

Income Inequality and Population Health in China: a Longitudinal Study From China Health and Nutrition Survey

Ting Shi

Southwestern University of Finance and Economics School of public administration

Wenbin Zang

Southwestern University of Finance and Economics School of Insurance

Dapeng Chen (✉ dac320@lehigh.edu)

Lehigh University <https://orcid.org/0000-0002-0631-7776>

Mina Xiehu

Dayi Maternal and Child Care Service Center

Research

Keywords: Income inequality, Population health, Health inequality, China

Posted Date: May 19th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-482904/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: China's economy has made great achievements in the past few decades. However, the income disparity has also inevitably become a much more serious and noteworthy problem, which is absolutely harmful to the equitable development in population health.

Methods: Data used in this study were obtained from ten waves from 1989 to 2015 of China Health and Nutrition Survey (CHNS), and we acquired a dataset with 78,235 observations in total. Regional Gini-index was used to reflect the extent of income inequality, with several other indicators employed as outcome variables. Thus, we applied a probit model to investigate the effect of income inequality on population health status.

Results: Based on a probit regression analysis, we found an inverted U-shape relationship between regional income inequality and population health status. With an increase in the income inequality level, the population health will firstly have a slight increase; however, once the threshold was exceeded, population health conditions will have a significant decrease. The possible channel for this phenomenon is that income disparity will hurt social trust as well as increasing individuals' mental stress, which could further change their health behaviors and thus finally affect individuals' health conditions. Since individuals' health status could directly affect their labor force participation, the income disparity will thus be affected by population health reversely. Therefore, we also utilized a lag term of income inequality as the independent variable and found the inverted U-shape relationship also exists, which helps our results become more credible.

Conclusion: High-level income inequality tends to induce unhealthy behaviors such as smoking and drinking, and thus have a negative effect on personal health conditions. With the approval of the plan for Healthy China 2030, to promote national population health conditions, the Chinese government is supposed to shed more light on the increasingly serious income disparity problem.

Introduction And Background

It is common sense that human development does not merely focus on economic growth, but also concerns with the raise of total welfare, where population health played an essential role. Since the 1950s, extensive research on the influencing factors affecting personal health was given by scholars over the world [1, 2].

General results that believe people with higher income tend to be in better health conditions were gradually confirmed by empirical studies [3, 4]. Later, in the 1990s, the income inequality hypothesis which emphasizes the importance of the income disparities were formed. It claims the affecting factors of population health within areas are more than personal income level, and the degree of income inequality played an indispensable role [2, 5, 6].

Since the 1970s, researchers have started to shed light on the effect of income inequality on individuals' health conditions. From an empirical study on the US National Health Survey, Soobader [7] found the negative association between county-level Gini-Index and self-rated health condition, which was confirmed lately by Surbramanian (2003) [8] through applying state-level Gini-Index for a similar analysis. As for other commonly used indexes measuring health, life expectancy was found to have a negative correlation with Gini-Index [4, 9–11], and infants' mortality was claimed positively related to income inequality [12, 13].

Intuitively speaking, the income gap within a population could be a major source for social trust and personal pressure and thus has a negative effect both on individuals' mental and physical health conditions [14, 15]. Indeed, mental health diseases and depression are more likely to happen in districts with a higher level of income inequality [16, 17], since individuals' health behaviors (like smoking and drinking) are significantly changed, and then combined with deteriorating mental health conditions as well as physical health status [18–20].

While some might argue the results are mainly from the impact of income but not the extent of inequality. However, Wilkinson (1992) [10, 11] showed individuals with a similar amount of income from different countries have quite different health outcomes, which indicated the relative income level did play an important role [21]. Indeed, people live in South Africa and Bangladesh have much lower income than the poor in America, but their health conditions might be much better [22]. Then it will not be surprised to find the population mortality is higher in countries with a higher level of income inequality [13, 23]. Given the negative effect of disparity

distribution of income on population health [23, 24], to give a raise to social welfare, trying to eliminate or weaken the inequality on income might be a suitable standpoint [25, 26].

