also means that transfer income from high earners to low-income people, to improve the overall health level, this article will this effect is called the "macro effect", To distinguish it from the "individual effect" in which income inequality directly affects individual health.

2.2 Individual Effects of Income Inequality on Health: Direct Mechanism

The above macro effects of income inequality are based on the "absolute income hypothesis" theory (depression effect) that income influences individual life spans. In addition to the "absolute income hypothesis", many scholars (Subramanian et al., 2004; Pickett et al., 2015; Wen, 2018; Ma et al., 2018) believed that income inequality itself would directly affect individual health. We call the effect of income inequality on individual health the "individual effects." Clearly, this individual effect can also be seen in the impact of income inequality on the overall health of the population.

The most direct way that income inequality affects individual health is the social psychological mechanism. As human beings are social animals, they are always in a certain social relationship. Therefore, people living in social groups will inevitably make social comparisons. The results of comparison will bring "sense of relative deprivation" to the inferior party, and then increase the frustration and pressure of the inferior party. As a result, individual health deteriorates as relative income declines. In general, the negative effects are seen in the lower income groups, which are more vulnerable to the health effects of income inequality. As a result of individual's social comparison of income, relative deprivation of income mainly affects individuals in the form of "envy effect" (Li et al., 2006; Ma et al., 2018; Su & Zhang, 2021). When individuals are aware of the seriousness of income inequality, the individual's sense of relative deprivation of income will occur, and the resulting "envy effect" will increase the individual's negative emotions such as depression, depression, and jealousy, which will cause great psychological pressure on them and lead to the deterioration of their health condition.

The sense of relative deprivation brought by income inequality to individuals may also affect their lifestyles (Wang, 2007; Wen & Guo, 2015; Hou & Ge, 2020), resulting in an increase in the frequency of bad behaviors such as smoking, alcohol abuse and violent crime, and affecting the health of residents. The research of Nicolas Sommet (2018) shows that those who face economic scarcity tend to be in a lower social class, and they are more prone to class anxiety. Income inequality will reduce their happiness and induce more mental health problems.

2.3 The Individual Effect of Income Inequality on Health: Indirect Mechanism

One of the indirect effects of income inequality on individual health is that income inequality will affect individual health through resource allocation. According to the economic principle of scarce resource allocation, people's demand for health-promoting materials and services will increase with the increase in income, and the increase in demand will correspondingly raise the price level of the material resources and services that maintain health. Thus, individuals at the higher income levels of a social group have greater access to health goods and services than poor individuals and are more likely to access the physical resources and medical services in the market to maintain health (Subramanian et al., 2004; Ren et al., 2017). The lack of health protection products and medical services is detrimental to the health status of poor groups. On the other hand, groups with higher income level and groups with lower income level have a great difference in preference for health products and medical services. Groups with higher income level prefer to obtain better medical services and products, while groups with lower income level cannot afford better medical services and products. So rich group would be to better medical service areas, in addition, due to the scarcity of resources and the supply of resources will always be gathered to the biggest profit, this will cause the supply of medical resources is not uniform, the low level of income group is difficult to access to health care products and health services and medical technology upgrade, the "know-how" of bad for their health.

Another indirect mechanism of income inequality on individual health is that income inequality will affect individual health through social cohesion. China is a traditional relationship-based society. Studies show that one of the important ways for individuals to mobilize social resources is social capital, which is conducive to individuals' access to medical resources and thus has a significant positive effect on individual health (Zhou et al., 2014). Expansion of income inequality erodes social capital (Villalonga shrub et al., 2015). When social capital is eroded, it is difficult for poor groups facing serious disease to obtain loans and transfer payments from relatives and friends to raise funds to cure disease through rich social capital, thus adversely affecting the health of poor individuals. On the other hand, severe income inequality will widen the social distance between members of the society, leading to tension in social relations between individuals, distrust among members of the society, indifference in interpersonal relations, and lower social cohesion (Qi, 2006). This, in turn, may affect individual health through the psychosocial responses' mechanism. For example, the lack of trust in members of society is likely to lead to social conflicts, destroy the harmonious social atmosphere, increase the frequency of crime and violence, and have a negative impact on people's health.

