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Accounting for Horizontal Inequity in the Delivery of Health Care: A Framework for Measurement and Decomposition

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Authors' contributions

Zhao set the framework and did the main empirical work; Cao did parts of the empirical work and wrote the main parts of paper; Ma cleaned the data and wrote parts of the paper. All authors read and approved the final manuscript

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Abstract: The pursuit of equity is an objective of many healthcare systems. Horizontal equity, interpreted as "equal treatment for equal need", has received much attention in both the policy and academia arenas. By combining the indirect standardization method with regression-based Shapley value decomposition, the paper aims to propose a framework for measuring and decomposing horizontal inequity and to investigate the contributors to horizontal inequity in health care delivery in China using the China Health and Nutrition Survey (CHNS) dataset. The horizontal inequity indicated by the Gini coefficient of indirectly standardized healthcare expenditure accounts for approximately 68.63 percent of the overall inequality, and the non-need factors, such as household registration, region, work status, education, income, insurance, and marital status, explain between 50 and 70 percent of the inequity, with household registration and region being the two largest contributors.

Key words: Horizontal inequity; Health care delivery; Decomposition analysis; China

JEL Codes: D63; I14

1. Introduction

Achieving equity and equality in health care delivery is a widely pursued but seldom accomplished policy objective in many countries. There are many theoretical and empirical studies on the inequity in health and health care (Wagstaff & van Doorslear, 2000a; Fleurbaey & Schokkaert, 2009; Van de Poel et al., 2012; Terraneo, 2015). Among the various dimensions of healthcare inequity, horizontal equity receives much attention in the literature. Horizontal equity means "equal treatment for equal need (hereafter ETEN)" and is referred to as "unfair inequality" in Fleurbeay & Schokkaert (2009). This indicates that individuals with the same healthcare need should receive the same amount of resources, irrespective of other socioeconomic factors, such as education, household registration and area of residence (Wagstaff et al., 1991). While health inequalities attributable to biological variations or free choice are unavoidable, others due to the uneven distribution of social determinants of health are

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avoidable. Thus, investigating horizontal inequality in health care has significant policy implications.

China, with a population of 1.4 billion, is one of the largest developing countries, and its healthcare system determines the health welfare of approximately one-fifth of the world's population. Its healthcare system is undergoing a major reform, one of the most complex and far-reaching efforts ever undertaken by any public health system in the world. For example, China decentralized the fiscal system in the mid-1980s to rectify the inefficiencies of the centralized command system. The decision making of health care spending was also decentralized to provinces and local governments. A decentralized health care system might increase efficiency in terms of expenditure and investment. However, the disarray in decentralization diminishes the government’s role in managing public health programs and aggravates inequality in the accessibility and delivery of healthcare provision. Under this decentralized allocation of decision-making power, how to maintain equity in the health care delivery is a paramount issue for the 1.4 billion population and thus deserves a thorough scrutiny.

Given the dominant importance of horizontal inequity in the literature, coupled with the unprecedented healthcare system reform in China, this paper attempts to achieve two objectives: first, proposing a framework for measuring and decomposing horizontal inequity and second, exploring the possible sources of horizontal inequity in healthcare delivery in China.

The contributions of the paper are four folds: 1) The method we propose to measure and decompose horizontal inequity is closely related to the concept of egalitarian-equivalence in the literature on fair allocation because they are both inspired by the ideal situation in which all individuals have the same circumstances (Fleurbaey, 2008; Fleurbaey & Schokkaert, 2009). 2) The method satisfies path independence (Fortin et al., 2011) and would not be contingent on the model specification. 3) We identify the difference between horizontal inequity and overall inequality with raw data. As shown in Table 6, the horizontal inequity is much smaller than the overall inequality and has an obviously different theoretical foundation. 4) While most papers study the horizontal inequity for developed countries, there is a scarcity of studies on the topic for China. This paper fills the void by contributing some evidence for the largest developing country.

We obtain the following findings. First, contrary to the common belief, we find that the horizontal inequity of indirectly standardized healthcare expenditure (ISHE inequality) from 1991-2011 mainly results from the non-need factors, such as household registration, region, work status, education,

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insurance, and marital status, rather than from household income per capita. To be more specific, household registration is the most significant contributor, which accounts for approximately 20 percent of the total horizontal inequity. Region is the second largest factor, contributing 11.24 percent to 18.32 percent. Table 4 lists the contributions of all the variables. It is notable that household income per capita only ranks the sixth largest contributor in most years, ranging between 3 and 5 percent. Second, we find that the horizontal inequity indicated by the Gini coefficient of indirect standardized healthcare expenditure accounts for approximately 68.63 percent of the overall inequality.[1] This indicates that the overall inequality with raw data in health care delivery does not fully reflect the inequity in reality.

The remainder of this paper is structured as follows. Section 2 introduces the theory of horizontal equity. Section 3 reviews the previous literature. Section 4 elaborates the new framework for measuring and decomposing horizontal inequity. Section 5 investigates the sources of inequity in China's healthcare system. Section 6 carries out the empirical analyses of health care delivery in China. Section 7 concludes.