Since China's reform and opening-up policy in the 1980s, the Chinese people have experienced a huge increase in their income. Meanwhile, the income gap also changed dramatically between individuals and districts, accompanied by cruel competition in the labor market, which inevitably had a huge impact on citizens' health behaviors as well as health conditions [27, 28]. The existing related literature is mainly focused on cross-sectional data or some two-year panel data [29], using self-evaluated health as the major health outcomes, and still do not have a consistent conclusion on this topic. This paper used 15-year longitudinal data from CHNS, and also pick up a balanced panel for handling on endogeneity problem. Besides, we also added indexes such as WHR and BMI, for more objective research. In a word, this paper trying to figure out the effect of income inequality on Chinese population health, based upon a more comprehensive dataset and health measuring indexes.

Data And Methods

Data Resource

The sample used in this study was drawn from ten waves (1989–2015) of the China Health and Nutrition Survey (CHNS). The CHNS is an international collaborative project between the National Institute for Nutrition and Health (NINH) at the Chinese Center for Disease Control and Prevention (CCDC) and the Carolina Population Center (CPC) at the University of North Carolina Chapel Hill. CHNS was designed to focus on investigating Chinese residents' health and nutrition status, and how the status was affected by the social and economic transformation of Chinese society. Hence it contains abundant information on individuals' demographic background, health status, as well as some other household-level information, etc.

Based on a multi-stage stratified random cluster process, the survey draws 7,200 households with over 30,000 individuals (both citizens and villagers) coming from 15 provinces and municipal cities, covered a large part of China's territory, and thus eligible for representing Chinese residents. We restricted our sample to individuals who are at least 16 years old and with a full-scale of information on health status as well as some other covariates. Also, we excluded families with zero income or less as these observations could barely contribute to our study. Finally, we obtained 78,235 observations in total and a ten-wave balanced panel with 121 observations from each period.

Dependent variables

Based on the CHNS survey, the key dependent variables are mainly indexes measuring individuals' health conditions, including body mass index (BMI), waist-hip rate (WHR), self-reported health, ADL, as well as indicators on diabetes and high blood pressure. According to Li H and Mellor [30, 31], all the dependent variables were transformed into binary variables which equal to 1 indicate a good health condition and 0 otherwise.

BMI is an international measurement for obesity and health, the standard value ranges between 18.5 and 23.9, and a higher value indicates more serious obesity and unhealthy status. In this study, we use a dummy variable that equals 1 for the standard values (18.5–23.9) and 0 otherwise, to reflect information on BMI. Compared with BMI, WHR is available for expressing the distribution of body fat, which can also be used as a prediction for elderly's mortality [32] as well as females' fertility and pressure [33]. WHR is also represented by a binary variable that takes 1 if WHR less than or equal to 0.8 for women and 0.9 for men and takes 0 otherwise. Self-reported health status (SRHS) includes five different categories ("very good", "good", "fair", "bad", "very bad") in total, here we also use a dummy variable that equals 1 if the interviewer reports a good or very good health condition and equals to 0 otherwise. High blood pressure (HBP) and diabetes are indicators reflecting if the person has been diagnosed with related diseases. Activities of daily living (ADL) are a series of basic activities necessary for independent living at home or in the community [34, 35], which are mainly consisted of personal hygiene, dressing, eating, maintaining continence, and mobility. Hence, we applied a binary variable (ADL) which indicates if the respondents can finish all of these basic activities.

Independent variables

The key independent variables in this study are county-level Gini-index and Theil-index which account for income inequality. In China, a county is a basic unit for the fiscal system as well as responsible for public health and healthcare utilization [29]. Thus, these two variables should be suitable for measuring districts' income inequality.

Individual-level control variables include income (proxied by family aggregate income divided on family size), length of education, age, gender, ethnicity (ethnic minority or not), marital status (has a spouse or not), occupation, affiliation, Hukou (China's household registration system indicates the residents registered in rural or urban areas), and health insurances (have insurance or not) [36]. Moreover, we also controlled for some household-level covariates such as family size, access to tap water, and indoor toilet.

