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Impact of income inequality and fiscal decentralization on public health: Evidence from China

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ABSTRACT

In this study, the interrelationship between income inequality, fiscal decentralization, and public health is investigated within a comprehensive research framework for the first time. Using the panel data of 23 Chinese provinces for a period between 2002 and 2012, a carefully designed simultaneous equation model is used to control for potential endogeneity. The estimation results indicate that higher income inequality has a significant negative impact on public health performance. Interestingly, fiscal decentralization has negative direct and indirect effects on public health. Therefore, the empirical results suggest that China's provincial governments, which have gained significant fiscal power through increased fiscal decentralization, should take the problem of income inequality more seriously, because fiscal decentralization and income equality may both have the potential to benefit public health.

1. Introduction

Health is the basic condition for human survival and development, and everyone should enjoy the basic right to health (Barro, 1996; Bhargava et al., 2001). The health status of residents is an important indicator to measure the level of economic and social development of a country or region (Bloom et al., 2004). Sen (1998) argued that mortality is one of the most important indicators to measure the quality of life, and reducing mortality and improving the health level of residents are the main goals of government work. Medical and health services are directly linked to the health level of residents, which is one of the major livelihood issues (Wu et al., 2020). China has always attached great importance to the development of medical and health services, and is committed to improving and improving China's medical and health service system. In 2015, the State Council of China released the outline of national health service system planning (2015–2020). This outline proposes to optimize the allocation of medical resources in an all-round way, build a close cooperation and complete medical and health service system, and lay a solid foundation for the realization of the basic medical and health system for urban and rural residents by 2020. In recent years, China has been increasing expenditure on medical and health services, and the level of medical and health services has also made some progress. But with the continuous improvement of economic development level, people's demand for medical and health services is also increasing. At the same time, China has a large population, the aging degree is also increasing, and the demand for medical and health services is increasing day by day. There are different degrees of shortage of medical and health services in various regions of China, which puts forward new challenges to the current medical and health service system.

Under the Chinese fiscal decentralization system, the local

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government is responsible for most of the supply of medical and health services. Different regions in China have different levels of economic development, different financial resources held by local governments, and different investment in the field of medical and health services (Yee, 2001; Uchimura and Jütting, 2009). Previous studies have shown that "Chinese style" decentralization has brought about rapid economic growth (Yee, 2001). However, fiscal decentralization makes local governments pay too much attention to infrastructure investment, while the investment in health services is insufficient (Jin and Sun, 2011). To some extent, this weakens the expenditure of public services, which is obviously not conducive to the development of medical and health services in China. At the same time, under the Chinese fiscal decentralization system, income inequality is becoming more and more prominent.

Income inequality is a common by-product of fast-growing economies and has received increasing attention in recent years (Woo and Ren, 2002; Egawa, 2013). As shown by Dabla-Norris et al. (2015), the tendency has been toward increased inequality within most developed and developing countries in recent years. This increase is a major challenge to modern society and has received widespread attention. The problem of income inequality is particularly serious in China. As stressed by Xie and Zhou (2014), China's income disparity is currently higher than that during the pre-reform period (1949–1976) and is also higher than that in many other countries (e.g., Brazil, India and Indonesia) with similar levels of economic development.[2] According to the data of the National Bureau of statistics of China, the Gini coefficient of national residents' income decreased from 0.474 in 2012 to 0.462 in 2015, but the Gini coefficient of national residents' income in 2016 was 0.465, an increase of 0.003 compared with 2015. Although the gap between the rich and the poor of Chinese residents has been narrowing in general, unfortunately, the Gini coefficient of Chinese residents' income still far exceeds the internationally recognized warning line of 0.4. This not only reflects the existence of serious income inequality in China, but also further restricts the improvement of the health level of Chinese residents. Therefore, deepening the reform of financial system, reconstructing the mechanism and channel of income distribution regulation, narrowing the income gap between urban and rural areas and between regions, and promoting the improvement of residents' health level are the urgent problems to be solved in China.

This paper quantitatively examines how fiscal decentralization affects public health performance by considering direct and indirect effects. In the literature, the relationships between income disparity and public health, fiscal policies and income inequality, and public policies and health performance have been investigated separately (e.g., Mellor and Milyo, 2001; Song, 2013; Cavalieri and Ferrante, 2016). However, thus far, research incorporating all three of these key variables to examine the comprehensive impact of fiscal decentralization on public health has been scarce and largely ignored the endogeneity problem that may exist because of potential bilateral causality among these key variables. In addition, the Gini coefficient of different provinces published by the National Bureau of statistics of China is only until 2012, and the data of some provinces are missing. Therefore, panel data of 23 provinces in China from 2002 to 2012 are used to study the relationship between fiscal decentralization, income inequality and public health.

In this regard, this paper makes three main contributions to the literature. First, the direct and indirect effects of fiscal decentralization on public health performance in China are investigated for the first time. Second, because the income gap is already a serious social problem in China, this study quantitatively examines how the income gap affects public health. Third, how fiscal decentralization affects public health through income inequality is studied in this paper. Therefore, the empirical results of this study could serve as valuable references for policy-makers when formulating and adjusting future fiscal, health, and social policies.

The remainder of this paper is organized as follows. Section 2 offers a brief literature review of relevant studies. Section 3 introduces the data sources and estimation methods used. Section 4 presents and discusses the results of the estimation. The final section concludes the study and suggests related policy.

2. Literature review

To clarify the interrelation of three factors—fiscal decentralization, income inequality, and public health—it is helpful to divide them into three parts and review the relations between each pair of factors separately. The relations between each pair have received extensive academic attention, as explained in subsections 2.1–2.3.

2.1. Fiscal decentralization and income inequality

According to the Asian Development Bank (2015), China is one of the most fiscally decentralized countries in the world. China's level of fiscal decentralization is significantly higher than that of other developing countries. Because of China's large and multicultural population, Kyriacou et al. (2015) argued that the subcentral governments in different regions should do more to understand the needs of the different parts of the populace. Fiscal decentralization policy is attractive to the government because the government can improve distribution and allocate resources in a more timely manner on the basis of more comprehensive information regarding the needs and performance of specific regions. Nevertheless, fiscal decentralization can have mixed results on other factors such as gross domestic product (GDP) (Iimi, 2005), income distribution (Xie and Zhou, 2014), poverty rate, and corruption. And most studies that have investigated its influence on income distribution have shown the same result: A greater level of fiscal decentralization correlates with a larger income disparity or regional inequality (West and Wong, 1995; Song, 2013).