2. Horizontal (in)equity and ETEN

There are many existing theories and specifications of horizontal equity (Wagstaff et al., 1991; Le-Grand, 1991; Mooney et al., 1991; Culyer et al., 1992). Mooney et al. (1991) define horizontal equity according to the idea that individuals with equal need should enjoy the same access to health care. However, even with the same access to the health care service, individuals usually end up consuming different amounts due to different demand curves. If individuals with the same access enjoy different amounts of health care, it will be very difficult for policy-makers to assess the equity among them (Culyer et al., 1992), which reveals the inappropriateness of the definition proposed by Mooney et al. (1991). Furthermore, Culyer et al. (1992) argue that individuals with equal need of health care should be treated in the same way irrelevant to other socio-economic factors, which is called "equal treatment for equal need (ETEN)" (Plotnick, 1981; Van de Poel et al., 2012; Terraneo, 2015). To illustrate, Table 1 summarizes various scenarios based on four hypothetical patients—Alex, Kate, Maria, and Sam. The severity of illness indicates one's need for health care, with 5 being the most severe and 1 being the least

[1] To measure the horizontal inequity in our study, we must eliminate the sample selection bias (the effect of the inverse Mills ratio in our model), except that inequality in utilization of health care must be standardized for differences in need.

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severe. It is evident that we cannot compare equity in scenario C.

Table 1
Needs and utilizations for Alex, Kate, Maria, and Sam.

Panel	Persons	Need characteristics	Healthcare utilization	Horizontal (in)equity	Comparable or not
A	Alex	1	5	Horizontal equity	Comparable
	Kate	1	5		
B	Maria	3	15	Horizontal inequity	Comparable
	Sam	3	18		
C	Kate	1	5	--	Not comparable
	Maria	3	15		
D	Kate	2	10	Horizontal equity	Comparable
	Maria	2	10		
E	Alex	2	10	Horizontal inequity	Comparable
	Kate	2	10		
	Maria	2	10		
	Sam	2	12		

However, the situation in panel C has a closer resemblance to reality, which is filled with heterogeneous individuals with different needs and healthcare utilizations. To identify whether there is horizontal equity in Panel C, we construct a counterfactual scenario in Panel D, where all the patients are designed to have the same need (equal to the mean). One can notice that there is still horizontal equity even if they have different needs and different healthcare utilizations. However, if Alex and Sam are included in the comparison, as shown in Panel E, the status will be switched to horizontal inequity.

3. Previous empirical research

For decades, the existing literature has focused mainly on developed countries, such as the UK (Morris et al. 2005), the US (van Doorslaer et al., 2000) and the Netherlands (Wagstaff & van Doorslaer, 2000a) and international comparisons among developed countries (Wagstaff et al., 1991; Lu et al., 2007; Terraneo, 2015). This may be because many healthcare systems in developed countries are based on the principle of horizontal equity (Kelley & Hurst, 2006; Terraneo, 2015). There is surprisingly little research of developing countries, such as China, despite the rapidly rising importance of China's healthcare system.

Morris et al. (2005) investigate the inequity in the use of general practitioner consultations, day

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cases, outpatient visits and inpatient stays in England and find that low-income individuals are more likely to use primary care and less likely to use secondary care. Lu et al. (2007) compare the extent of horizontal inequity in the healthcare systems of Hong Kong, Taiwan and South Korea. They find horizontal inequity in the usage of physicians and dental services in Hong Kong and inequity in outpatient utilization in Taiwan. By comparison, South Korea has achieved quasi-perfect horizontal equity, but the better-off population has the priority for using higher-level outpatient service.

Most of the previous literature is limited to socioeconomic inequity in health care delivery and uses the concentration index and concentration curve (Abu-Zaineh et al., 2011; Nordin et al., 2017; Pulok et al., 2018). For example, using a fixed effect approach and SHARE (Survey of Health, Ageing and Retirement in Europe) data, Terraneo (2015) finds that there is substantial inequity in healthcare use among individuals with different education levels in many European countries. Because of the unobservable interindividual variation in needs in cross-sectional data, Bago d'Uva et al. (2009) exploit panel data methods to control for the time-invariant part of the unobserved heterogeneity and improve the need-standardization procedure. They find that the estimates of horizontal inequity are significantly higher for most countries by using panel data methods. The results show that the distributions of doctor utilization are pro-rich in most countries. However, as detailed below, socioeconomic status, such as income, is not as important as found in the previous literature. This paper adds to the literature by providing evidence from the perspective of a developing country. The results suggest that other social factors (e.g., household registration, region, work status) should not be ignored.

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4. A new framework of measuring and decomposing horizontal inequity

As described in Section 2, horizontal equity is interpreted as the principle of equal treatment for equal need irrespective of social economic status. Horizontal inequity is the "unequal treatment of the equal need" (Jenkins,1988). Obviously, it is essential to distinguish between "need" factors and "non-need" factors (Culyer & Wagstaff, 1993; Culyer, 1995; O'Dennell et al., 2008). Morris et al. (2005) state that need factors are those that ought to affect the decision of health care usage, and non-need factors are those that ought not. In other words, we believe that need factors may legitimately affect the decision on the resource allocation, while non-need factors are illegitimate. In practice, researchers have relied on demographics (e.g., age, sex) and health status (e.g., self-assessed health, severity of illness) to proxy for need status (Wagstaff & van Doorslaer, 2000a; O'Dennell et al., 2008).

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4.1 Indirect standardization of a health care delivery distribution

A crucial problem arising when measuring and decomposing the extent of horizontal inequity is how should we deal with a real world filled with incomparable needs? A feasible method is to construct a counterfactual scenario describing the distribution of health care delivery for the same need. We thus adopt indirect standardization, as proposed by O'Dennell et al. (2008). We first estimate the healthcare utilization regression as described in model (1).

$$y_{it} = \alpha + \sum_j \beta_j x_{jit} + \sum_k \gamma_k z_{kit} + e_{it} \qquad t = 1991,1993,1997,2000,2004,2006,2009,2011 \tag{1}$$

where $y_{it} = ln(Y_{it})$, and Y_{it} is the healthcare expenditure of individual i in year t. To standardize the health care utilization distribution, we distinguish between two types of explanatory variables: need variables (x_j), i.e., the severity of sickness, age, sex (Lu et al.,2007; O'Dennell et al., 2008; Jie, 2009; Qi and Li, 2011), and other non-need variables (z_k) including marital status, income, education, household registration, work status, and medical insurance. β is the vector of coefficients for the need-standardizing variables, and γ is the vector of coefficients of non-need variables. ε_{it} is the error term.