3. Model and Method

Suppose the individual health function is: $\mathrm{h} = \mathrm{h}(y, G)$, In order to effectively separate the two different effects, we consider the specific function form:

$$\mathrm{h} = f(y) \cdot g(G) \quad (1)$$

Where, h represents individual health level (life expectancy measure is used in this paper), y>0 represents individual income, and G∈[0,1] represents Gini coefficient. f(y) content:

$$f(y) > 0, f'(y) > 0, f''(y) < 0, \lim_{y \to \infty} f(y) = a > 0$$

That is, income has a positive impact on health, and the impact (effect) is diminishing marginal; In addition, when the income is high enough, the individual life span will approach a positive limit value a. The functional relationship between absolute income and health is shown in Figure 1.

g(G) satisfies: $g(G) > 0$, $g(0) = 1$, $\mathrm{g}'(\mathrm{G}) < 0$, therefore: $g(G) < 1$.

So, h is equal to $f(y)$ when G is equal to 0. That is, when income distribution is completely equal, individual health (life span) is only affected by income, not by Gini coefficient.

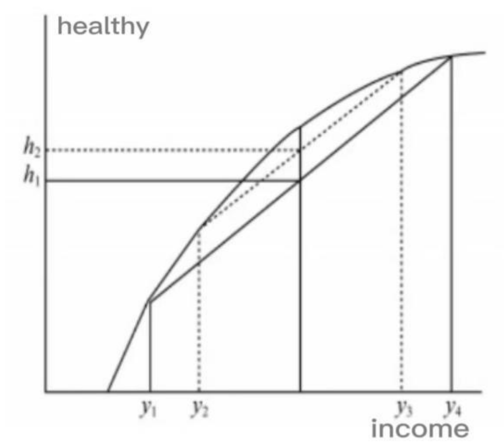

Figure 1. Absolute income as a function of health

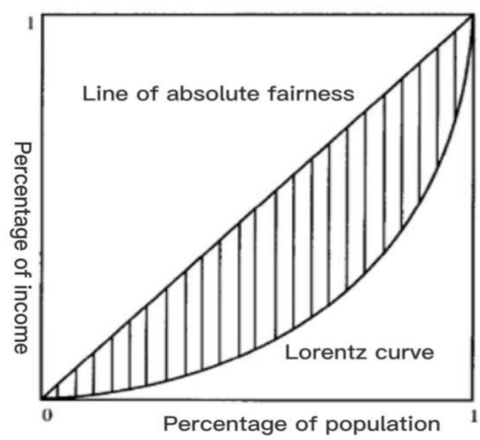

Figure 2. Lorentz curve

Subramania et al. (2004) called the marginal diminishing effect of income on health "concavity effect". Gini coefficient can be calculated by fitting Lorentz curve, and its calculation formula is as follows:

$$\mathrm{G} = 1 - 2\int_0^1 L(p)dp$$

Where $p \in [0,1]$ is the cumulative proportion of the population from low to high in terms of income, and the lorentz curve function L(p) is the income proportion of the corresponding population.

There are various methods to fit lorentz function, which depend on the specific form of income distribution. Sarabia (2008) sorted out lorentz curve functions corresponding to eight income distributions. Since the income distribution of developing countries is usually the classical Pareto distribution, the Lorentz curve function derived by Sarabia et al. (1999) based on the classical Pareto distribution has been widely used. Therefore, this paper selected the general Lorentz curve based on the classical Pareto income distribution to calculate the Gini coefficient. Lorentz curve function based on classical Pareto distribution is:

$$L(p) = 1 - (1-p)^m \ , \ 0 \le p \le 1, \ 0 \le m \le 1$$

Where p is population proportions and m is parameter. Then Gini coefficient is:

$$\mathrm{G} = 1 - 2\int_0^1 L(p)dp = (1-m)/(1+m)$$

So, $m = (1-G)/(1+G)$. Thus, lorentz curve equation is:

$$L(p) = 1 - (1-p)^{\frac{1-G}{1+G}} \tag{2}$$

Remembering $\bar{y}$ is the average income, and N is the total population, the income of the lowest resident in the total population is (Wang et al., 2011):

$$y_i = N\bar{y} \cdot \left[L\left(\tfrac{i}{N}\right) - L\left(\tfrac{i-1}{N}\right)\right] \ , \text{i=1,2,}\cdots\text{,N}$$

The average health level (life expectancy) of a country's inhabitant is:

$$\bar{h} = \frac{1}{N}\sum_{i=1}^{N} h_i = \frac{1}{N}g(G)\sum_{i=1}^{N} f(y_i) = \frac{1}{N}g(G)\sum_{i=1}^{i=N} f\left(Y \cdot \left[L\left(\frac{i}{N}\right) - L\left(\frac{i-1}{N}\right)\right]\right)$$