A study of developing countries, for example, countries in Latin America, and developed countries by Coady and Gupta (2012) demonstrated the impact of fiscal policy on inequality. They inferred that compared with developed economies, developing economies, especially those in Asia, have lower tax rates and transfer spending, which makes reducing income inequality through redistribution difficult. And when compared with only developing countries, a serious increase in income inequality in China is observed. Zhang (2006) asserted that the current tax policy improves the welfare of individuals considered rich but decreases the welfare of individuals residing in regions considered poor. By contrast, Lessmann (2009) reported that fiscal decentralization reduced income inequality in most OECD countries. Notably, evidence from Eastern European countries historically centralized in a similar manner to China supported the validity of Lessmann's finding. Despite the growing awareness of the influence of fiscal decentralization on income disparity, few studies have used data from China. Moreover, most of the literature has focused on inequalities between inland and coastal areas, rural and urban areas, and provinces in different counties (Liu et al., 2017) but not included detailed provincial analysis.

2.2. Fiscal decentralization and public health

Most studies have shown that fiscal decentralization benefits public health. Robalino et al. (2001) analyzed cross-country panel data from 1970 to 1995 that included high- and low-income countries and concluded that fiscal decentralization improved health outcomes. Research by Bossert (1998), Asfaw et al. (2007) and Cantarero and Pascual (2008) for developed countries has also found a positive relationship between fiscal decentralization and public health. With a higher degree of fiscal decentralization, subgovernments have a clearer understanding of the real needs of local individuals; thus, they can focus on the

[2] According to China's National Bureau of statistics, China's Gini coefficient was 0.18 before the reform and opening up, and 0.465 in 2016 after the reform and opening up.

improvements that are most important to their populace, for example, the provision of public services such as a healthcare service. However, what receives less attention is how the local governments act after fiscal decentralization. The amount they spend on the improvement of public healthcare will have a strong effect on the performance of local public health. However, this aspect of expenditure is sometimes given a low priority by local governments (Uchimura and Jütting, 2009). Thus, the impact of fiscal decentralization on public health includes the direct results of the policy consideration of the indirect influences that may occur during the implementation of the policy.

In recent years, scholars have arrived at an opposite conclusion from the common finding that fiscal decentralization is good for public health. Jin and Sun (2011) examined data from 32 provinces in China and found evidence that fiscal decentralization did not reduce the infant mortality rate, which can be used as a measure of public health. Indeed, many more recent studies have shown a negative correlation between fiscal decentralization and public health, with positive results reported for only developed countries such as those in Europe. In light of China's rapid development in recent years and indications that its economic performance is even better than that of developed countries, we are interested in whether the impact of decentralization remains positive in China.

2.3. Income inequality and public health

Based on the "relative position hypothesis," Wilkinson suggested that growing income disparity is related to decreasing public health performance (Wilkinson, 2002). A review of the studies of this phenomenon in developing countries (Wagstaff and van Doorslaer, 2000) has shown that most studies report a negative correlation between income inequality and public health. A study of conditions in China by Li and Zhu (2006) supported this conclusion. However, other studies have arrived at the opposite conclusion, for example, Bakkeli (2016), who illustrated that income inequality had no impact on public health. Therefore, further study is required because no consensus has been reached regarding the relationship between income inequality and public health in several countries and regions, including China. Furthermore, because data measuring provincial income inequality cannot be acquired directly, the research at this level has been insufficient. Such research is desirable because conditions vary from province to province.

3. Data sources and estimation methods

3.1. Data sources

This study employs data from 2002 to 2012 that includes cross-sectional data and panel data for 23 provinces. The main reason for choosing 2002–2012 as the sample period is that the two indicators for income inequality are not available before 2002 and after 2012. These data are used to investigate the correlations between income inequality, fiscal decentralization, and public health. The provincial data does not include Tianjin, Hunan, Yunnan, Jilin, Hainan, and Shandong. The income data for Tianjin, Hunan, and Yunnan are not provided after 2002, 2006, and 2007, respectively. The perinatal mortality of Jilin, Hainan, and Shandong are not available from 2002–2012.[3] The endogenous variables in this study are income inequality (measured by the Gini coefficient and the ratio of the per capita disposable income of urban residents to the per capita disposable income of rural residents), fiscal decentralization (measured by the ratio of provincial consolidated expenditure to national consolidated expenditure per capita), and public health (measured by perinatal mortality). The exogenous variables are capital stock per person, a time variable, average years in education, real GDP per capita, medical expenditure per person, the rate of total imports and exports of specific regions accounted to GDP, regional dummy variables, and urbanization rate.[4] The original data to estimate health conditions, Gini coefficient, urban–rural income gap, capital stock, foreign trade, and urbanization rate are from provincial statistical yearbooks. The original data used to estimate fiscal decentralization are collected from Chinese Fiscal Statistical Yearbooks (various issues). The data for GDP, population, and education level are from the Chinese Statistical Yearbooks (various issues). To control for price factors, the nominal provincial GDP per capita is then divided by the GDP deflator of the corresponding province to obtain real GDP per capita at constant 2000 prices. Similarly, the other two monetary variables, capital stock per capita (capitalp) and health expenditure (medical_exp), have also been converted to real terms.

3.2. Statistical indicators

3.2.1. Income inequality

To accurately measure income inequality, we use the Gini coefficient and the urban rural income gap. As outlined by Tian (2012), the Gini coefficient describes the relative degree of deviation of the average income of the population as a whole from the overall income expectation, represents the quantity limits of the degree of income inequality objectively and directly, and is widely accepted and adopted as an authoritative indicator of income distribution. The Gini coefficient in China is calculated for the data from 2002 to 2010 with the equation presented by Tian (2012):

$$G = P_c^2 \frac{u_c}{u} G_c + P_r^2 \frac{u_r}{u} G_r + P_c P_r \frac{u_c - u_r}{u} \quad (1)$$

In this equation, G_c and G_r represent the Gini coefficient of urban and rural residents, respectively. P_c and P_r are the rate of urban citizens and rural citizens, respectively. u_c and u_r describe the income of urban and rural residents, respectively. u represents the per capita income of the whole province (city, township). The urban rural income gap is calculated from the net incomes of urban and rural residents in the China Statistical Yearbook.