Table 1
Descriptive statistics of health, income, inequality and other variables

Variables	Obs	Mean	Std.dev	Min	Max
Health Variables					
WHR(normal = 1)	78235	.458	.499	0	1
BMI(normal = 1)	78235	.598	.49	0	1
SRHS(very good/good = 1)	46785	.704	.457	0	1
ADL(No difficulty = 1)	7950	.775	.417	0	1
Blood(normal = 1)	60692	.917	.276	0	1
Diabetes(No = 1)	46503	.978	.145	0	1
Health Behaviors					
Smoking rate	65635	.933	.060	.825	.998
Drinking rate	65635	.373	.025	.311	.424
Income and Income inequality indicators					
Country income per capita(log)	78235	8.88	.996	1.193	13.94
Family income per capita(log)	78235	8.825	1.298	.361	15.326
Gini	78235	.463	.035	.323	.544
Theil	78235	.427	.091	.208	.691
P10/P50	78235	.212	.073	.087	.545
P90/P10	78235	13.096	4.248	3.699	26.168
P90/P50	78235	2.524	.265	1.937	3.051
Other Variables					
Age	78235	45.103	15.384	16	100
Marriage(Yes = 1)	78235	.831	.375	0	1
Gender(Male = 1)	78235	.512	.5	0	1
Education	78235	7.578	4.244	0	18
Insurance(Yes = 1)	78235	.889	.314	0	1
Occupation	78235	3.822	1.509	1	6
Register(Rural = 1)	78235	.654	.476	0	1
Tap water(Yes = 1)	78235	.74	.439	0	1
Indoor toilet(Yes = 1)	78235	.437	.496	0	1
Family size	78235	3.924	1.585	1	15
Number of Medical Institutions	78235	1.277	.548	1	8
Distance(Minutes)	78235	14.537	23.246	0	3600

Empirical Model

As our outcome variables are all binary, this study applied a probit model. Except for the key independent variables, we also added the interaction term between income and Gini-index (Theil-index), and the squared income and Gini-index (Theil-index) are also included as covariates in the model, as we presented in Eq. (1) below:

$$Y_{ict} = \beta_1 Gini_{ct} + \beta_2 Gini_{ct} * Income_{ict} + \gamma X_{ict} + \mu_{ict}$$

Where subscript i , c , and t denote that the individual i from county c was interviewed in period t . The dependent variable consisted of several dummies indicate the interviewees were in a good health condition or not. The first independent variable Gini-index (Theil-index) reflects the degree of income inequality within a county, and the correlated estimates β_1 is the key of our interest, which depicts the marginal effect of income inequality on individuals' health conditions. Through interacting between Gini-index (Theil-index) and income, the second independent variable could help us figure out the heterogeneous effect of income inequality on the health of different income levels. X represents a series of covariates, including income, length of education, age, gender, ethnicity, marital status, occupation, affiliation, Hukou, health insurances, family size, access to tap water, and indoor toilet, as well as squared income and Gini-index (Theil-index). The error term was represented by μ .

Results

Health Outcomes

Table 2–4 reported the regression results on the effect of income inequality on individuals' health conditions, which was reflected by WHR, BMI, SRHS, ADL, Blood, and Diabetes. Column 1 only included Gini-index and its' squared term as independent variables, while column 2 added all other related covariates for comparison. Besides, the interaction term between Gini-index and personal income was included in column 3 to check the heterogeneous effects on different income levels' population.

According to column 2 from Table 1's three panels, we can identify an inverted-U shape correlation between the extent of income inequality and population health conditions, indicated by WHR, ADL, and HBP (if one has been diagnosed with high blood pressure or not). The thresholds that Gini-index makes these reversed U-shape relationships attain a local maximum are 0.52, 0.5, and 0.48, respectively, which is fairly close to each other. Besides, for BMI, SRHS (Self-Reported Health Status), and Diabetes, the reversed U-shape relationship between income inequality and population health also exists, although it is not statistically significant. The estimated value of the interaction term between personal income and Gini-index in column 3 is positive except for WHR. Thus, it is straightforward to figure out that income inequality has amplified the effect of personal income on health. In another word, a higher level of income inequality makes the rich people in better health conditions while the poor in worse health conditions. Hence, the health gap between the rich and poor was further increased by the income disparity.