Based on Eq. (1), we can obtain the parameter estimates $(\hat{\alpha}, \hat{\beta}_j, \hat{\gamma}_k)$. If we assume that $\bar{z}_k$ are the sample means of the non-need variables z_k and $\bar{y}_t$ is the sample mean of the dependent variable y_{it} for each survey year, estimates of the indirectly standardized healthcare expenditure $\hat{Y}_{it}^{IS}$ are then given by the following formula:

$$\begin{aligned} \hat{y}_{it}^{IS} &= y_{it} - \hat{y}_{it}^{X} + \bar{y}_t \\ \hat{Y}_{it}^{IS} &= exp(\ \hat{y}_{it}^{IS}) \end{aligned} \tag{2}$$

$\hat{y}_{it}^{X}$ is the predicted or "x-expected" values of log healthcare expenditure, which we can obtain by the formula $\hat{y}_{it}^{X} = \hat{\alpha} + \sum_j \hat{\beta}_j x_{jit} + \sum_k \hat{\gamma}_k \bar{z}_{kt}$. Exp(•) is an exponential function corresponding to the logarithmic function above.

A more intuitive expression can be found in Eq. (3) below. $\hat{Y}_{it}^{IS}$ (ISHE)[2] is a result of unequal treatment of equal needs. This finding is consistent with the criteria of horizontal equity.

[2] Indirect standardization, the basis of the framework we propose in this paper, follows the same logic as egalitarian-equivalence. It is a reasonable inference that the indirectly standardized healthcare expenditure (ISHE) automatically satisfies egalitarian-equivalence.

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4.2 Measuring and decomposing inequity in health care delivery

4.2.1 The measurement of health care delivery inequity

In most health economic studies, the concentration index and the concentration curve are widely used to represent health care inequality. As explained in Fleurbeay & Schokkaert (2009; 2012), there are several reasons we do not employ them. First, the concentration curve and the corresponding index can only be used in a setting where we consider inequality in one dimension (e.g., income or socioeconomic status). Focusing on socioeconomic or income-related inequalities without considering the impact of other non-need factors, such as household registration or region, may present only a partial picture of the prevailing inequalities. Second, there are still some obvious limitations in the use of the concentration curve and the corresponding index when considering only socioeconomic inequalities (Fleurbeay & Schokkaert, 2009). For example, the contribution of income or socioeconomic status cannot be estimated directly. We do not find evidence that the use of the concentration curve and the corresponding index are apparently better than other inequalities, such as the Gini coefficient.

Therefore, health economists attempt to use other inequality measures (Wagstaff & van Doorslaer, 2000b; Bago d'Uva et al., 2009), such as the Gini coefficient. The Gini coefficient satisfies four important principles: population independence, anonymity, scale independence, and transfer principle (Ray, 1998). Once healthcare expenditure has been standardized for need, horizontal inequity can be measured by the Gini coefficient.

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4.2.2 Decomposition of the health care delivery inequity

Inequity in health care delivery can be explained through the well-known regression-based Shapley value decomposition, which was proposed in Wan (2004). It proposed a framework for inequality decomposition in which ISHE inequality can be decomposed into components associated with different non-need variables, e.g., education, income, household registration, or region, in Eq. (3).

$$\begin{aligned}\hat{Y}_{it}^{IS} &= exp(\ y_{it} - \hat{y}_{it}^{X} + \overline{y}_t) \\ &= exp\left[(\hat{\alpha} + \sum_j \hat{\beta}_j x_{jit} + \sum_k \hat{\gamma}_k z_{kit} + \hat{\varepsilon}_{it}) - (\hat{\alpha} + \sum_j \hat{\beta}_j x_{jit} + \sum_k \hat{\gamma}_k \overline{z}_{kt}) + (\hat{\alpha} + \sum_j \hat{\beta}_j \overline{x}_{jt} + \sum_k \hat{\gamma}_k \overline{z}_{kt}) \right] \\ &= exp(\ \hat{\alpha} + \sum_j \hat{\beta}_j \overline{x}_{jt} + \sum_k \hat{\gamma}_k z_{kit} + \hat{\varepsilon}_{it})\end{aligned} \tag{3}$$

To account for the contribution of the residual term, Wan (2004) follows the procedure in Shorrocks (1999) and eliminates the contribution of ε_t from Eq. (4). $G(\cdot)$ and PC denote the Gini coefficient and percentage, respectively.

$$G(\varepsilon_t) = G(\hat{Y}_t^{IS}) - G(\hat{Y}_t^{IS} \mid \hat{\varepsilon}_t = 0)$$
$$PC_{e_t} = G(e_t) / G(\hat{Y}_t^{IS}) \tag{4}$$

When a residual term is the same as its mean (zero) for every individual, its contribution to inequity is naturally eliminated. That is why $G(\varepsilon_t)$ equals $G(\hat{Y}_t^{IS}) - G(\hat{Y}_t^{IS} \mid \hat{\varepsilon}_t = 0)$. Similarly, we can eliminate the contribution of need variable x_j with the formula $G(\hat{Y}_t^{IS}) - G(\hat{Y}_t^{IS} \mid x_{jt} = \bar{x}_{jt})$. Therefore, the contributions of the remaining need variables and the constant are eliminated as well.