To show the regional differences in income disparities, the geographical distribution of provincial Gini coefficients is depicted in Fig. 1. As shown clearly in Fig. 1, income inequality was more severe in relatively poor western provinces such as Qinghai, Gansu, and Shaanxi.

3.2.2. Fiscal decentralization

The most commonly used measures in recent years have been the financial revenue indicator and financial expenditure indicator. However, use of the financial revenue indicator is complicated by Chinese economic policy. Since the tax reform in 1994, most local governments have needed transfer payments from the central government to plug the gap between real tax revenue and tax expenditure, and yet, the tax revenue indicator cannot represent the economic influence of transfer payment. According to Liu et al. (2017), Qiao et al. (2008) and Wu and Wang (2013), neither the local tax rate nor reallocated tax revenue is determined by local government in China, and complex factors such as transfer payment and rebates controlled by the central government further complicate determinations of revenue. Conversely, the expenditure indicator is an effective measure of the activities of the local government in the public sector, making this indicator a more suitable means for quantifying fiscal decentralization in China. Notably, the literature has

[3] For the convenience of analysis, the term "province" is utilized to represent all provincial administrative units in China, including provinces, municipalities, and minority autonomous regions.

[4] Following the definition from the *China Statistics Yearbook*, medical expenditure comprises the expenditures for health care management services, medical services, community health services, medical security, disease prevention and control, health supervision, maternal and child health, rural health, Chinese medicine, and other medical and health expenditures. The educational level is measured by the average schooling years of the residents in a certain province.

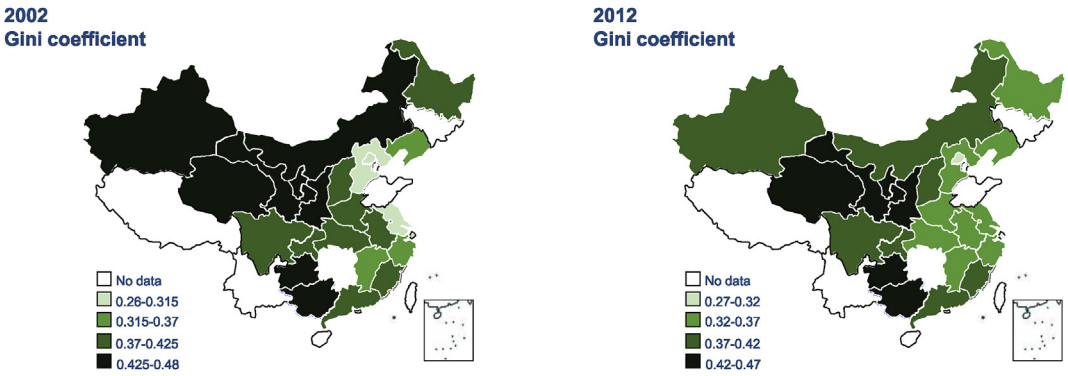

Fig. 1. Provincial Gini coefficient conditions in 2002 (left) and 2012 (right).

used the expenditure indicator as the measurement of China's fiscal decentralization level (e.g., Zhang and Zou, 1998; Jin and Zou, 2005; Sun et al., 2017). As a result, in this study, the fiscal decentralization is measured in terms of expenditure.

The geographical distribution of fiscal expenditure levels is shown in Fig. 2. As can be clearly observed, the northern and western provinces had relatively high levels of fiscal decentralization during the sample period.

3.2.3. Public health

Public health is measured using perinatal mortality, which is a better measure of public health than expected lifetime or infant mortality. The World Health Organization (2006) states that "*perinatal mortality is both deaths in the first week of life and fetal deaths (stillbirths). Perinatal mortality is a critical indicator of maternal care and of maternal health and nutrition; it also reflects the quality of obstetric and paediatric care available.*" Infant mortality is more easily influenced by human factors such as prejudice against baby girls, because it is illegal to know the sex of a baby before the birth. In this article, perinatal mortality represents the performance of public health. Because there is no data for 2005, we use the mean of perinatal mortality from 2003 to 2007 as compensation data.

As shown in Fig. 3, the distribution of the provincial public health conditions is to some extent similar to that for income inequality and fiscal decentralization. The perinatal mortality rates were relatively higher in the poor western provinces, including Xinjiang, Qinghai, and Gansu; by contrast, the health conditions were considerably better in the prosperous eastern coastal provinces, such as Zhejiang, Jiangsu, and Guangdong.

3.2.4. Exogenous variables

The urbanization rate is a control variable. The policy of "the first to get rich drive the rest, gradually leading to common prosperity" holds that faster development in cities attracts rural individuals and therefore gradually increases the urbanization rate. Due to coordinated development of urban and rural areas, public policies including fiscal decentralization may be influenced by the urbanization rate.

We also choose openness to trade as a control variable. Kessing and Kalamova (2010) argued that decentralization can affect trade by creating barriers to international trade and making international trade relatively more attractive. Because openness to trade affects the development of the regional economy and the main purpose of fiscal decentralization policies is to improve the economy, openness to trade as revealed through the rate of imports and exports may also affect policy-making regarding fiscal decentralization.

Education is also used in majority of literature as it could have influence on income inequality. A different level of education influences comprehensive judgments of an individual's quality, such as their job prospects and future personal value, and can create a barrier to changing jobs and affect income. From Table 1, it can be found that the Gini coefficient variable has the smallest change range and real GDP per capita variable has the largest change range. Generally, the data of the variables used have a smaller change range and relatively stable data, effectively avoiding the errors caused by extreme values on the regression results. The descriptive statistics of the variables are reported in Table 1.