Table 2
 Probit regressions measuring the effects of income inequality on WHR and BMI

	WHR			BMI		
	(1)	(2)	(3)	(4)	(5)	(6)
Gini	2.907***(0.74)	3.92***(0.84)	4.37***(0.87)	0.23(0.73)	0.467(0.77)	0.35(0.81)
Gini squared	-3.64***(0.81)	-3.74***(0.93)	-2.89***(1.01)	-0.89(0.79)	-0.825(0.86)	-2.146***(0.93)
Income		0.02(0.03)	0.05(0.05)		-0.072***(0.02)	0.04(0.03)
Income squared		-0.002(0.001)	-0.001(0.001)		0.003*(0.001)	-0.004****(0.0007)
Gini*income			-0.08(0.06)			0.19***(0.08)
Control X	No	Yes	Yes	No	Yes	Yes
Obs	78,235	78,235	78,235	78,235	78,235	78,235
<i>t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01</i>						

Table 3
 Probit regressions measuring the effects of income inequality on SRHS and ADL

	SRHS			ADL		
	(1)	(2)	(3)	(4)	(5)	(6)
Gini	-0.128(1.65)	2.62(1.69)	3.105*(1.76)	33.16****(6.37)	17.36****(6.59)	17.07***(6.9)
Gini squared	-1.388(1.76)	-3.985***(1.8)	-3.7***(1.88)	-33.52****(6.53)	-17.27***(6.76)	-17.51****(6.76)
Income		0.047(0.03)	0.152***(0.06)		0.0046(0.07)	0.07(0.16)
Income squared		-0.0024(0.002)	-0.002(0.002)		0.001(0.004)	0.001(0.004)
Gini*income			0.154*(0.08)			0.2(0.195)
Control X	No	Yes	Yes	No	Yes	Yes
Obs	46,785	46,785	46,785	7,950	7,950	7,950
<i>t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01</i>						

Table 4
Probit regressions measuring the effects of income inequality on Blood and Diabetes

	Diabetes			Blood		
	(1)	(2)	(3)	(4)	(5)	(6)
Gini	3.217***(0.7)	0.576(0.48)	1.097*(0.56)	0.0795(0.99)	1.520**(0.72)	1.137(0.76)
Gini squared	-3.138*** (0.75)	-0.509(0.51)	-0.733(0.53)	-0.0280(1.06)	-1.577**(0.76)	-1.626**(0.76)
Income		0.0071(0.006)	0.0227*(0.01)		-0.018(0.01)	0.0039(0.02)
Income squared		-0.0005(0.0004)	-0.0005(0.0003)		0.0004(0.0006)	-0.0006* (0.0003)
Gini*income			1.68e-05(0.02)			0.011**(0.005)
Control X	No	Yes	Yes	No	Yes	Yes
Obs	46,503	46,503	46,503	60,692	60,692	60,692
<i>t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01</i>						

Health Behaviors

Previous literature has shown that income disparity affects personal health by increasing health-hazardous behaviors [37]. We try to verify this potential channel through analysis on the relationship between the increment in income inequality extend and the probability of individuals' participating in health-hazardous behaviors (smoking and drinking).

Table 5 showed the positive correlation between income inequality and the amount of daily smoking and drinking, which indicates that a greater income gap does result in more personal daily consumption of alcohol and cigarettes. This result also coincides with what was found by Walker and Foster L et al., [38] that low-income people with lower social positions are more likely to be put under pressure and thus affected their health behaviors as well as worsen their health conditions.

Table 5
Income inequality and health behaviors

	Daily smoking		Drinking frequency	
	(1)	(2)	(3)	(4)
Gini	10.38***(2.31)	7.256***(2.549)	3.228***(0.336)	1.891***(0.353)
Income		0.295***(0.108)		0.0322**(0.0151)
Control X	No	Yes	No	Yes
Obs	19,068	19,068	22,780	22,780
<i>t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01</i>				

Robustness Check

Different Index (Theil Index)

Indicators measuring income inequality including the Gini index, Theil index, Atkinson index, Robinhood index, coefficient of variation, etc, among where Gini index can more intuitively reflect the difference between the rich and the poor, and also with the highest

application rate. However, the calculation of the Gini index involves the proportion of the population and different income groups, so the estimation results may be affected by some other random factors. Therefore, to get rid of this kind of randomness, we replicate our regression analysis again by applying the Theil index.

The regression results in Table 6–7 showed that regardless of whether the Theil index or the quantile income ratio P90/P10 is used to replace the Gini coefficient, the regression results could barely be recognized with any change. The estimated effects of income inequality on health outcomes based on these two indexes show the same trend as the Gini index: the inverted U-shaped relationship between income inequality and individual health does exist.