Substitute (2) into the above equation, get:

$$\bar{h} = g(G) \cdot \tfrac{1}{N}\textstyle\sum_{i=1}^{N} f\left(N\bar{y}\left[(1-\tfrac{i-1}{N})^{\frac{1-G}{1+G}} - (1-\tfrac{i}{N})^{\frac{1-G}{1+G}}\right]\right) \tag{3}$$

And, $F(\bar{y}, G) = \frac{1}{N}\sum_{i=1}^{N} f\left(N\bar{y}\left[(1-\frac{i-1}{N})^{\frac{1-G}{1+G}} - (1-\frac{i}{N})^{\frac{1-G}{1+G}}\right]\right)$, therefore $\bar{h} = g(G)F(\bar{y}, G)$

Thus, the following propositions can be obtained:

Proposition 1 $\frac{\partial \bar{h}}{\partial G} < 0$, the higher the income inequality, the lower the average life expectancy[1].

Proposition 1 implies that the "pitting effect" of income on individual health leads to the negative impact of income inequality on average life expectancy.

When average income remains unchanged, calculate the (static) loss of life expectancy due to income inequality:

$$Th = g(0)F(\bar{y}, 0) - g(G)F(\bar{y}, G) = [f(\bar{y}) - F(\bar{y}, G)] + [1 - g(G)]F(\bar{y}, G) \tag{4}$$

$$Th_1 = f(\bar{y}) - F(\bar{y}, G), \ Th_2 = [1 - g(G)]F(\bar{y}, G) \tag{5}$$

Th_1 is the loss caused by macro effect (sag effect), and Th_2 is the individual effect loss.

In actual equation estimations, if the function g(G)[2] cannot be estimated alone, $g(G)F(\bar{y}, G)$ can be replaced by the population effect (estimation) function $H(\bar{y}, G)$, then:

$$Th = f(\bar{y}) - H(\bar{y}, G) \ , \ Th_1 = f(\bar{y}) - F(\bar{y}, G), \ Th_2 = F(\bar{y}, G) - H(\bar{y}, G)$$

Because $Th_1 > 0$, and $lim_{\bar{y}\to\infty}[f(\bar{y}) - F(\bar{y}, G)] = 0$, thus we easily come to proposition 2:

Proposition 2 The "general trends" of income inequality's macro effect loss on life expectancy declines to zero, meaning that when average income $\bar{y}$ is large enough, the macro effect loss Th_1 becomes very small.

This proposition is very intuitive, because when the average income is large enough, it indicates that the income of most individuals is high enough, and the life expectancy gradually approaches the limit value. Therefore, the income gap at this time has little influence on average life expectancy. And when average income is low, the

[1] For the proof process, please refer to Wang Songtao and Wu Chaolin (2013).

[2] Estimating g (G) must use a combination of micro and community data.

impact of rising income inequality on life expectancy is greater, because there is a very limited amount of additional life expectancy for high earners.

Considering that the total income also changes at the same time, the change of income inequality on the change of life expectancy. Assuming that the Gini coefficient changes is ΔG and the average income of residents' changes is $\Delta\bar{y}$, the change in average life expectancy can be calculated by the following formula:

$$\Delta\bar{h} = H(\bar{y} + \Delta\bar{y}, G + \Delta G) - H(\bar{y}, G) \quad (6)$$

Among them, changes in average life expectancy caused by changes in income inequality can be calculated by the following formula:

$$\Delta\bar{h} = [H(\bar{y} + \Delta\bar{y}, G + \Delta G) - H(\bar{y}, G + \Delta G)] + [H(\bar{y}, G + \Delta G) - H(\bar{y}, G)]$$

$$\Delta\bar{h} = \Delta\bar{h}_y + [\mathrm{Th}' - \mathrm{Th}] = \Delta\bar{h}_y + [\mathrm{Th'}_1 - \mathrm{Th}_1] + [\mathrm{Th'}_2 - \mathrm{Th}_2] = \Delta\bar{h}_y + \Delta\mathrm{Th}_1 + \Delta\mathrm{Th}_2$$

Among them, the first item is the impact of income change in life expectancy, the second item is the impact of macro effect of income gaps on average life expectancy, and the third item is the direct impact of income gap change on individual life expectancy.

