Child Indicators Research (2022) 15:137–159
https://doi.org/10.1007/s12187-021-09854-9

The Health Inequality of Children in China: A Regression-Based Decomposition Analysis

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Accepted: 20 August 2021 / Published online: 28 September 2021

Abstract

The health inequality of children is particularly important due to its far-reaching impact. Many empirical studies have shown that the lack of health-related human capital accumulation during childhood has many adverse effects. However, the health inequality of children seems to be less discussed in China. In this paper, we investigate the status and contributing factors of health inequality of children in China. The dataset used in this paper is called Rural-Urban Migration in China 2008 (RUMiC 2008), which was initiated by the Australian National University alongside a few other institutions. Using the data, firstly, we calculate the concentration index for stunting and underweight to track their status among children. Then, we decompose the concentration index using a regression equation method. The results show that household per capita income is the most important contributional factor to the concentration index of stunting for rural children. The next most important factor is the education of the household head. As expected, household per capita income is not an important contributional factor toward the concentration index of stunting in the urban sample. Its most important contributional factor is the education of the household head. For both rural and urban children, household per capita income is the most important contributional factor for the concentration index of underweight. Well-designed policies to increase the household per capita income and the education of the household heads may help to reduce the health inequality of their children.

Keywords China · Children · Health inequality · Concentration index · Regression-based decomposition

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1 Introduction

As a basic human right of every member in society, the acquisition of good health is not only closely related to the life and development of individuals, but also related to important public policy choices. Hence, it has captured close attention of those institutions aiming to promote human development. The World Health Organization regards health improvement as an important goal for human development, and the United Nations also regards health as an important indicator of the degree of development of a country or region. Achieving the common enjoyment of good health among all members of society is becoming one of the key objectives of policy makers worldwide. Undoubtedly, health inequality has attracted the attention of researchers, who believe that it is more worrying than other kinds of inequality (Marmot, 2015; Sen, 2002; Tobin, 1970).

As issued by the United Nations Convention on the Rights of the Child, every child has every right. It is worth emphasizing that an important part of Right 24 in the United Nations Convention on the Rights of the Child has promised to protect children's rights. Rights 24 states, "Children have the right to the best health care possible, clean water to drink, healthy food and a clean and safe environment to live in. All adults and children should have information about how to stay safe and healthy." (United Nations International Children's Emergency Fund, 2021). How to conceptualize children is intrinsic to the ways of understanding rights of the children. Different conceptualizations of children arise, flowing from a fundamental question—whether the child is the human becoming or the human being (Huang, 2019). The vision that referred to children as becoming is due to they think childhood is a transitional stage in which children are preparing to become adults (Baader et al., 2016; Tisdall & Punch, 2012). The vision that referred to children as being is due to they think children could also contribute to a wider process of societal maintenance and cultural reproduction (Corsaro, 2015; James, 2011; Katsiada et al., 2018). As a third viewpoint, several studies refer to children as "beings and becomings" (Brembeck et al., 2004; James, 1998; Lee, 2002; Uprichard, 2008). In this study, we refer to children as "beings and becomings".

The importance of bringing down levels of inequality with regard to children's health is particularly important due to its far-reaching impact on their lifelong development. Achieving good health during a child's growth plays an important role in the development of individuals, families, society, and the country (Strauss & Thomas, 1998; Glick & Sahn, 1998; Guillem et al., 2005; Schultz 2005; Deaton, 2008; Wong et al., 2014; Simon et al., 2018). The children of the day are labor force of the future. The accumulation of health capital before reaching adulthood lays the foundation for future income attainment, and good human capital accumulation in childhood also contributes to the country's economic development in the future (Liu et al., 2004; Meng & Yamauchi, 2017; Wei, 2004; Zhang et al., 2013).

On the contrary, the lack of health-related human capital accumulation during childhood has many adverse effects. Specifically, at child and family levels, it hinders access to the viable capacity of many aspects of life. Health inequality reinforces inequalities in other areas, and these inequalities will continue to manifest themselves over time (Elgar et al., 2016; The World Bank, 2005; Viner et al., 2012), which leads to the intergenerational transmission of poverty (Aizer & Currie, 2014; Robertson & O'Brien, 2018; Zhu, 2008). At the national development level, as an important reserve of future human capital, children's health accumulation is a key factor for the stable and sustainable development of the economy and is related to a country's long-term potential for economic development (Bloom et al. 2001; Banerjee et al., 2004; Zhang et al., 2013). From a legal point of view, health is a basic human right of children which should not be deprived in any case (United Nations International Children's Emergency Fund, 2021). So, the state of health inequality is actually a form of violation of basic human rights. Moreover, health inequality would damage the egalitarian justice and social development in many ways (Asada & Schokkaert, 2019; Hosseinpoor et al., 2018; Marchman Andersen et al., 2013).