Table 6
Different Index–Theil Index

	WHR			ADL		
	(1)	(2)	(3)	(4)	(5)	(6)
Theil	0.244(0.59)	3.040 ^{***} (6.60)	2.992 ^{***} (5.12)	13.78 ^{***} (5.13)	7.288 ^{**} (2.44)	7.529 [*] (1.83)
Theil squared	-1.091 ^{**} (-2.50)	-2.921 ^{***} (-6.09)	-2.946 ^{***} (-5.68)	-14.15 ^{***} (-5.05)	-7.285 ^{**} (-2.33)	-7.357 ^{**} (-2.35)
Theil*income			-0.000143(-0.00)			0.205(0.77)
Control X	NO	YES	YES	NO	YES	YES
Obs	78235	78235	78235	7950	7950	7950
	Blood			Diabetes		
	(1)	(2)	(3)	(4)	(5)	(6)
Theil	-7.52 ^{***} (-7.56)	0.828(0.72)	-0.983(-0.61)	3.581 [*] (1.67)	7.303 ^{***} (3.06)	10.38 ^{***} (2.97)
Theil squared	7.289 ^{***} (6.74)	-1.150(-0.93)	-1.357(-1.09)	-2.964(-1.30)	-7.037 ^{***} (-2.76)	-7.11 ^{***} (-2.76)
Theil*income			0.0191(0.14)			0.35(1.30)
Control X	NO	YES	YES	NO	YES	YES
Obs	60692	60692	60692	46503	46503	46503
<i>t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01</i>						

Table 7
Different Index—p90/p10

	WHR			BMI		
	(1)	(2)	(3)	(4)	(5)	(6)
P90/p10	0.0316 ^{***} (6.95)	0.0484 ^{***} (9.71)	0.0583 ^{***} (5.44)	0.0142 ^{***} (3.11)	0.0007(0.15)	0.0343 ^{***} (-3.39)
(P90/p10) squared	-0.0012 ^{***} (-7.49)	-0.0013 ^{***} (-7.76)	-0.0013 ^{***} (-7.13)	-0.0007 ^{***} (-4.53)	-0.0002(-0.95)	-0.0003 ^{**} (-2.04)
(P90/p10)* income			-0.00144(-0.85)			0.00326 ^{**} (2.07)
Control X	NO	YES	YES	NO	YES	YES
Obs	78235	78235	78235	78235	78235	78235
	SRHS			ADL		
	(1)	(2)	(3)	(4)	(5)	(6)
P90/p10	-0.0959 ^{***} (-8.4)	-0.0758 ^{***} (-6.31)	-0.0741 ^{***} (-3.6)	0.201 ^{***} (4.91)	0.265 ^{***} (5.84)	0.296 ^{***} (4.53)
(P90/p10) squared	0.0017 ^{***} (4.82)	0.00144 ^{***} (3.76)	0.00144 ^{***} (3.63)	-0.0055 ^{***} (-4.56)	-0.0069 ^{***} (-5.25)	-0.0069 ^{***} (-5.24)
(P90/p10)* income			0.00224(1.15)			0.00717(1.48)
Control X	NO	YES	YES	NO	YES	YES
Obs	46785	46785	46785	7950	7950	7950
	Blood			Diabetes		
	(1)	(2)	(3)	(4)	(5)	(6)
P90/p10	0.185 ^{***} (15.10)	0.0603 ^{***} (4.15)	0.0203(0.71)	0.194 ^{***} (9.18)	0.0719 ^{***} (2.73)	0.105 [*] (1.84)
(P90/p10) squared	-0.0058 ^{***} (-13.9)	-0.0018 ^{***} (-3.66)	-0.0016 ^{***} (-3.40)	-0.0053 ^{***} (-7.32)	-0.0016 [*] (-1.8)	-0.0018 [*] (-1.92)
Income		-0.207 [*] (-1.71)	0.0804(1.14)		0.27(1.21)	0.242(0.94)
(P90/p10)* income			0.00377(1.15)			0.00208(0.33)
Control X	NO	YES	YES	NO	YES	YES
Obs	60692	60692	60692	46503	46503	46503

Simultaneous Causality_Lag

The most common problem on this topic is simultaneous causality, which directly affects the credibility of the causality on regression. On the one hand, income inequality will have an effect on individuals' health behaviors and thus affect population health outcomes; on the other hand, the health status disparity has influences on individuals' labor force participation, and thus further affect personal income too.