Based on the above theoretical analysis and proposition derivation, this paper proposes the following research hypotheses:

Hypothesis 1: The higher the level of regional economic development, the better the average health status of residents in the region.

Hypothesis 2: The greater the level of income inequality in a region, the worse the average health status of its residents.

Hypothesis 3: With the continuous increase of GDP per capital, the macro effect loss of income inequality on life expectancy decreases gradually, and its overall trend tends to decrease to 0.

According to the functional form of health (1), in the empirical analysis, we set a regression model to estimate the overall health function:

$$\mathrm{Log(pLife)}_{it} = a_0 + \mathrm{a}_1\mathrm{Log(pGdp)}_{it} + \mathrm{a}_2\mathrm{Gini}_{it} + \mathrm{a}_3\mathrm{X}_{it} + \varepsilon_{it} \quad (7)$$

Therefore, if the coefficient values of a_0, a_1, a_2 are estimated, the specific effect value can be calculated. In Formula (7), i and t represent provinces and periods respectively, pLife is the per capital life expectancy of each province, pGdp is the per capital GDP level of each province, and Gini is the Gini coefficient of resident income of each province. Since the correlation between income and health is non-linear, the per capital GDP level of each province is logarithmic, while Log represents logarithmic. X_{it} is each control variable, specifically including urbanization rate citys (Waldman, 1992; Mao & Yao, 2015; Ding et al., 2018), per capital education level[3] pEdu (Zhu et al., 2011; Zhao & Hu, 2016; Proportion of male Males (Su & Zhang, 2021), and ε_{it} represents random error. The expected sign of a_0 is positive, the expected sign of a_1 is positive, and the expected sign of a_2 is negative.

4. Data and Results

4.1 The Data Source

The inter-provincial data used in this paper are from wind database and national and provincial statistical yearbooks. But because data onto life expectancy are scarce and updated only every decade, they are actually 1990, 2000 and 2010[4]. All nominal data have been price adjusted (based on 1990) for real values; The Gini coefficient was calculated using the income data onto urban and rural residents in each province in three years (from the statistical yearbook of each province) [5]. STATA 16 software was used for data analysis. Table 1 shows descriptive statistics for all variables.

---

[3] The weighted method was used for calculation, and the calculation method was based on the processing method of Zhu Chengliang et al. (2011).

[4] As Chongqing was not classified as a municipality directly under the Central Government in 1990, some variables lacked the data of Chongqing in 1990.

[5] Statistics show that the Gini coefficient at the provincial level is smaller than that of the whole country in the same year. This is because part of the Gini coefficient at the national level is caused by the gap between regions or provinces, while the income gap within provinces is relatively smaller.

Table 1. Descriptive statistics of variables

The variable name	Variable meaning	Sample size	The mean	The standard deviation	The minimum value	The maximum
plive	Average life expectancy	92	71.45	4.216	59.64	80.26
pgdp	GDP per capita	92	0.618	0.611	0.0810	2.657
Gini	Gini coefficient of household income	92	0.360	0.0658	0.193	0.495
pEdu	Years of education per capita	92	7.452	1.243	4.744	11.07
citys	Urbanization rate	92	0.413	0.184	0.140	0.893
males	Proportion of male	92	0.516	0.0108	0.500	0.602

4.2 Regression Results

This article uses the multiphase mixture regression crossed section data (Pool data) model, because the panel data interval of 10 years, life expectancy for a lot of influence of other factors (such as climate, customs, and habits, and even the scope of administrative divisions, etc.) have changed, and only four years of data, individual character is not obvious, data structure has more cross section properties. In fact, whether the mixed cross-section data model can be used depends on whether the model structures changes significantly during the period (Wooldridge, 2008). Therefore, we conducted Zou Zhizhuang F test, and the corresponding P value (F=0.9124) was 0.5391. But the inspection should be in the same variance assumption, therefore we will mainly explain the variable Gini and Log (pGdp) interaction with virtual variable time and join in the model, the results showed that the interaction volume was not significant, so we can rest assured to accept the null hypothesis, namely the model structure has not changed significantly, along with the change of time and the multiphase mix cross-section regression. At the same time, we consider the possible adverse consequences of heteroscedasticity and spatial autocorrelation, so robust standard error is used for estimation to ensure robustness. [6]The estimated results are shown in Table 2.