3.3. Economic model

A single equation model and a simultaneous equation model (SEM) are employed to analyze the interrelation of three variables: fiscal decentralization, income inequality, and public health. The three equations used are as following:

$$gini_{it} = \alpha_0 + \alpha_1 dce_{it} + \alpha_2 \ln cap_{it} + \alpha_3 health_{it} + \alpha_4 t + \alpha_5 lnedc_{it} + \varepsilon_{it} \quad (2)$$

$$gap_{it} = \alpha_0 + \alpha_1 dce_{it} + \alpha_2 \ln cap_{it} + \alpha_3 health_{it} + \alpha_4 t + \alpha_5 lnedc_{it} + \varepsilon_{it} \quad (3)$$

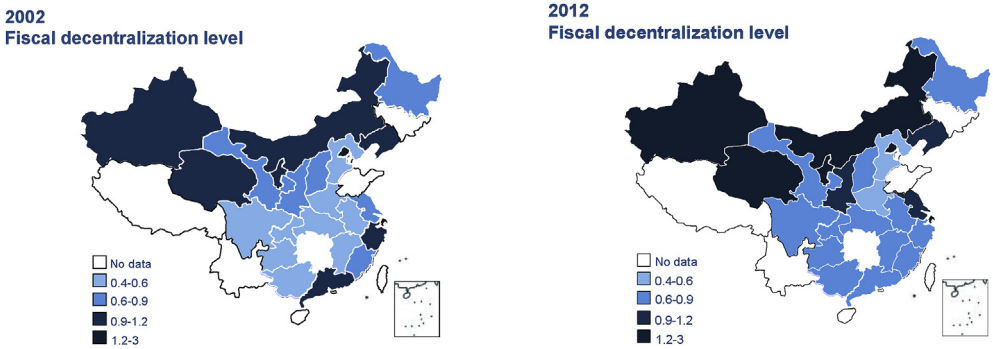

Fig. 2. Provincial fiscal decentralization levels in 2002 (left) and 2012 (right).

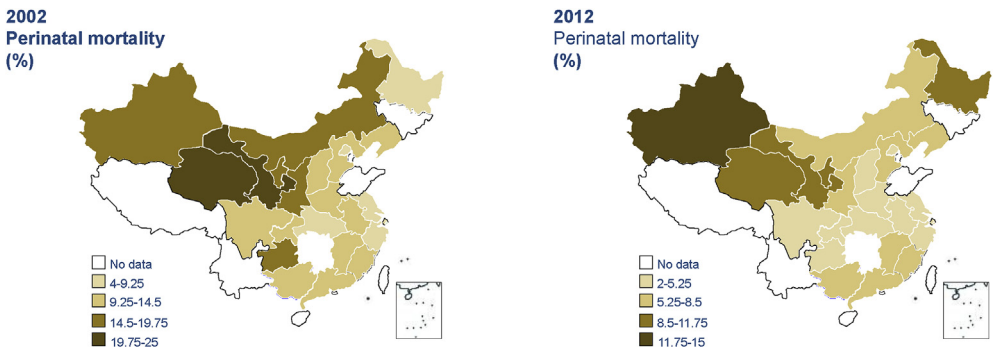

Fig. 3. Provincial public health conditions in 2002 (left) and 2012 (right).

Table 1
Descriptive statistics of all variables used in the study.

Variable	Definition	Unit	Average	Max.	Min.	Std.Dev	Obs
gini	Gini coefficient		0.398	0.491	0.265	0.051	253
gap	Ratio of per capita disposable income of urban residents to per capita disposable income of rural residents		3.030	4.594	2.055	0.570	253
dce	Ratio of provincial consolidated expenditure per capita to national consolidated expenditure per capita		0.990	3.423	0.410	0.577	253
health	Perinatal mortality	‰	9.702	28.820	2.490	4.235	253
capi	Capital per person	yuan	20,533.100	98,810.260	3374.786	16,403.710	253
t	Year dummy	y	6	11	1	3.169	253
edc	Average years in education	y	8.484	11.836	6.348	1.022	253
gdp	Real GDP per capita (constant 2000 prices)	yuan	18,878.640	69,596.920	3185.911	13,210.160	253
med	Medical expenditure per person	yuan	542.350	1579.742	115.314	298.018	253
mid	Dummy for Central China		0.304	1	0	0.461	253
east	Dummy for Eastern China		0.391	1	0	0.489	253
trade	Rate of total imports and exports of specific regions accounted to GDP	%	36.118	172.148	3.572	45.792	253
ur	Urbanization rate	%	47.805	89.300	24.293	14.903	253
pop	The number of people in each provinces	10,000 persons	4582.619	11,044	529	2782.295	253

$$health_{it} = \beta_0 + \beta_1 gini_{it} + \beta_2 dce_{it} + \beta_3 lngdp_{it} + \beta_4 lnmed_{it} + \beta_5 mid + \beta_6 east + \beta_7 t + \mu_{it} \quad (4)$$

$$health_{it} = \beta_0 + \beta_1 gap_{it} + \beta_2 dce_{it} + \beta_3 lngdp_{it} + \beta_4 lnmed_{it} + \beta_5 mid + \beta_6 east + \beta_7 t + \mu_{it} \quad (5)$$

$$dce_{it} = \gamma_0 + \gamma_1 gini_{it} + \gamma_2 health_{it} + \gamma_3 ur_{it} + \gamma_4 trade_{it} + \gamma_5 lnpop_{it} + \eta_{it} \quad (6)$$

$$dce_{it} = \gamma_0 + \gamma_1 gap_{it} + \gamma_2 health_{it} + \gamma_3 ur_{it} + \gamma_4 trade_{it} + \gamma_5 lnpop_{it} + \eta_{it} \quad (7)$$

The definitions of the variables are shown in Table 1. The subscriptions i and t indicate province and year, respectively. The Greek letters ε, μ, and η are the disturbance terms in three equations, respectively. *mid* and *east* are the regional dummies and represent the central and eastern region, respectively.[5] Because the differences in economic and social development across Chinese geological regions are remarkable (e.g., Démurger, 2001; Jones and Cheng, 2003; Wang et al., 2018), the regional dummies are introduced to control for the time-invariant regional fixed effects. The choices of the specifications are based on previous literature. For instance, according to the literature on the determinants of the public health situation in China such as Tang et al. (2008), Uchimura and Jütting (2009) and Fang et al. (2010), public health conditions are affected by income inequality, living standard (usually measured by GDP per capita), and the government expenditure level and its share allocated to medical care. Therefore, these factors are introduced as explanatory variables in Eq. (3).[6]