The essence is to estimate the contribution of the non-need variables, including income, education and household registration. To estimate the contribution of any non-need variable z_k, we can use its mean $\bar{z}_k$ in Eq. (3) and then predict the healthcare expenditure that is based only on the remaining k-1 non-need factors[3]. In this case, the contribution of z_k to horizontal inequity is given as follows:

$$G(k) = G(K) - G(K \setminus \{k\}), \qquad k \in K \tag{5}$$

where $G(K)$ is the Gini coefficient for ISHE, and $G(K \setminus \{k\})$ is the Gini coefficient for the predicted healthcare expenditure where prediction is dependent on the real value of K-1 non-need variables (after excluding z_k) at the mean of z_k. This procedure is so-called "eliminating z_k" (Pal, 2015).

However, this method does not give the exact decomposition (Shorrocks, 1999; 2013). In Eq. (5), some other non-need variable, say $z_l (l \neq k,\ l \in K)$, may already be eliminated before z_k is eliminated. Therefore, the decomposition result is not unique because it depends on the order to remove the non-need variables. This is the "path dependence" noted by Shorrocks (2013). To deal with it, all K! possible ways to remove the non-need variables are considered, and then the contribution of z_k can be obtained in Eq. (6) as the average taken over the averages for each way (Wan & Zhou, 2005).

$$G(z_k) = \sum_{s=0}^{K-1} \sum_{\substack{S \subseteq K \setminus \{k\} \\ |S| = s}} \frac{(K-1-s)!s!}{K!} \left[G(S \cup \{k\}) - G(S) \right] \tag{6}$$

Here, S is a set of non-need variables present in Eq. (3) excluding z_k. s is the number of variables in S, and $s = |S|$. Since the Shapley value (Shapley, 1953) is applied in Eq. (6), we call it regression-based Shapley value decomposition.

It should be noted that in Eq. (1), the year dummy variable is included to control for the effect of the time-invariant factor. When decomposing the Gini coefficient in the framework of the

[3] In the framework of Shapley value decomposition, the value of need variables in Eq. (3) is always equal to their mean and can be ignored like the constant term. So, the explanatory variables in Eq. (3) are only non-need factors, and the number is k.

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regression-based Shapley value decomposition, both the dummy variable and constant term can be removed without affecting the decomposition results (Wan, 2004). Finally, we have $G(\hat{Y}_t^{IS}) = \sum_k G(z_{kt}) + G(e_t)$.

In sum, the steps of the empirical study to decompose the horizontal inequity are as follows:

First, a regression model (Eq. (1)) is used to estimate healthcare utilization using all need variables and non-need variables.

Second, a counterfactual distribution[4] of healthcare utilization is constructed using the indirect standardization method (Eq. (3)), in which the need variables are controlled at the mean to eliminate their contributions to inequity. Therefore, we can approximate the horizontal inequity of raw healthcare utilization by computing the Gini coefficient of the counterfactual healthcare utilization.

Finally, a regression-based Shapley value procedure is applied to decompose the horizontal inequity of healthcare utilization based on ISHE to estimate the exact contribution of each non-need variable (Eq. (6)).

5. Inequity in China's healthcare system

Since market-oriented reforms began in 1978, China has implemented a strategy of promoting unbalanced development in economic and social sectors, which has led to substantial inequalities across regions, between urban and rural areas and between coastal and inland districts (Qin & Hsieh, 2014; Zhang et al., 2019). The market-oriented reforms have also changed the traditional healthcare system established for a low-level economy based on an equalitarian health policy.

Notably, heterogeneity is a key characteristic of China's healthcare system (Burns & Liu, 2017). On the one hand, the backbone of the social medical insurance system in China consists of three different schemes: the Urban Employee Basic Medical Insurance (UEBMI), which became effective in 1998 and covers city dwellers who are employed; the New Rural Cooperative Medical Scheme (NRCMS), which was launched in 2003 and covers rural residents; and the Urban Resident Basic Medical Insurance (URBMI), which began in some pilot cities in 2007 and covers unemployed city dwellers (Wang, 2009). The institutional design and the benefits of the three schemes vary widely among different cities and rural areas (Burns & Liu, 2017; An et al., 2018), which is called "fragmented design" in academia and

[4] In the counterfactual scenario, each of the individuals in the sample have equal need.

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governments. Although a series of reforms focusing on fairness have been carried out in recent years, the equity of healthcare financing and medical treatments among the Chinese population is difficult to achieve, and the gap of different schemes still exists. For instance, a worker in Beijing city will have a different social medical insurance scheme from a farmer in Anhui Province. On the other hand, eastern China has developed much more rapidly than central and western China due to an unbalanced resource allocation. This causes significant regional differences in the design and development of the healthcare system because the financing of healthcare is mostly dependent on economic development.