Table 2. Multi-stage mixed cross section regression results

	(1)	(2)	(3)	(4)	(5)	(6)
	m1	m2	m3	m4	m5	m6
Log(pGdp)	0.054***	0.058***	0.028***	0.038***	0.027***	0.036***
	(0.004)	(0.004)	(0.004)	(0.006)	(0.004)	(0.006)
Gini		-0.187***		-0.132***		-0.129***
		(0.044)		(0.047)		(0.047)
pEdu			0.027***	0.023***	0.027***	0.023***
			(0.005)	(0.005)	(0.005)	(0.005)
citys			-0.048**	-0.063**	-0.047**	-0.062**
			(0.023)	(0.027)	(0.024)	(0.027)
males					-0.336*	-0.311**
					(0.181)	(0.124)
_cons	4.317***	4.388***	4.116***	4.208***	4.285***	4.364***
	(0.003)	(0.016)	(0.037)	(0.049)	(0.098)	(0.089)
N	103	103	101	101	101	101
r2	0.714	0.752	0.818	0.835	0.822	0.838

Note: 1. Values in brackets are standard error 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[6] The coefficient estimation results obtained by WLS with residual square as the weight are not significantly different from those obtained by POLS. Since we cannot confirm the specific form of heteroscedasticity, we prefer to use robust standard error regression results.

In model (1), we only consider the impact of per capital GDP level on per capita life expectancy. Regression results show that per capital GDP level is significant at the significance level of 1%, and its coefficient sign is positive, indicating that the better economic development is, the longer the average life expectancy of residents is when other factors remain unchanged. Based on Model (1), Gini coefficient of household income and various control variables were added into Model (2) and Model (6). The results showed that the sign of the level coefficient of per capital GDP was still positive and significant at the significance level of 1%. It further proves that regional per capital GDP has a significant positive effect on residents' health status. The more developed the regional economy is, the higher the average life expectancy of residents is, which is consistent with hypothesis 1 of this paper.

Model (2) based on the model (1) only joined the residents income Gini coefficients of the variables, the result shows that income Gini coefficient Gini significantly in the 1% significance level, its coefficient of symbol is negative, indicates that under the condition of the other factors unchanged, the higher the degree of income inequality, the shorter the residents' average life expectancy. If a series of control variables are added into model (3) - (6), the influence direction of income inequality on residents' health will not be affected. This result provides empirical support for hypothesis 2.

Various control variables were added into Model (3) - Model (6), including per capital education level, urbanization rate and male ratio. Theoretically, the consistent explanation for the impact of individual education on their health is as follows: on the one hand, compared with the population of lower education level, people with higher education level generally know more about health care and have stronger self-health maintenance consciousness; On the other hand, well-educated people are more likely to be rewarded for their work, which in turn allows them to choose higher-priced and better-quality food and life, which contributes to improved health. Finally, in terms of the promotion of learning for human physiological functions, the development and utilization of the brain of the population with high education degree is higher, and the conduction between nerves is closer, which is not only conducive to the nutrition of the cells of the body organs, but also can give full play to the vitality and function of the cells, contributing to human health. The impact of urbanization rates on health suggests that the improvement of urbanization level can improve individual health conditions. The influence of regional male ratios of regional average life expectancy is based on the fact that men are more promiscuous in social activities and living habits than women, such as smoking and drinking among men; On the other hand, men are more affected by income inequality than women, which may be due to different gender division of labor (Luoa et al., 2020). Generally speaking, "men work outside while women work inside", which causes men to face greater competition in work and life and have a stronger perception of income inequality. Therefore, we expect the sign of per capital education levels to be positive, the sign of urbanization rate variable to be positive, and the sign of male ratio variable to be negative. According to the empirical results of model (6), the regression coefficient symbols of per capital education level and male ratio are in line with expectations, which are 0.023 and -0.311 respectively, and are significant at the significance level of 1% and 5% respectively. However, the regression coefficient sign of the urbanization rates variable is contrary to the expectation. One possible explanation is that the improvement of the urbanization level leads to the rapid popularization of all kinds of food, and people have more convenient and frequent access to high-calorie and unhealthy food, which is not conducive to individual health.

As the goal of regression analysis is to estimate parameters and calculate specific effect values in the following paper, we should also focus on the fitting degree of the equation, namely, adjusting R2 value. According to the results, the fitting degree of all models is relatively high, among which the adjusted R2 value of model (6) is 0.838, indicating that the equation has good explanatory power.