The single equation model interprets the influence of every independent variable on the dependent variable in each equation; thus, it is a good preliminary analysis for each relationship between two of the three key variables as shown in Eqs. (2)–(7). However, when analyzing three related variables, there may be endogeneity problem caused by the simultaneity bias due to the existence of bilateral causality. Lu et al. (2017) argued that a simultaneous equation model interprets comprehensive relationships more efficiently and accurately. This improved interpretation may be because, first, a single equation model does not consider that the correlation of every single equation in the system would affect the results of the regression. For example, income inequality affects public health (Kawachi and Kennedy, 1999; Wagstaff and van Doorslaer, 2000; Wang et al., 2018) but health can also influence inequality by

[5] In this article, three geological regions of China are considered (i.e., east, center and west). Central region includes Shanxi, Inner Mongolia, Heilongjiang, Anhui, Jiangxi, Henan, Guangxi. Eastern region includes Beijing, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Hubei, and Guangdong. Western region includes all the other provinces, municipalities, and autonomous regions in the sample.

[6] It is noteworthy that some literature on public health claimed to find evidence for the relationship between education and health (e.g., infant mortality), when educational level is directly introduced as an explanatory variable in Eq. (4), the coefficients of itself and some other important variables (e.g., income inequality and GDP per capita) are estimated to be insignificant. Therefore, the educational level is not added in Eq. (4). Instead, it is found that the education indeed affects income inequality as its coefficient turns out to be significant in Eq. (2). Because income inequality is also an explanatory variable in Eq. (4), it is probably that the influence of education on health is not direct but through its effects on income inequality.

affecting earnings, educational attainment, and the probability of getting married (Leigh et al., 2009). Second, the bias of single equation estimation results may be caused by the interrelations between independent variables and error terms in the single equation model. In the SEM, the two-stage least squares (2SLS) estimator is utilized to analyze the interrelation of the equations and improve the robustness of the estimations. SEM instead of the ordinary least squares (OLS) is chosen as the benchmark estimation method. This is because, as indicated by Wooldridge (2009) pointed out, the OLS estimator may lead to a biased estimate when there is potential endogeneity problem.

To improve the explanatory power of the estimation results, both of the Gini coefficient and the ratio of urban to rural income are used to measure the income inequality, and the results when latter is used could serve as the robustness test.

4. Estimation results and discussions

In this section, the estimation results from the simultaneous equation model (SEM) for the 23 provinces by using a two-stage least squares (2SLS) analysis are reported and analyzed. The estimation results by SEM are depicted in Tables 2 and 3, respectively. As a comparison, the results from the single equation model are also presented in Table 4.

The results in Tables 2 and 3 are for the SEMs with the three core variables—fiscal decentralization, public health, and income inequality plus control variables when different indicators for income inequality are utilized. Because multicollinearity is encountered in the 2SLS estimation procedure, we include only the main variables and then apply the change to a different equation. In Table 2, income inequality is measured by the Gini coefficient, and in Table 3, income inequality is measured by the ratio of urban to rural income. In the two tables, model 1 includes regressions of all three endogenous variables; in model 2, the income inequality variable (the Gini coefficient or the ratio of urban to rural income) is dropped from the health equation.

For the income equation (Table 4), the single equation regression results indicate that if the level of fiscal decentralization (*dce*) increases by one percentage point, the Gini coefficient would increase by 0.019 in Eq. (2), other conditions being equal. Comparatively, according to the benchmark SEM estimation results, for the change of fiscal decentralization by one percentage point, the Gini coefficient would change by

Table 2
SEM regression results when the Gini coefficient is used to measure income inequality.

Variable	Model 1		Model 2	
	Estimate	Std. Error	Estimate	Std. Error
Gini equation				
dc_exp	0.022**	0.009	0.022**	0.009
lncap	−0.044***	0.009	−0.044***	0.009
health	0.007***	0.001	0.007***	0.001
T	0.010***	0.001	0.010***	0.001
lnedc	−0.145***	0.032	−0.145***	0.032
Sum squared resid	0.181		0.181	
Health equation				
gini	88.408***	16.936		
dc_exp	4.809***	1.453	1.994*	1.111
lngdp	−4.688**	1.865	−5.366***	1.532
lnmed	−0.502	1.670	−0.005	1.290
mid	2.222*	1.224	−2.287***	0.714
east	4.961**	2.136	−1.647	1.417
T	0.249	0.353	−0.016	0.287
Sum squared resid	3001.762		2043.562	
Dc_exp equation				
gini	1.013	2.840	1.013	2.840
health	−0.156***	0.060	−0.156***	0.060
downtone	−0.013	0.009	−0.013	0.009
trade	0.007***	0.001	0.007***	0.001
lnpop	−0.805***	0.140	−0.805***	0.140
T	−0.042*	0.025	−0.042*	0.025
Sum squared resid	37.645		37.645	
observations	253		253	

Note: *, **, and *** denote significance levels of 10%, 5%, and 1%, respectively. The exogenous variables are as follows: cap, t, edc, gdp, med, mid east, downtone, trade, and pop. ln means taking logarithmic form of the variable.

Table 3
SEM regression results when the gap is used to measure income inequality.

Variable	Model 1		Model 2	
	Estimate	Std. Error	Estimate	Std. Error
Gap equation				
dc_exp	0.495***	0.119	0.495***	0.119
lncap	−0.634***	0.121	−0.634***	0.121
health	0.079***	0.013	0.079***	0.013
T	0.139***	0.015	0.139***	0.015
lnedc	−1.404***	0.408	−1.404***	0.408
Sum squared resid	29.530		29.530	
Health equation				
gap	6.763***	1.680		
dc_exp	0.909	1.333	1.994*	1.111
lngdp	−1.339	2.060	−5.366***	1.532
lnmed	0.926	1.533	−0.005	1.290
mid	0.712	1.122	−2.287***	0.714
east	1.507	1.840	−1.647	1.417
T	−0.493	0.358	−0.016	0.287
Sum squared resid	2811.006		2043.562	
Dc_exp equation				
gap	0.685**	0.305	0.685**	0.305
health	−0.192***	0.051	−0.192***	0.051
downtone	0.009	0.015	0.009	0.015
trade	0.003	0.002	0.003	0.002
lnpop	−0.678***	0.154	−0.678***	0.154
T	−0.094***	0.032	−0.094***	0.032
Sum squared resid	55.119		55.119	
observations	253		253	

Note: *, **, and *** denote significance levels of 10%, 5%, and 1%, respectively. The exogenous variables are as follows: cap, t, edc, gdp, med, mid east, downtone, trade, and pop. ln means taking logarithmic form of the variable.