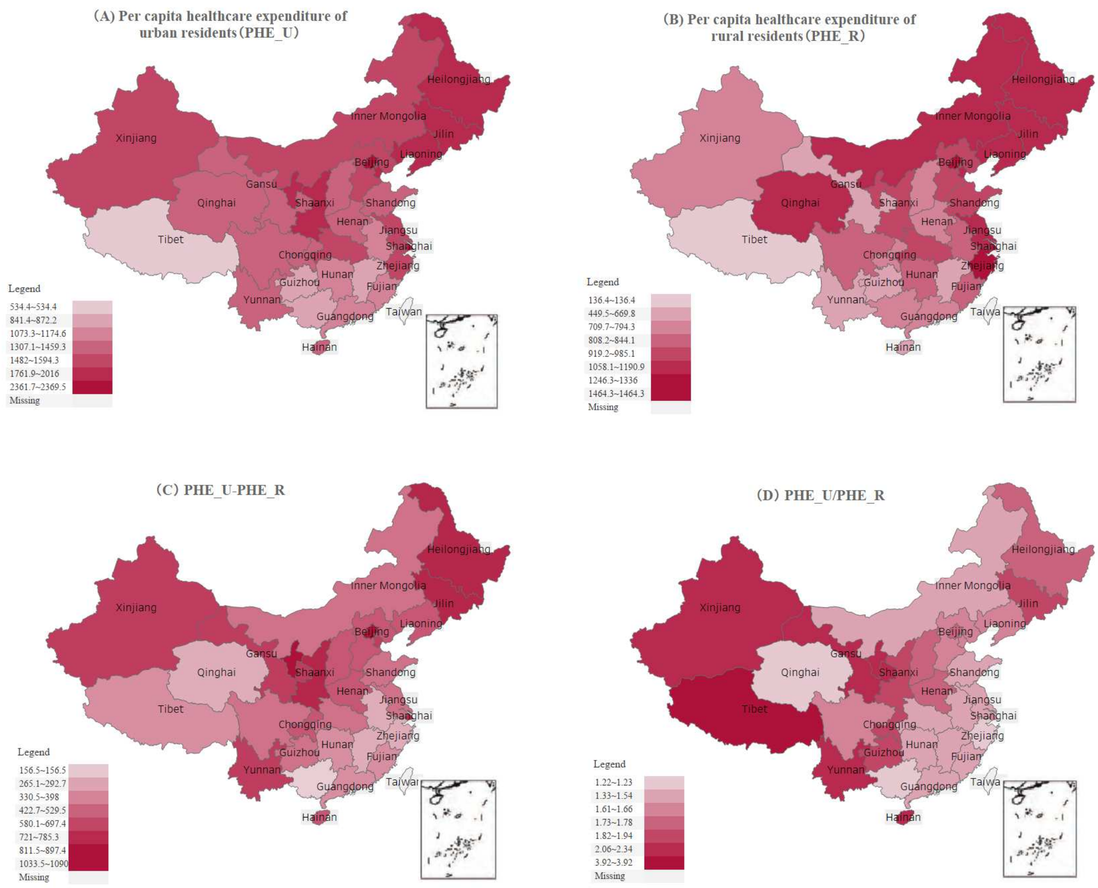

Fig. 1. Per capita healthcare expenditure of urban and rural residents in 2015 (yuan).

Notes: (1) Source: Chinese Health and Family Planning Statistics Yearbook 2017; (2) The upper limit of each interval in the legend is the actual value of the largest PHE (per capita healthcare expenditure) in the corresponding interval, and the lower is the smallest; (3) Figure C is the surplus of per capita healthcare expenditure of urban residents (PHE_U) minus the per capita healthcare expenditure of rural residents (PHE_R), and Figure D is the ratio of the two.

Figure 1 illustrates the inequity of China's healthcare system. In 2015, the per capita healthcare expenditure of rural residents was 846.0 yuan, only 58.6 percent of the expenditure of urban residents (1443.4 yuan). Within the provinces, a larger gap is identified between urban and rural areas in Tibet, Yunnan, Ningxia, Gansu, Xinjiang, and Hainan, and the per capita healthcare expenditure of urban residents is more than twice that of rural residents, while the gap is relatively smaller in Zhejiang, Qinghai, and Guangxi Provinces (Figure 1D). In terms of absolute difference, the per capita healthcare expenditure of urban residents is at least 1000 yuan more than that of rural residents in Ningxia and Beijing, while the difference is less than 300 yuan in Qinghai, Anhui and Guangxi (Figure 1C). Comparing urban areas among different provinces in 2015, the per capita healthcare expenditure exceeds 1700 yuan in Beijing (2369.5 yuan), Shanghai (2361.7 yuan), Ningxia, Heilongjiang, Jilin, Tianjin, Shaanxi and Liaoning (Figure 1A), which are 3.3-4.3 times the expenditure in Tibet. Comparing the rural areas, the per capita healthcare expenditure in Shanghai, Beijing and Zhejiang exceeds 1200 yuan, while the expenditure in Yunnan, Jiangxi, Guizhou and Tibet is less than 600 yuan (Figure 1B), among which the expenditure in Tibet was only 136.4 yuan. It can be concluded that provincial disparities in healthcare expenditure exist within rural and urban areas.

Although Figure 1 well demonstrates the difference among provincial regions and between urban and rural areas, it ignores the heterogeneity of healthcare expenditure among different individuals in the same area. To explore the heterogeneity and its reasons, the framework proposed above is implemented to measure and decompose the total horizontal inequity of healthcare delivery. The next section describes the data set and elaborates the empirical findings from the decomposition analysis.

6. Empirical application to health care delivery in China

6.1 Data and variables

To investigate the determinants of healthcare expenditure and its inequity in China, we employ repeated cross sections from the China Health and Nutrition Survey[5] (CHNS), which is a longitudinal dataset conducted in nine waves (1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011). The CHNS includes information such as demographics, socioeconomic status, health and nutrition, so we can examine the effects of Chinese economic and social transformation on the nutritional status and health of the population. In this study, we used survey data from the waves in 1991, 1993, 1997, 2000, 2004, 2006,

[5] Source: http://www.cpc.unc.edu/projects/china.

2009 and 2011. In this study, we drop the first wave for 1989 because of the inconsistency in key questions in the questionnaire compared with those in other waves. In total, 10011 observations are considered in the analysis by only including people with illness during the past four weeks and aged 18 and over.

The dependent variable in the empirical models is the logarithm of real healthcare expenditure, which comes from the responses to the question "How much money did you spend on illness or injury? (yuan)" during the past four weeks and is adjusted by using the price deflator in 2011 in the CHNS. As explanatory factors of the health care utilization model, the analysis includes health needs measured by severity of illness, sex, and age and non-need factors, such as household registration, region, education, work status, household income per capita, and medical insurance (Lim, Lee, & Shin, 2018). Table 2 shows the descriptions and summary statistics of all variables in our study.