In the last two decades, there are many studies which have focused on the investigation of health inequality all over the world (Allanson & Petrie, 2013; Carrieri & Jones, 2018; Lauridsen et al., 2007; Pradhan et al., 2003; Sahn & Younger, 2009; Wildman, 2003). For example, Wildman (2003) decomposed health inequality in the UK between 1992 and 1998 to examine the impact of income inequality on health inequality. The results show that subjective financial status has a large impact on health and is the main contributor to income-related health inequality. Van Ourti et al. (2009) used self-reported health indicators to decompose income-related health inequality in 13 European Union member countries. By using interval regression methods, they calculated the concentration index and decomposed inequality into each contributor. The results show that health is not only a reflection of income inequality but also contributes to the regional health inequality of the population. Sahn and Younger (2009) used BMI to measure health inequality and broke down overall health inequality into health inequality between families and health inequality within families. The results show that about half of health inequality exists within the families themselves, which indicates that health inequality measured by family-level data may underestimate true health inequality.

In general, the body of research on the decomposition of health inequality for China is minute. Xie (2009) focused on the contribution of income factors to health inequality from the perspective of medical service utilization by using data from the China Health and Nutrition Survey (CHNS) from 1991 to 2006. The decomposition of the concentration index showed that there existed pro-rich health inequality in China. Deng (2010) used 2006 Urban Household Survey (UHS) data to estimate and decompose the health inequality of urban residents by using an interval regression method. The results show that income contributes to as much as 70% of health inequality. In addition, Du and Wang (2013) used the Chinese Longitudinal Healthy Longevity Survey (CLHLS) to study the health inequality of the elderly in China from 1998 to 2008, and found that the health inequality of the elderly is gradually deepening. However, these studies mainly used data from urban samples, and moreover did not specifically study children's health inequality.

In fact, the research on children's health inequality is still relatively limited, and this is especially true for China. Wagstaff et al. (2003) decomposed children malnutrition in Vietnam by using Vietnamese quality of life survey data between 1993 and 1998. Their results show that the main factors affecting children's health inequality in Vietnam are family consumption and unobserved community-level factors. Meanwhile, Wagstaff and Doorslaer (2004) attempted to unify total health inequality and socioeconomic-related health inequality with one measure for Vietnamese children. It leads to the conclusion that socioeconomic-related health inequality accounts for about a quarter of total health inequality. Moreover, there is still much less research focusing on children's health inequality in China. Wang et al. (2003) used the National Child Health Survey data to measure child's health and its inequality by two indicators: child's mortality and morbidity. The results show that the mother's education is one of major contributors to children's health inequality, and it also concludes that children's health inequality will worsen as China's reform process continues. Chen et al. (2007) used CHNS data to identify significant inequality in Chinese children's malnutrition between urban and rural areas by using the age-specific Z-score, and it shows that the place where children live matters significantly for their health.

However, The results of these several studies which focused on the children's health inequality in China mainly describe the fact of Chinese children's health inequality at the end of the last century. Due to the data limitation, they can't capture the more recent changes in Chinese children's health inequality in the new century. Furthermore, the child mortality and morbidity rates of China are already at low levels since the same time. Therefore, the mechanical applicability of the health indicators from the previous study is insufficient.

There exists a significant dual structure of urban and rural areas in China. Before the Reform and Opening Up, China's macro policies pointed to a strong urban bias which enabled urban residents to have access to food and healthcare at much lower prices compared to their rural counterparts (Lin et al., 1999). Market reforms have actually increased rural-urban inequality (Park, 2008). As a result, those persons living in rural areas and those in urban areas enjoy totally different health services and it shows surprisingly health inequality between rural areas and urban areas in China (Zhang & Kanbur, 2005; Liu et al., 2013; Zhang, 2018; Dong et al., 2019b). Based on a unique survey data which contains the accurate information of height, weight, and age for sampled children in China, this study aims to investigate the status and contributing factors of health inequality of children in China. All of previous studies discussed above give us reason to put forward Hypotheses 1–3.

Hypothesis 1: There exists health inequality of children in China.

Hypothesis 2: Socioeconomic-related factors have significant contributions to children's health inequality in China.

Hypothesis 3: There exists heterogeneity on the contributions to children's health inequality between rural areas and urban areas in China.

Following previous studies, we mainly employ two health indicators, stunting and underweight, to measure the concentration index of children's health inequality (Arokiasamy & Pradhan, 2011; Krishna et al., 2017; Lee et al., 2012). Then, we decompose it based on a regression equation and analyzes the influencing factors and contribution of children's health inequality in urban and rural areas.