However, it is reasonable for us to believe that our current health status will not affect either the income disparity or income levels in the past, which is highly correlated with current income inequality at the same time.

Therefore, we utilized the lag term of Gini-Index as the independent variable in this part of the robustness check, which could help us better identify the causal relationship between income disparity and individual health conditions. By replacing the current Gini-index

with that in the past in Table 8, it is obvious that the inverted U-shaped relationship between income disparity and health outcomes still exists, which indicates that there is no significant difference in the results, either use Gini-Index in the past or current.

Table 8
Probit regressions measuring the effects of lagged income inequality on health

	WHR			BMI		
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Gini	11.46**(5.16)	15.15*** (5.03)	16.18*** (5.29)	1.761*** (0.57)	0.257** (0.12)	0.19(4.38)
Lagged Gini squared	-14.16** (5.96)	-10.48(7.47)	-10.60*(6.42)	-0.479*** (0.16)	-7.66(6.24)	-2.25(5.35)
Income		0.374(0.29)			-0.279(0.26)	
Lagged Gini *income		-0.81(0.624)			0.537(0.56)	
Lagged income			-0.0229(0.26)			-0.163(0.2)
Lagged Gini *Lagged income			-0.0763(0.57)			-0.258(0.49)
Control X	NO	YES	YES	NO	YES	YES
Obs	1,089	1,089	1,089	1,089	1,089	1,089
	SRHS			Blood		
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Gini	1.778*** (0.58)	8.961(9.49)	5.960**(2.68)	0.816(5.05)	1.632(4.13)	2.385(4.13)
Lagged Gini squared	-0.11**(0.05)	-5.4(11.39)	-9.127** (4.11)	-1.545(5.49)	4.47(6.97)	-1.493(5.74)
Income		0.147(0.44)			0.358(0.29)	
Lagged Gini *income		-0.3(0.94)			0.198(0.68)	
Lagged income			0.204(0.41)			0.218(0.31)
Lagged Gini *Lagged income			0.552(0.69)			0.106(0.5)
Control X						
Obs	709	709	709	921	921	921
<i>t statistics in parentheses</i> * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$						

Discussion

This article uses China Health and Nutrition Survey (CHNS) data to estimate the impact of income inequality on population health. The main findings are as follows:

Firstly, there is an inverted U-shaped relationship between income disparity and individuals' health status. After the extent of income inequality exceeds the threshold, it will have a significant negative effect on personal health.

Secondly, we tried to figure out the possible causal channel of this relationship based upon individuals' health behaviors. The results proved that income inequality increased the possibility and frequency of health-hazardous behaviors such as smoking and alcohol abuse.

Lastly, we also found the existence of heterogeneous effects on groups of different income levels. Income inequality has further increased the health gap between the poor and the rich, indirectly caused health inequality, and it even has a greater impact on the low-income population.

In addition, we identified a balanced panel across the ten waves from 1989 to 2015, with 121 observations for each. Repeating our analysis on this balanced panel could help us examine the long-term impact of income disparity on an individual's health status, which also makes our results more credible. Table 9 presents the relationship between income disparity and population health, which is an inverted "U" shape again. Although the estimated values on self-reported health status are not statistically significant anymore, the direction is still the same and consistent with our previous results.

Table 9
Balanced Panel

	WHR			BMI		
	(1)	(2)	(3)	(4)	(5)	(6)
Gini	11.74**(4.88)	11.46**(4.8)	12.75**(4.97)	9.933**(4.47)	9.171**(4.07)	6.955*(4.2)
Gini squared	-14**(5.59)	-12.24**(5.54)	-4.257(6.62)	-13.64*** (5.14)	-10.68**(4.69)	-14.72*** (5.48)
Gini*income			0.288**(0.13)			1.011**(0.5)
Control X	NO	YES	YES	NO	YES	YES
Obs	1,210	1,210	1,210	1,210	1,210	1,210
	SRHS			Blood		
	(1)	(2)	(3)	(4)	(5)	(6)
Gini	-12.89(14.38)	3.457(14.73)	4.01(14.99)	7.396*** (2.42)	3.111(8.3)	8.348(8.63)
Gini squared	11.36(15.48)	-5.242(15.96)	-6.856(17.86)	-8.440** (3.8)	-3.220(8.85)	-0.469(9.02)
Gini*income			1.036(1.41)			0.541(0.57)
Control X	NO	YES	YES	NO	YES	YES
Obs	710	710	710	920	920	920
<i>t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01</i>						