Table 2
Definitions, means, and standard deviations of variables.

Variable	Description of variable	Mean (SD)
Real healthcare expenditure [a]	Money spent on illness or injury during the past four weeks (yuan) and deflated by the CHNS price index	1196.935 (5085.871)
Household registration	Dichotomous variable that equals 1 if respondent belongs to the urban type of household registration	0.364 (0.481)
Region [b]		
Eastern China	Dichotomous variable that equals 1 if respondent is living in Eastern China	0.450 (0.498)
Central China	Dichotomous variable that equals 1 if respondent is living in Central China	0.272 (0.445)
Western China	Dichotomous variable that equals 1 if respondent is living in Western China	0.278 (0.448)
Education	Years of formal education that respondent has completed in a regular school	6.422 (4.443)
Household income per capita	Real household income divided by number of household members (yuan)	8739.594 (10673.31)
Work status	Dichotomous variable that equals 1 if respondent is presently working	0.504 (0.500)
Insurance	Dichotomous variable that equals 1 if respondent has medical insurance	0.580 (0.494)
Distance to most commonly used clinic	The time that it takes to travel one way to the most commonly used medical facility(minutes)	17.093 (38.625)

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Cold treatment fee	The treatment fee for a common cold in this facility (yuan)	22.253 (42.033)
Severity of illness		
Not severe	Dichotomous variable that equals 1 if the illness of respondent is not severe	0.366 (0.482)
Somewhat severe	Dichotomous variable that equals 1 if the illness of respondent is somewhat severe	0.495 (0.499)
Quite severe	Dichotomous variable that equals 1 if the illness of respondent is quite severe	0.139 (0.346）
Sex	Dichotomous variable that equals 1 if respondent is male	0.438 (0.496)
Age	Age of respondent	54.938 (15.627)
Marital status	Dichotomous variable that equals 1 if respondent is married	0.804 (0.397)

Notes: a. The sample size is 5786 for the real healthcare expenditure and 10011 for the remaining variables.

b. Eastern China includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Liaoning, Shandong, Guangdong, and Hainan; Central China includes Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Jilin, and Heilongjiang; Western China includes inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

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In summary, 45 percent of the respondents are from Eastern China, 27.8 percent from Central China, and the rest are from Western China. Approximately 36 percent of respondents belong to the urban type of household registration, 50.4 percent have jobs, 58 percent are insured, 43.8 percent are male, and 80.4 percent are married. The average household income per capita is 8739.594 yuan. On average, a sick person spent 1196.935 yuan on the illness or injury during the past four weeks and completed approximately 6 years of formal education in regular school. When asked “How severe was the illness or injury”, approximately 36.6 percent responded “not severe”, 49.5 percent responded “somewhat severe”, and 13.9 percent indicated that the illness was “quite severe”.

6.2 Regression results

We start by fitting a regression model (Eq. (1)) of the health care delivery. To address the selection bias arising due to the significant amount of missing values for the dependent variable (Li & Hu, 2019), the Heckman selection model and 2SLS are conducted to estimate the coefficients of determinants of the healthcare expenditure, which are shown in Columns 2 and 3 in Table 3, with the same results from the OLS regression in Column 1 as a comparison. Since the coefficient of the inverse Mills ratio

(IMR=-2.278) is statistically significant at the 1% level, the sample selection bias cannot be ignored such that the results of OLS regression are biased. Therefore, the coefficients from the 2nd stage of 2SLS are reported as the final results.

Table 3
Regression results.

	(1)	(2)	(3)
	OLS	Heckman sample selection model	
		1st stage	2nd stage
Household registration (Ref: rural)	0.315***	-0.274***	0.605***
	(5.622)	(-9.067)	(7.821)
Region (Ref: Eastern China)			
Central China	-0.234***	0.135***	-0.363***
	(-3.816)	(4.141)	(-4.884)
Western China	-0.508***	0.179***	-0.624***
	(-8.884)	(5.472)	(-8.511)
Severity of illness (Ref: not severe)			
Somewhat severe	0.880***	0.240***	0.551***
	(16.994)	(8.509)	(7.267)
Quite severe	2.055***	0.474***	1.419***
	(27.617)	(11.265)	(11.974)
Education	0.021***	-0.014***	0.037***
	(2.844)	(-3.782)	(4.234)
Household income per capita	0.105***	0.003	0.081***
	(4.998)	(0.263)	(3.102)
Work status	-0.391***	0.100***	-0.494***
	(-6.619)	(3.114)	(-6.825)
Insurance	0.210***	-0.080**	0.266***
	(3.412)	(-2.389)	(3.589)
Age	0.007***	-0.006***	0.015***
	(3.592)	(-5.398)	(5.642)
Sex	0.048	-0.074***	0.160**
	(0.952)	(-2.708)	(2.556)
Marital status	0.288***	0.125***	0.133*
	(4.568)	(3.707)	(1.688)
Distance of the most commonly used clinic		-0.001*	
		(-1.786)	
Cold treat fee		0.005***	
		(13.551)	
Constant	3.014***	0.381***	4.470***
	(12.783)	(2.992)	(13.166)
Inverse Mills ratio (IMR)			-2.278***