4.3 Calculation of Macro Effect and Individual Effect

First, we use the regression coefficient of model (6) in Table 2 to estimate the average life expectancy of Chinese residents based on China's per capital GDP and Gini coefficient over the years, and then calculate the static relative overall impact of Gini coefficient on life expectancy. Then the serial data of China from 1990 to 2010 are used for programming with c++ language and calculation with visual c++ 6.0 software. The index data and calculation results over the years are shown in Table 3.

Table 3. Impact of income inequality on life expectancy from 1990 to 2010

year	pGDP	pEdu	N	Gini	pLifestatistics	pLife Calculated value H(y,z,G)	Relative error %	G is 0Life expectancy H(y,z,0)	F(y,G)	The overall loss Th	Loss rate%	The macro effect Th0	Individual effect Th1	Macro effect contribution rate % pTh0	Individual effect contribution rate % pTh1
1990	1654	6.246	114,333	0.343	68.55	68.19	-0.53	70.58	69.35	2.39	3.39	1.22	1.17	51.05	48.95
1991	1840	6.250	115,823	0.352	68.84	68.48	-0.51	70.95	69.78	2.47	3.48	1.17	1.30	47.35	52.65
1992	2112	6.360	117,171	0.361	69.12	69.05	-0.10	71.60	70.52	2.55	3.57	1.08	1.47	42.49	57.51
1993	2389	6.470	118,517	0.370	69.41	69.53	0.17	72.16	71.14	2.64	3.65	1.02	1.62	38.65	61.35
1994	2596	6.594	119,850	0.379	69.69	69.90	0.30	72.62	71.62	2.72	3.74	0.99	1.72	36.55	63.45
1995	2767	6.715	121,121	0.389	69.98	70.20	0.32	73.00	72.01	2.80	3.84	0.99	1.81	35.32	64.68
1996	2960	6.794	122,389	0.375	70.26	70.58	0.46	73.29	72.43	2.71	3.70	0.86	1.85	31.76	68.24
1997	3163	7.009	123,626	0.379	70.55	71.06	0.74	73.83	72.99	2.76	3.74	0.83	1.93	30.09	69.91
1998	3375	7.088	124,761	0.386	70.83	71.27	0.62	74.09	73.28	2.82	3.81	0.81	2.01	28.80	71.20
1999	3605	7.179	125,786	0.397	71.12	71.45	0.48	74.36	73.55	2.91	3.91	0.81	2.10	27.84	72.16
2000	3941	7.314	126,743	0.417	71.40	71.67	0.38	74.74	73.91	3.07	4.11	0.83	2.24	26.97	73.03
2001	4294	7.598	127,627	0.447	71.74	72.02	0.39	75.33	74.44	3.31	4.40	0.89	2.42	26.94	73.06
2002	4718	7.734	128,453	0.463	72.05	72.23	0.25	75.67	74.79	3.44	4.55	0.88	2.56	25.66	74.34
2003	5230	7.911	129,227	0.479	72.33	72.49	0.22	76.07	75.20	3.58	4.70	0.87	2.71	24.23	75.77
2004	5888	8.010	129,988	0.473	72.58	72.80	0.30	76.35	75.59	3.55	4.65	0.75	2.79	21.20	78.80
2005	6651	8.025	130,756	0.485	72.80	72.85	0.06	76.49	75.78	3.64	4.76	0.71	2.93	19.43	80.57
2006	7632	8.040	131,448	0.487	73.01	72.97	-0.05	76.64	76.01	3.66	4.78	0.62	3.04	17.05	82.95
2007	8923	8.186	132,129	0.484	73.19	73.31	0.16	76.96	76.43	3.66	4.75	0.53	3.13	14.48	85.52
2008	9911	8.270	132,802	0.491	73.35	73.43	0.11	77.15	76.65	3.72	4.82	0.49	3.22	13.30	86.70
2009	10836	8.380	133,450	0.490	73.50	73.63	0.18	77.35	76.90	3.72	4.81	0.45	3.27	12.14	87.86
2010	12347	8.613	134,091	0.481	74.83	74.05	-1.04	77.72	77.34	3.67	4.72	0.38	3.29	10.39	89.61
average	5087	7.370	125,719	0.425	71.39	71.48	0.14	74.62	73.80	3.13	4.18	0.82	2.31	27.70	72.30

Note: The life expectancy of 1990-2000-2010 was derived from the Chinese census, and the rest years were calculated by interpolation method. PLife calculation is only based on the estimation equation of regression analysis, using the data of pGdp and Gini, and the relative error is the relative error of calculated value and statistical value