Conclusions

China's economy undoubtedly had a rapid development over the last few decades. However, what is accompanied is the serious income inequality that can not be ignored, especially when it is highly correlated with population health. In this paper, we applied a probit model and analyzed the data drawn from ten waves of the China Health and Nutrition Survey (CHNS), which found an inverted U-shaped relationship between income disparity and population health status. In other words, a lower level of income disparity might benefit population health at the very beginning, but with the continuous increase in income inequality, population health will be much worse off. Also, with the interaction term between personal income and Gini-index, we further proved that the poor people were affected much more by income disparity, and the possible causation channel might be that individuals' health behaviors were changed a lot.

With the approval of the plan for a Healthy China 2030, the impact of income inequality on population health should be paying more attention. Therefore, how to improve population health by effectively alleviate income inequality will always be an important issue to work on in the long run.

Declarations

Acknowledgements

The authors are grateful to the officers and data management staff of CHNS. In addition, we are grateful to the professors and experts who have made valuable comments on our research in various conferences and seminars.

Authors' contributions

WZ conducted and guided the research. ST collected and analysed data. ST and WZ interpreted results and wrote the manuscript. DC revised the manuscript. The authors read and approved the final manuscript.

Funding

None.

Availability of data and materials

All data came from public domain and could be accessed from the link below:

China Health and Nutrition Survey

<http://data.cpc.unc.edu/projects/7/view>

Ethics approval and consent to participate

All data came from public domain. Ethics approval and consent to participate was not applicable.

Competing interests

We declare no competing interests.

Consent for publication

All authors have contributed to this work and have consented for its publication.

References

1. Pickett KE, Wilkinson RG. Income inequality and health: A causal review. *Soc. Sci. Med.* 2015;128:316-26.
2. Hugh, Gravelle, and, John, Wildman, and, et al. Income, income inequality and health: what can we learn from aggregate data? - ScienceDirect. *Soc. Sci. Med.* 2002;54.
3. Lynch J, Smith G, Hillemeier M, Raghunathan T, Kaplan G, Shaw M. Income inequality, the psychosocial environment, and health: comparisons of wealthy nations. *Lancet.* 2001;358(9277):194-200.
4. Preston SH. Health Programs and Population Growth. *Popul Dev Rev.* 1975;1(2):189.
5. Deaton A. Health, Inequality, and Economic Development. *J. Econ. Lit.* 2003;41(1):p.113-58.
6. Subramanian SV, Ichiro K. The association between state income inequality and worse health is not confounded by race. *Int. J. Epidemiol.* (6):1022-8.
7. Soobader MJ, Leclere FB. Aggregation and the measurement of income inequality: effects on morbidity. *Soc. Sci. Med.* 1999;48(6):733-44.
8. Subramanian SV, Ichiro K. Income Inequality and Health: What Have We Learned So Far? *Epidemiol. Rev.* 2004(1):1.
9. Rodgers GB. Income and Inequality as Determinants of Mortality: An International Cross-Section Analysis. *Population Stud.* 1979.
10. Wilkinson, R. G. G. For Debate – Income Distribution and Life Expectancy. *Bmj Clinical Research.* 1992;304(6820):165-8.
11. Wilkinson RG. National mortality rates: The impact of inequality? *Am. J. Public Health.* 1992;82(8):1082-4.
12. Easterly W. The Lost Decades: The Developing Countries Stagnation in Spite of Policy Reform. *J. Econ. Growth.* 2001;6(2):135-57.

13. Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D. Social capital, income inequality, and mortality. *Am. J. Public Health.* 1997;87(9):1491-8.
14. Lin Y, Zhang Q, Chen W, Ling L. The social income inequality, social integration and health status of internal migrants in China. *Int J Equity Health.* 2017;16(1):1-11.
15. Ribeiro WS, Andreoli SB, Ferri CP, Prince M, Mari JJ. Exposure to violence and mental health problems in low and middle-income countries: A literature review. *Revista Brasileira de Psiquiatria.* 2009;31 Suppl 2(S2):S49-57.
16. Fone D, Greene G, Farewell D, White J, Kelly M, Dunstan F. Common mental disorders, neighbourhood income inequality and income deprivation: small-area multilevel analysis. *Br. J. Psychiatry.* 2013;202(4):286-93.
17. Burns, J. K. Poverty, inequality and a political economy of mental health. *Epidemiol Psychiatr.* 2015;24(02):107-13.
18. Blakely TA, Kennedy BP, Glass R, Kawachi I. What is the lag time between income inequality and health status? *Br. J. Soc. Med.* 2000;54(4):318-.
19. Kawachi I, Kennedy BP, Wilkinson RA. *The Society and Population Health Reader, Volume I: Income Inequality and Health.* 1999.
20. Kawachi I, Kennedy BP. Income inequality and health: pathways and mechanisms. *Health Serv. Res.* 1999;34(1 Pt 2):215-27.
21. Torre R, Myrskyl M. Income inequality and population health: An analysis of panel data for 21 developed countries, 1975-2006. *Population Stud.* 2014;68.
22. Kim, Ki-tae. Income inequality, welfare regimes and aggregate health: Review of reviews. *Int. J. Soc. Welfare.* 2019.
23. Patel V, Burns JK, Dhingra M, Tarver L, Kohrt BA, Lund C. Income inequality and depression: a systematic review and meta-analysis of the association and a scoping review of mechanisms. *World Psychiatry.* 2018;17(1).
24. Asgeirsdóttir T, Ragnarsdóttir DO. Health-income inequality: The effects of the Icelandic economic collapse. *Int J Equity Health.* 2014;13(1):50.
25. Vincens N, Emmelin M, Stafstr?M M. Social capital, income inequality and the social gradient in self-rated health in Latin America: A fixed effects analysis. *Soc. Sci. Med.* 2018.
26. Webb C, Bywaters P, Elliott M, Scourfield J. Income inequality & child welfare interventions in England and Wales. *J. Epidemiol. Community Health.* 2020.
27. Tan Z, Shi F, Zhang H, Li N, Xu Y, Liang Y. Household income, income inequality, and health-related quality of life measured by the EQ-5D in Shaanxi, China: a cross-sectional study. *Int J Equity Health.* 2018;17(1):32.
28. Wagstaff A, Doorslaer EV. Income inequality and health: what does the literature tell us? *Sick of Inequality.* 2016;21(1):543-67.
29. Jin F, Yu Y. Income inequality and health in rural China. *Economic Research Journal.* 2007.
30. Li H, Zhu Y. Income, income inequality, and health: Evidence from China. *J. Comp. Econ.* 2008;34.
31. And J, Milyo JD. Income inequality and health. *J. Policy Anal. Manage.* 2001.
32. Price GM, Uauy R, Breeze E, Bulpitt CJ, Fletcher AE. Weight, shape, and mortality risk in older persons: elevated waist-hip ratio, not high body mass index, is associated with a greater risk of death. *Am. J. Clin. Nutr.* 2006;84(2):449-60.
33. Epel ES, Mcewen B, Seeman T, Matthews K, Ca Stellazzo G, Brownell KD, et al. Stress and body shape: stress-induced cortisol secretion is consistently greater among women with central fat. *Psychosom. Med.* 2000;62(5):623.
34. Ichida Y, Kondo K, Hirai H, Hanibuchi T, Yoshikawa G, Murata C. Social capital, income inequality and self-rated health in Chita peninsula, Japan: a multilevel analysis of older people in 25 communities. *Soc. Sci. Med.* 2009;69(4):489-99.
35. *Studies of Illness in the Aged. The Index of Adl: A Standardized Measure of Biological and Psychosocial Function.* *JAMA-J Am Med Assoc.* 1963;185(12):914-9.
36. Grossman, Michael. On the Concept of Health Capital and the Demand for Health. *J. Polit. Economy.* 1972;80(2):223-55.
37. Ramos D, Daly M, Seidl- De -Moura ML, Nadanovsky P. The role of city income inequality, sex ratio and youth mortality rates in the effect of violent victimization on health-risk behaviors in Brazilian adolescents. *Soc. Sci. Med.* 2017;181:17-23.
38. Foster L, Tomlinson M, Walker A. Older People and Social Quality - What difference does income make? *Ageing Soc.* 2018.