Table 4
Single equation regression results.

Variable	Model 1		Model 2	
	Estimate	Std. Error	Estimate	Std. Error
Gini equation			**Gap equation**	
dc_exp	0.019***	0.005	0.516***	0.063
lncap	−0.039***	0.005	−0.723***	0.067
health	0.005***	0.001	0.047***	0.006
T	0.010***	0.001	0.137***	0.010
lnedc	−0.187***	0.024	−1.721***	0.304
R-squared	0.74		0.67	
Health equation			**Health equation**	
gini	31.368***	5.321	1.395***	0.524
dc_exp	−0.599	0.514	−1.386**	0.542
lngdp	−0.110	0.845	0.126	0.968
lnmed	1.571**	0.797	1.447*	0.839
mid	−2.527***	0.520	−3.316***	0.536
east	−3.746***	0.778	−5.000***	0.781
T	−0.802***	0.117	−0.833***	0.129
R-squared	0.66		0.63	
Dc_exp equation			**Dc_exp equation**	
gini	−0.614	0.576	0.114***	0.044
health	−0.028***	0.007	−0.033***	0.007
downtone	0.013***	0.003	0.019***	0.003
trade	0.004***	0.001	0.003***	0.001
lnpop	−0.421***	0.030	−0.386***	0.030
T	−0.020***	0.007	−0.031***	0.007
R-squared	0.82		0.82	
observations	253		253	

Note: *, **, and *** denote significance levels of 10%, 5%, and 1%, respectively. ln means taking logarithmic form of the variable.

0.022. The single equation regression results are quite similar to the results obtained by using the SEM. And the relevant estimation results are also significant in Table 3 and column 4 in Table 4. Therefore, these results suggest fiscal decentralization is positively and significantly related to income inequality. These results remain consistent although the estimated coefficients of the control variables (time trend and years of education) are slightly different. We also do regression with GMM and FGLS methods, which lead to similar results and are shown in Tables A1–A3 in the appendix.

It should be noted that there is a key difference between the results of SEM (in Tables 2 and 3) and OLS (in Table 4): the coefficients of fiscal decentralization in the SEM estimates are significantly positive, while the estimated coefficients are negative by OLS. Given that OLS simply ignores endogeneity problem, OLS estimates are prone to endogeneity bias. Therefore, the direct effect of fiscal decentralization on public health is also negative. One possible reason for such finding is that, higher level of fiscal decentralization allows local government to utilize more fiscal resources to boost local economic development, and the local government may even limit and reduce the input on public health and invest more on the productive programs that are beneficial to local growth when more fiscal freedom is given. For instance, Maskin et al. (2000) asserted that the main indicator used to measure the performance of local governments in China was economic development. Blanchard and Shleifer (2001) demonstrated that local government officials in China compared with other developing countries paid much more attention to economic development. Therefore, the central and local governments in China have considered improving the material conditions of people's lives as an overridingly important factor during the post-reform era. However, Yao (1999) showed that a huge income inequality went hand-in-hand with rapid economic growth. A study of both developing countries, such as Latin America, and developed countries by Coady and Gupta (2012) showed evidence for the impact of fiscal policy on inequality. They inferred that, compared with developed economies, developing economies, especially those in Asia, have lower tax rates and transfer spending, which makes it difficult to reduce income inequality through redistribution. Thus, with a higher degree of fiscal decentralization, a reasonable expectation is that some inequality in distribution will occur. For example, local governments may prefer to spend more money in areas where it can earn more, for example, in cities rather the countryside (Xie and Zhou, 2014), or in manufacture industry rather in education. To conclude, China requires a rapid improvement in economic development, and fiscal decentralization can have a positive impact on the growth of it. However, the rapid increase in economic development is usually attended by a widening of the income gap. Thus, a widening income gap can be a by-product of fiscal decentralization.

Before discussing the results of the other equations, we would like to highlight the results of the regression of public health on income inequality (i.e., Eqs. (2) and (3)). In the single equation model, the coefficient of the Gini variable is negative but not significant. Based on the benchmark SEM results shown in model 1 of Table 2, if perinatal mortality increases by one percentage point, the Gini coefficient would increase by 0.007, implying that the impact of perinatal mortality on the Gini coefficient is also negative (although the scale of the influence is limited). We drop the health variable in the other four models because these regression results show that the impact of health on income inequality is either slight or insignificant.

As for the health equations (4) and (5), from the benchmark SEM regression results shown in Table 2, if the Gini coefficient is decreased by 0.01, the perinatal mortality would decrease by 88.408*0.01 = 0.88‰. The results of both two models suggested that public health conditions would improve as the level of income inequality drops. And it indicates that an increase in the income inequality would lead to an increase in perinatal mortality. The relevant estimation results are also significant in Table 3 and column 4 in Table 4, using income gap as the indicator for income inequality. With GMM method, it has the same result as its estimated with 2SLS method. (Table A1 and A2). There are three possible reasons for this finding. First, high income inequality may lead to anxiety in individuals and influences their mental and physical health. Equality reduces stress, while income disparities increase negative emotions and violence and cause chronic illness. Second, income inequality makes it difficult to institute public healthcare policies that fully account for the needs of all sectors and classes of the society. Less social support will be supplied in less equal society. Third, high income inequality is a major problem for society and requires a large investment, leaving less capital to invest in health (Kawachi and Kennedy, 1999; Kawachi et al., 1994; Lynch and Kaplan, 1997; Wang et al., 2019). From the view of Deaton (2003), in some rich countries, the impact of income inequality on health is greater than income itself. For the United States, mortality rates due to income inequality at the end of the 20th century were even greater than the sum of death rates due to pneumonia, diabetes, suicide, homicide and other factors. With the improvement of China's economic development in recent years, the widening income gap could adversely affect citizens' health from the above aspects.