As can be seen from Table 3, from 1990 to 2010, with the continuous improvement of GDP per capital in China, the macro effect of income gaps have less and less impact on life expectancy, which is manifested by the smaller and smaller macro effect loss Th1 and the lower macro effect contribution rate year by year. Accordingly, the individual effect increases year by year with the increase of China's per capital GDP. From 1990 to 2010, the contribution of income inequality to the life expectancy of Chinese residents is 27.7% from the macro effect, and 72.3% from the micro effect. The impact of income inequality on the life expectancy of Chinese residents is more reflected in the impact on individual health.

5. Conclusion and Enlightenment

Based on the census data onto 1990, 2000 and 2010 and the statistical data of provinces and regions in the corresponding years, the impact of income inequality on average life expectancy was studied using a multi-period mixed cross-section data model. The main findings of the study are as follows: the improvement in regional economic development is conducive to the improvement in the average health status of residents in the region, but with the continuous expansion of regional income inequality, the average health status of residents in the region is worse. Income inequality in further research on life expectancy contribution rates and the total effect of macro effects of individual effect contribution, found with the constant improvement of the level of

GDP per capital in China, the income gap of the macro effect impact on life expectancy is more and more small, characterized by macro effect loss Th1 smaller and smaller, the macro effect contribution rate reduced year by year.

Policy implications of this article are also obvious, should not only by economic development and effective policy to reduce the income inequality, continuously eliminate the macro effect of income inequality affect residents' life expectancy, even want to take concrete measures, on the basis of mechanism of income inequality can affect the health of residents, intervention and elimination due to the impact of income inequality for individual health, We will comprehensively improve the health of the Chinese people.

References

Before, C., & Li, Y. (2020). Educational level, relative deprivation and health of floating population. *Journal of yunnan university of finance and economics, 36*(11), 26-35.

Cao, R. R., & Hao, L. (2018). The influence of health on labor supply of middle and old age under the background of population aging. *Economic Issues,* (10), 33-40.

Cuesta, M. B. (2015). Income Deprivation and Mental Well-being: The Role of Non-cognitive. *Biology,* (17), 16-28. https://doi.org/10.1016/j.ehb.2014.11.004

Deaton, A., & Lubotsky, D. (2003). Mortality, Inequality and Race in American Cities and States. *Social Science and Medicine, 6*(6), 1139-1153. https://doi.org/10.1016/S0277-9536(02)00115-6

Ding, H., Cheng, Q., & Ni, R. Z. (2018). Urbanization inequality, citizenization and residents' health level. *Nankai Economic Research,* (6), 20-35.

Feng, J., & Yu, Y. Y. (2007). Income inequality and health in rural China. *Economic research journal,* (1), 79-88.

Gong S. S., Chen, Y., Zhang, T., & Zhang Z. J. (2020). The correlation between life expectancy and GDP per capita in China from 1990 to 2010 and its changing characteristics. *Economic geography, 40*(2), 23-30, 51.

Huang, Y., Ren, G. Q., & Zhou, Y. B. (2019). The impact of income inequality on physical and mental health of rural residents: An empirical analysis based on CGSS2015 data. *Journal of Agro-Technical Economics,* (3), 25-37.

Li, H., & Zhu, Y. (2006). Income, Income Inequality and Health: Evidence from China. *Journal of Comparative Economics, 34*(4), 668-693. https://doi.org/10.1057/9780230584259_6

Liu, Y., & Nie, R. (2019). Income inequality, health insurance and health poverty: Evidence from CFPS data. *Journal of liaoning university (philosophy and social sciences), 47*(4), 55-63.

Lu, C., & Wu, A. L. (2019). Income gap, social support and mental health of the new generation of migrant workers. *Population and development, 25*(4), 65-77.

Ma, S., Zang, W. B., & Gan, L. (2011). Analysis of the impact of new rural cooperative medical insurance on food consumption of rural residents. *Economic quarterly, 10*(1), 249-270.

Ma, W. C., Wang, X. H., & Li, H. (2018). The influence mechanism of income gap on happiness. *Economic Trends,* (11), 74-87.

Mao, F. F., & Yao, J. F. (2015). Urbanization and "Fat China": Income, income inequality and BMI. *Business Economics and Management,* (4), 84-96.