			(-8.125)
Observations	5786	10011	5786
R^2	0.274		
Adjusted R^2	0.271		

Notes: *t* statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In Column 3 of Table 3, all the coefficients of the explanatory variables are statistically significant at the 1% level in the expected direction, except for sex and marital status, which are significant at the 5% and 10% levels, respectively. The coefficient of household registration estimated by 2SLS is 0.605, which means that, on average, sick people with the urban type of household registration have an 83.13 percent higher healthcare expenditure than their rural counterparts. Average healthcare expenditure varies significantly among different regions in China. On average, respondents from Central China or Western China spend 43.76 percent or 86.64 percent lower on medical services, respectively, than those from Eastern China. The results also show that the coefficients of sex, age, and marital status are significantly positive, indicating that men (compared with women) and older people spend much more in healthcare. Both household income per capita (on a natural log scale) and education have a significantly positive association with healthcare expenditure (on a natural log scale), indicating that individuals with higher income and education generally spend more. On average, an increase of ten percent in household income per capita or of one year of formal education raises the healthcare expenditure by 0.81 percent or 3.7 percent, respectively. A person who is not working spends, on average, 63.89 percent more than a person who is working. This is probably because the latter prefers to choose a simple and cheap treatment when he is ill. As expected, a somewhat severe illness or injury costs 73.5 percent more than an injury that is not severe, and a quite severe illness or injury costs 3.1 times more. Compared with people who are not insured, the insured spend 30.47 percent more on medical services because medical insurance softens their budgetary constraints (Lee & Zhang, 2017). The results are consistent with those of previous studies and our expectations, suggesting that the results from the Heckman selection model and 2SLS are credible and robust.

6.3 Decomposition results

Based on the results in Column 3 of Table 3 (Eq. (3)), we implement indirect standardization to construct the counterfactual distribution of healthcare expenditure, which is the core measurement of horizontal inequity. The next step is to implement the regression-based Shapley value decomposition to

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identify the root sources of health care delivery inequity in China by using a Java program UNU-WIDER developed by the World Institute for Development Economics Research of the United Nations University.

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Table 4
Decomposition results.

		Household registration	Region	Education	Household income per capita	Work status	Insurance	Marital status	Residual	Horizontal inequity
1991	Gini	0.11509	0.07582	0.04034	0.01646	0.06666	0.04389	0.00194	0.19962	0.55984
	%	20.56	13.54	7.21	2.94	11.91	7.84	0.35	35.66	100.00
1993	Gini	0.11	0.07843	0.04109	0.01779	0.06506	0.04246	0.00179	0.34092	0.69753
	%	15.77	11.24	5.89	2.55	9.33	6.09	0.26	48.88	100.00
1997	Gini	0.11404	0.08483	0.0384	0.01647	0.06905	0.04183	0.00494	0.28650	0.65607
	%	17.38	12.93	5.85	2.51	10.52	6.38	0.75	43.67	100.00
2000	Gini	0.11248	0.07685	0.04308	0.02188	0.07334	0.03651	0.00262	0.17713	0.54389
	%	20.68	14.13	7.92	4.02	13.48	6.71	0.48	32.57	100.00
2004	Gini	0.09748	0.07469	0.04047	0.02363	0.06422	0.03643	0.00283	0.28892	0.62866
	%	15.51	11.88	6.44	3.76	10.22	5.79	0.45	45.96	100.00
2006	Gini	0.09512	0.0712	0.04242	0.02003	0.06409	0.02448	0.00284	0.25329	0.57348
	%	16.59	12.42	7.40	3.49	11.18	4.27	0.50	44.17	100.00
2009	Gini	0.09517	0.08041	0.03816	0.02031	0.06412	0.00916	0.00342	0.20190	0.51265
	%	18.56	15.69	7.44	3.96	12.51	1.79	0.67	39.38	100.00
2011	Gini	0.1054	0.08853	0.05085	0.02465	0.05958	0.00487	0.004	0.14526	0.48315
	%	21.82	18.32	10.52	5.10	12.33	1.01	0.83	30.06	100.00

Notes: a. The base regression for Shapley decomposition is Column 3 in Table 3;

b. The results of the region in Column 4 are the sum of the contributions of “Western China” and “Central China”;

c. The Gini represent the absolute contributions of each variable to the horizontal inequity of healthcare expenditure, and % represent their relative contributions;

d. Horizontal inequity is the surplus of the Gini coefficient of indirect standardized healthcare expenditure minus the contribution of the inverse Mills ratio.

In terms of composition, the relative contributions are similar across the survey years. All explanatory variables have a positive contribution to horizontal inequity in China, and their ranking changes little from one survey year to another (see Table 5). As expected, household registration is the most significant identifiable contributor and contributes to approximately 20 percent of the total horizontal inequity (Table 4). Region ranks the second largest contributor to horizontal inequity, with a contribution from 11.24 percent to 18.32 percent. Given that individuals in wealthier regions (such as urban areas and Eastern China) can afford more health investment and better medical facilities, an inequity-increasing effect is expected as the disparity continues to grow. For example, most tertiary hospitals are distributed mainly in large cities in Eastern China. Work status explains between 9.33 and 13.48 percent of the total inequity and ranks the third largest contributor to horizontal inequity.

As shown in Table 4, there are no significant differences between the contribution of education and insurance to horizontal inequity until the percentage of insurance decreases to approximately 1 percent in 2009 and 2011. The contribution of insurance to horizontal inequity is likely to continue to increase unless governments establish a medical insurance system that can assist poor families in obtaining medical services. For the remaining non-need factors, education ranked the fourth largest contributor to horizontal inequity until 2000. Household income per capita ranks only the sixth largest contributor to horizontal inequity in most years, with a contribution of approximately 3-5 percent, which indicates that income is not as important as we think. Marital status is the smallest contributor to horizontal inequity, with a contribution of less than 1 percent, showing little difference in the distribution of the ISHE regardless of marital status. In general, all explanatory variables in our model jointly explain between 50 and 70 percent of the total horizontal inequity.