The estimation results also indicate that fiscal decentralization would affect public health. In the single equation model (Table 4), if the fiscal decentralization level (*dce*) is increased by one percentage point, perinatal mortality would decrease by approximately 0.6‰. However, from the benchmark SEM regression results shown in Table 2, at the 1% significance level, if the level of fiscal decentralization (*dce*) is increased by 0.1% (one-tenth of one percentage point), the perinatal mortality rises by 4.809*0.1% = 0.48‰. and the results with GMM method also support that fiscal decentralization has bad influence on public health. The estimation results from the SEM are more reliable after controlling for potential endogeneity and multiple collinearity, and they imply that fiscal decentralization increases perinatal mortality and is therefore negatively related to public health performance. Notably, according to the existent literature, there has been so far no consensus on the relationship between fiscal decentralization and public health. Some studies, including Asfaw et al. (2007) and Jiménez-Rubio (2011), found that fiscal decentralization helps reduce infant mortality rates in India and OECD countries, respectively. By contrast, in a more recent study, Brock et al. (2015) found fiscal decentralization is positively related to the infant mortality rate in China. The finding from the benchmark SEM results provides fresh evidence that fiscal decentralization is, in general, not helpful to improving public health in China.

The conflicting conclusions from the single equation model and SEM regressions are mainly because the single equation model ignores the endogeneity problem that may occur due to the bilateral causality between the key variables. As fiscal decentralization increases income inequality, and income inequality increases perinatal mortality significantly, the impact of fiscal decentralization on perinatal mortality becomes positive from this perspective. According to Robalino et al. (2001), inequality between regions without well-designed transfer mechanisms would influence the performance of fiscal policies, implying that the inequality variable should not be ignored when analyzing the effects of fiscal policies. Further analysis on this issue can be performed by using the mediator variable method (Fig. 4). Baron and Kenny (1986) asserted and explained this method and defined both "full mediation" and "partial mediation".

According to the results shown in Tables 2 and 3, fiscal decentralization (dce) affects income inequality significantly, and income inequality is also significantly related to public health performance. Without the income inequality variable measured by the Gini coefficient or the ratio of urban to rural income in the health equation of the SEM in Tables 2 and 3, the coefficient of fiscal decentralization is significantly positive. According to the definition of the mediator variable method, a partial mediation is observed. Thus, this empirical analysis shows that fiscal decentralization would increase income inequality, and income inequality would in turn cause higher perinatal mortality, which illustrates a critical role for the indirect influence of fiscal decentralization on public health. Overall, public health performance is negatively correlated with fiscal decentralization after dealing with endogeneity and multiple

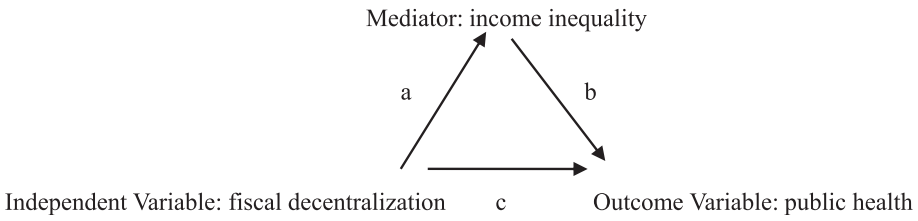

Fig. 4. Mediator variable method.

collinearity. When the income gap is measured by Gini coefficient (as shown in model 1 of Table 2), if the level of fiscal decentralization (dce) is increased by 0.1, the direct effect is to increase perinatal mortality by 0.1% *4.809‰ = 0.48‰, while the indirect effect is that the perinatal through the impact of income inequality would increase by 0.1*0.022*88.408‰ = 0.19‰. Therefore, the direct and indirect effects are comparable in magnitudes, and direct effect is a little larger. From previous discussions, it could be seen that as too much attention has been paid on economic development, local governments tend to widen the income gap in order to have higher speed of economy if they have more fiscal resources. Moreover, the widen income gap have negative impact on public health as it leads to anxiety and creates difficulties in the allocation of public resources. So we can see that the higher degree of fiscal decentralization leads to a deterioration in public health performance.

In the dc_exp equation (6) from the benchmark SEM regression results shown in Table 2, the increase in dc_exp is 0.1 corresponding to a 0.1 increase in the Gini coefficient insignificantly. And in dc_exp equation (7) in Table 3, at the 1% significance level, if the level of fiscal decentralization (*dce*) is increased by 0.1%. So the SEM indicates that income inequality has a positive impact on fiscal decentralization. When these two equations estimated by GMM and GFLS methods, they have the same results as they estimated with 2SLS method. And in the single equation model, it has a similar result when income inequality is measured by the gap. Clearly, fiscal decentralization has a positive effect on China's economic growth (Lin and Liu, 2000) but widens the income gap at the same time. The increase in income inequality leads to further fiscal decentralization. These estimation results suggest that the government may lay insufficient emphasis on the impact of income inequality when formulating fiscal decentralization policy, as the central and local governments in China may have placed more emphasis on economic growth than the fairness. It is also possible that at least the policies aiming to eliminate the income gap were not effective as expected. The relationship between perinatal mortality and fiscal decentralization is negative, according to the benchmark SEM and single equation regression results. Concretely, an increase in the perinatal mortality by 1‰ would lead to a decrease in fiscal decentralization level (*dce*) by 0.03–0.19. The results are statistically significant but not remarkable in magnitude. These regression results indicate that the impacts of income inequality and public health performance on fiscal decentralization are either insignificantly or trivial in magnitude.

5. Conclusion and policy suggestions

This study investigates the relationship between public health, income inequality, and fiscal decentralization. The estimation results indicate that the current fiscal decentralization policy and increased subgovernment fiscal expenditure have coincided with an increasing trend in income inequality in 23 provinces in China. Moreover, the empirical evidence suggests that both direct and indirect effects of income inequality on public health performance in China are negative. The findings of this study have important reference significance for the government to formulate relevant policies. Based on the above research results, the following policy recommendations are proposed.