Pickett, K. E., & Wilkinson, R. G. (2015). Income inequality and health: A causal review. *Social Science & Medicine, 128,* 316-326. https://doi.org/10.1016/j.socscimed.2014.12.031

Preston, S. H. (1975). The Changing Relation between Mortality and Level of Economic Development. *Population Studies, 29*(2), 231-248. https://doi.org/10.1080/00324728.1975.10410201

Qi, L. S. (2006). *Economic Research Journal,* (11), 16-26.

Qi, Y. Q., & Li, L. (2018). Changes in life expectancy in China based on regional differences and its socio-economic determinants: 1981-2010. *Chinese health policy research, 11*(8), 29-35.

Ren, G. Q., Huang, Y., & Zhou, Y. B. (2017). How does individual income deprivation affect the health of urban residents? *Economic Science,* (4), 77-93.

Ren, G. Q., Wang, F. Z., & Luo, Y. H. (2016). The impact of income deprivation on health of urban and rural residents: An empirical analysis based on CGSS2010 data. *Nankai Economic Research,* (6), 3-22.

Rodgers, G. B. (1979). Income and inequality as determinants of mortality: an international cross-sectional analysis. *Population studies, 33,* 343-351. https://doi.org/10.1080/00324728.1979.10410449

Sommet, N. (2018). Income Inequality Affects the Psychological Health of Only the People Facing Scarcity. *Psychological Science, 29*(12), 1911-1921. https://doi.org/10.1177/0956797618798620

Su, Z. P., & Zhang, Y. L. (2021). Effects of income inequality on health of rural residents: A micro-perspective of relative deprivation. *Journal of Agrotechnical Economics,* (3), 132-144.

Subramanian, S. V., & Kawachi, I. (2004). Income inequality and health: What have we learned so far? (Review). *Epidemiologic Reviews, 26*(1), 78-91. https://doi.org/10.1093/epirev/mxh003

Sun, B. Z., & Zhou, J. T. (2009). A review of the impact of income inequality on health. *Economic Trends,* (7), 118-123.

Villalongaolives, E., & Kawachi, I. (2015). The Measurement of Bridging Social Capital in Population Health Research. *Health and Place, 36,* 47-56. https://doi.org/10.1016/j.healthplace.2015.09.002

Wang, Q., & Liu, M. M. (2005). The value of health and its Determinants: A Literature review. *Economic Quarterly,* (4), 1-52.

Wang, S. J. (2007). A review of the impact of income inequality on population health. C*ontemporary Economic Science,* (6), 116-121, 126.

Wang, S. J. (2007). Empirical analysis on the influence of income inequality to population health in china. *Yunnan University of Finance and Economics,* (3), 14-19.

Wang, S. T., & Wu, C. L. (2013). The Macro Effects of Household income inequality in China: Models, Methods and Data. *Economic Review,* (6).

Wei, X. L., & Yu, X. (2020). Economic Growth, Income Inequality and Life Expectancy in China. *Social science & medicine, 1982,* 113046. https://doi.org/10.1016/j.socscimed.2020.113046

Wen, H. W., & Guo, Z. Q. (2015). An empirical study on the impact of income inequality on residents' health in China. *Health Economics Research,* (5), 27-29.

Wen, X. X. (2018). Effects of relative deprivation on health status of middle-aged and elderly in rural areas: An analysis based on The Data of China health and old-age Tracking Survey. *China Rural Survey,* (6), 110-127.

Wu, Q., & Zhang, P. K. (2020). Do self-rated health measures change over time? *Population and development, 26*(1), 52-59.

You, L., Huo, X. X., & Du, W. C. (2018). Absolute income, social comparison and subjective well-being of farmers: A case study of two whole villages in Shaanxi Province. *Journal of Agro-Technical Economics,* (4), 111-125.

Zhao, H. J., & Hu, Y. M. (2016). Does education necessarily improve health? - Empirical analysis based on China Household Tracking Survey (CFPS). *World Economic Review,* (6), 90-106.

Zhao, J. G., & Chen, L. (2018). *Research on Financial and Economic Issues,* (11), 122-128.

Zhou, G. S., Fan, G., & Shen, G. J. (2014). Income gap, social capital and health: An empirical analysis based on The Chinese Family Tracking Survey (CFPS). Management World, (7), 12-21, 51,187.

Zia, Q. (2014). Reliability and validity analysis of self-assessment of general health. *Chinese Journal of Sociology, 34*(6), 196-215.