Table 5
Ranking of different variables from one survey to another.

	1991	1993	1997	2000	2004	2006	2009	2011
Household registration	1	1	1	1	1	1	1	1
Region	2	2	2	2	2	2	2	2
Education	5	5	5	4	4	4	4	4
Household income per capita	6	6	6	6	6	6	5	5
Work Status	3	3	3	3	3	3	3	3
Insurance	4	4	4	5	5	5	6	6
Marital status	7	7	7	7	7	7	7	7

Note: we sort the percentage contributions of different variables in Table 4 in descending order.

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To clarify, there is a clear distinction between inequality and inequity in this paper. As shown in Table 6, overall inequality is computed using raw data of healthcare expenditure and is approximately 0.8-0.9 across years and is much higher in 2000, 2004, and 2006 than in other survey years. Horizontal inequity is the highlight of this paper, which is the surplus of ISME inequality minus the contribution of the inverse Mills ratio (see Table 4 and Table 6). Fortunately, the indirect standardization method can be perfectly combined with the principle of horizontal equity. For individuals with equal medical needs, the inequality of health care delivery is, on average, approximately 0.582 across survey years, which accounts for approximately 68.63 percent of the overall inequality. Since the horizontal inequity is much smaller than the overall inequality and has an obviously different theoretical foundation, we must be careful with them in the discussion of health care equity and health policy research.

Table 6
The difference between overall inequality and horizontal inequity and the contributions of the inverse Mills ratio and need variables.

		1991	1993	1997	2000	2004	2006	2009	2011
Overall inequality[a]	Gini	0.85584	0.82747	0.80216	0.89	0.86145	0.87296	0.84181	0.84998
Horizontal inequity[b]	Gini	0.55984	0.69753	0.65607	0.54389	0.62866	0.57348	0.51265	0.48315
	%	65.41	84.30	81.79	61.15	72.98	65.69	60.90	56.84
Inverse Mills ratio	Gini	0.06946	0.06889	0.05195	0.06078	0.05945	0.05693	0.04967	0.0702
	%	8.12	8.33	6.48	6.83	6.90	6.52	5.90	8.26
Need variables[c]	Gini	0.22654	0.06105	0.09414	0.28473	0.17334	0.24255	0.27949	0.29664
	%	26.47	7.38	11.74	32.01	20.12	27.78	33.20	34.90

Notes: a. Overall inequality is data showing inequality, which is computed by using data in the real world;
b. Horizontal inequity is the surplus of the Gini coefficient of indirect standardized healthcare expenditure minus the contribution of the inverse Mills ratio;
c. Based on the theory of "before-after", the contribution of need variables to overall inequality is the surplus of overall inequality minus horizontal inequity and the contribution of the inverse Mills ratio.

Accounting for the sample selection bias in the regression analysis is a significant improvement in this study (see Rows 5 and 6 in Table 6). The results in Row 6 of Table 6 show that the contribution of sample selection bias to overall inequality is, on average, approximately 7.17 percent (highest in 1993, 8.33 percent) in addition to need and non-need factors. Such a contribution should be removed when computing horizontal inequity in health care delivery.

Furthermore, we compute the contribution of need variables to overall inequality based on the theory of “before-after”. It is the surplus of overall inequality minus horizontal inequity and the contribution of the inverse Mills ratio. As reported in Table 6, we find that the total contribution of all need variables (including health status, age, and sex) is between 7.38 and 34.90 percent of the overall inequality. Taking 2011 as an example, this means that 34.90 percent of the overall inequality is legitimate and needs to be considered when implementing inequity-reducing policy.

7. Conclusion

In this paper, a new framework is proposed combining indirect standardization mothed with regression-based Shapley value decomposition to investigate horizontal inequity in health care delivery in China using the China Health and Nutrition Survey (CHNS) dataset. On the one hand, the indirect standardization could control for the differences of need factors, such as severity of illness, age, and sex, and identify the difference between horizontal inequity and overall inequality with raw data. On the other hand, the regression-based Shapley value decomposition could eliminate path dependency, given that the decomposition method meets lateral additivity of contributions from explanatory variables.

Based on the framework above, we not only define and calculate horizonal inequity but also identify the root sources of horizontal inequity. The results show that, on average, the horizontal inequity measured by the Gini coefficient of ISHE accounts for approximately 68.63 percent of the overall inequality. This means the overall inequality with the real-world data in health care use does not fully reflect the real inequity. Moreover, the non-need variables, such as household registration, region, work status, education, income, insurance, and marital status, jointly explain between 50 and 70 percent of the total horizontal inequity. Household registration is the most significant identifiable contributor, and region ranks second. The percentage contribution of household income per capita is approximately 3-5 percent, the sixth largest contributor in most years, indicating that income is not as important as we think in China.

We tentatively draw some policy implications based on the results. First, our findings could help arouse policy makers’ concerns about inequity in the delivery of health care and raise an intense debate on how to achieve equity and equality in health care in China. Second, our exploration of the root sources may serve as a guidance to policy makers in fighting horizontal inequity through channels such

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as reducing disparities among rural and urban areas and reprioritizing the allocation of health resources among different regions in China.

There are some limitations in our study. First, total healthcare expenditure is a rough indicator because the patterns of inequity may be different for different health care items, such as outpatient visits or inpatient stays. However, the outpatient visits and other information are not available in the data set, while the number of hospitalizations during the past 4 weeks (717) is too small to build a robust model. Second, although the Gini coefficient is the most commonly used and intuitive measurement of inequality, it is particularly sensitive to changes in middle-level income. Given that different inequality indices are associated with different social welfare functions that assume different aversions to inequality (Wan, 2004), we should try other inequality indices, such as Theil L and Theil T, in future research.

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