First, fiscal decentralization policy provides local governments more fiscal power; however, it also increases the income inequality problem. This income disparity also has an adverse impact on public health performance. To resolve this problem, the degree of fiscal decentralization should be appropriately reduced. Because the central government has a holistic view of the development of the society, it could use its regained fiscal power to improve its comprehensive plans to alleviate social problems, especially plans regarding the social infrastructure. While increasing the adjustment of tax policies to the high-income people, local governments should increase all kinds of people's livelihood expenditures that favor the low-income people, and reduce the income inequality from the two dimensions of reducing the high-income and compensating the low-income, so as to realize the fair income distribution.

Second, some policies regarding the assessment of local government performance should be adjusted. For sustainable economic development, local officials should be rewarded for growth in local GDP and improving the balance between economic development and equality. The government can improve the individual income tax system and transfer payment system to achieve fair distribution. Under the socialist market economy system, the government establishes a security mechanism for vulnerable groups through free transfer payment, which is conducive to social stability and effective operation of the market mechanism. Local government officials should also be assessed on the long-term effects of their performance over a longer time period than their term of office (Chen et al., 2005).

Last but not the least, the Chinese government must pay more attention to its investment in public healthcare. The serious income inequality problem in China means that the populace can be separated into numerous groups by income. More specific policies, therefore, must be introduced to improve the health of the different groups. For example, there should be substantial improvements to the medical infrastructure in township and community hospitals, where most patients will have similar needs. For low-income individuals, in particular, the development of hospitals in the countryside or in their communities would improve their access to healthcare. At the same time, the government should change the "top-down" assessment method and increase the proportion of "bottom-up" assessment. Only in this way can local governments and officials really pay attention to the needs of local residents, and fully consider the basic medical needs in the process of formulating policies.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1
GMM regression results when the Gini coefficient is used to measure income inequality

Variable	Model 1		Model 2	
	Estimate	Std. Error	Estimate	Std. Error
Gini equation				
dc_exp	0.013*	0.007	0.034***	0.009
lncap	−0.034***	0.006	−0.053***	0.008
health	0.008***	0.001	0.005***	0.001
T	0.010***	0.001	0.011***	0.001
lnedc	−0.139***	0.024	−0.204***	0.029
Sum squared resid	0.187		0.180	
Health equation				
gini	79.051***	11.027		
dc_exp	4.169***	0.939	1.970**	0.885
lngdp	−2.475***	0.889	−4.791***	1.004
lnmed	−0.852	1.001	−0.302	1.093
mid	1.441***	0.518	−2.595***	0.621
east	3.092***	0.922	−1.934*	1.002
T	−0.116	0.188	0.054	0.196
Sum squared resid	2459.914		2074.691	
Dc_exp equation				
gini	3.837*	2.840	−2.861	2.089
health	−0.207***	0.054	−0.104**	0.051
downtone	−0.018**	0.008	−0.018**	0.007
trade	0.008***	0.001	0.008***	0.001
lnpop	−0.863***	0.125	−0.713***	0.118
T	−0.049**	0.025	−0.003	0.024
Sum squared resid	60.594		28.627	
observations	253		253	

Note: *, **, and *** denote significance levels of 10%, 5%, and 1%, respectively. The exogenous variables are as follows: cap, edc, gdp, med, mid east, downtone, trade, and pop. ln means taking logarithmic form of the variable.

Table A2
GMM regression results when the gap is used to measure income inequality

Variable	Model 1		Model 2	
	Estimate	Std. Error	Estimate	Std. Error
Gap equation				
dc_exp	0.476***	0.058	0.574***	0.061
lncap	−0.571***	0.054	−0.702***	0.061
health	0.086***	0.007	0.076***	0.008
T	0.151***	0.012	0.158***	0.011
lnedc	−1.499***	0.238	−1.583***	0.258
Sum squared resid	31.391		29.679	
Health equation				
gap	6.390***	0.952		
dc_exp	1.230*	0.682	0.808	0.935
lngdp	−1.369*	0.819	−2.808**	1.134
lnmed	0.589	0.843	−0.566	0.967
mid	0.881**	0.436	−2.798***	0.660
east	2.046***	0.645	−3.197***	1.124
T	−0.505**	0.167	−0.180	0.200
Sum squared resid	2809.390		1891.336	
Dc_exp equation				
gap	1.175***	0.207	0.545***	0.176
health	−0.293***	0.034	−0.234***	0.035
downtone	0.004	0.010	−0.005	0.009
trade	0.004**	0.002	0.005***	0.002
lnpop	−0.764***	0.096	−0.795***	0.093
T	−0.142***	0.024	−0.102***	0.022
Sum squared resid	131,045		73.304	
observations	253		253	

Note: *, **, and *** denote significance levels of 10%, 5%, and 1%, respectively. The exogenous variables are as follows: cap, edc, gdp, med, mid east, downtone, trade, and pop. ln means taking logarithmic form of the variable.

Table A3
FGLS regression results

Variable	Model 1		Model 2	
	Estimate	Std.Error	Estimate	Std.Error
Gini equation			**Gap equation**	
dc_exp	0.017**	0.007	0.332***	0.041
lncap	−0.051***	0.008	−0.642***	0.029
health	0.003***	0.000	0.021***	0.003
T	0.008***	0.001	0.110***	0.006
lnedc	−0.104***	0.013	−1.282***	0.137
Health equation			**Health equation**	
Gini/gap	10.455***	1.173	0.033	0.540
dc_exp	0.062	0.361	−0.246	0.749
lngdp	−1.101	0.671	−1.197	1.336
lnmed	−0.488	0.355	−0.833	0.843
mid	−2.751***	0.583	−3.015***	0.923
east	−4.072***	0.731	−4.083***	1.321
T	−0.413***	0.082	−0.379***	0.167
Dc_exp equation			**Dc_exp equation**	
Gini/gap	0.110	0.104	0.011	0.017
health	−0.014***	0.002	−0.014**	0.001
ur	0.020***	0.002	0.020**	0.001
trade	0.000	0.000	0.000	0.000
lnpop	−0.389***	0.027	−0.390***	0.024
T	−0.022***	0.004	−0.022***	0.004
observations	253		253	

Note: *, **, and *** denote significance levels of 10%, 5%, and 1%, respectively. ln means taking logarithmic form of the variable.

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