The rest of this study is structured as follows: the following section gives a brief introduction of the data and variables, and Section 3 introduces the method used in this study. Section 4 gives descriptive statistics, estimates the linear probability model of stunting and underweight, calculates the concentration index, and performs a regression-based decomposition. The last section summarizes and proposes some policy implications.

2 Data and Variables

2.1 Data

The dataset used in this paper is called Rural-Urban Migration in China (RUMiC). The RUMiC project is a research collaboration initiated by a group of researchers at the Australian National University, the University of Queensland, and the Beijing Normal University and supported by Institute of Labor Economics (IZA), which provides the Scientific Use Files through IDSC, its data bank center. It consists of three independent parts: the Urban Household Survey (UHS), the Rural Household Survey (RHS), and the Migrant Household Survey (MHS). The RHS and UHS have been conducted in collaboration with the National Bureau of Statistics of China (NBS), while the MHS has been conducted in partnership with a professional survey company. The RHS and UHS were conducted using random samples from the annual household income and expenditure surveys carried out in cities and rural villages (Kong 2010). A multi-stage stratified sampling procedure is used to select the sample. During the sampling process, efforts were made to cover rural and urban areas with representative income and population levels. The RHS was conducted in villages across nine provinces which contained 8000 rural households, while the UHS was carried out in eighteen cities and contained 5000 urban households. The criterion to divide rural and urban households is based on hukou status and their actual residence. They should meet two conditions at the same time. Household survey is conducted by statisticians in each county.

The income data in the UHS and RHS surveys are provided by the NBS. NBS collects income and expenditure information through daily household income and expenditure diaries in its annual household surveys. Using the data from these diaries, the NBS constructs estimates of household income. In this regard, the NBS (and thus the UHS and RHS) income variables differ from the estimates of income in many other Chinese household survey datasets that rely on recall by the respondents. Unfortunately, we cannot make a similar empirical analysis by using the MHS due to it has a different sampling strategy and questionnaire structure. Based on the availability of data and the reason stated above, this study employs household survey data of RHS and UHS from RUMiC 2008. Referring to the United Nations Convention on the Rights of the Child and according to the literature (Li & Zang, 2010), this study defines the age range of children as younger than 18 years. 20.65% of the rural sample was children younger than 18 years. This percentage is 15.56% in the urban sample. Sample provinces or province-level municipalities (Shanghai, Jiangsu, Sichuan, Shaanxi, Guangdong et al.) were randomly selected from each of China's major regions (the east region, the central region, and the west region). Then, sample cities were selected from each province. In general, sample cities in each province are constituted by the provincial capital and other one or two medium-sized cities (Luo & Li, 2011; Luo et al., 2017). The detailed sampling and data collection process were described in Luo and Li (2011).

2.2 Variables

This study includes the following variables: health-related variables, household income, educational attainment of the household heads, gender, age group, ethnicity, regional variables, and so on. The definitions of variables are described in detail below.

2.2.1 Health-Related Variables

This study uses four health indicators to measure children's health status: height-for-age z-score (HAZ), weight-for-age z-score (WAZ), stunting (HAZ < -2), and underweight (WAZ < -2). The calculation of the Z-score in this study refers to the UK reference growth charts and is generated using the command "zanthro" in the Stata software. Please refer to Table 1 for the variables and specific definitions of these four health indicators.

2.2.2 Income Variable

This paper uses the data of household income from the RUMiC data as a measure of the living standard of individuals and their families. By using annual income of the household and household size, the household per capita income can be calculated.[1] Considering the significant heterogeneity between urban and rural areas in China, the empirical analysis of the latter part will analyze the urban and rural areas separately. At the same time, we use the log of the household per capita income in the regression rather than income per capita.

2.2.3 Other Variables

Given the fact that there are huge differences among sample locations, and in order to follow the precedent set by the previous studies, this paper divides the sample provincial administrative region into three types of regions: the eastern region, the central region, and the western region.[2] In terms of age group, we split the sample children into four groups: group A (aged less than 3 years), group B (aged

[1] The definition of household income is referred to the study of Luo and Sicular (2013).

[2] The criteria of the three types of regions are as follows: the eastern region (Liaoning province, Beijing municipality, Tianjin municipality, Hebei province, Shandong province, Jiangsu province, Shanghai municipality, Zhejiang province, Fujian province, Guangdong province, Guangxi autonomous region, and Hainan province); the central region (Shanxi province, Inner Mongolia autonomous region, Jilin province, Heilongjiang province, Anhui province, Jiangxi province, Henan province, Hubei province, and Hunan province); and the western region (Shaanxi province, Gansu province, Qinghai province,

Table 1 Variables and their descriptions

Variables	Descriptions
Height-for-age z-score (HAZ)	HAZ = (Height of each child–the median of reference's height) /the standard error of reference's height.
Weight-for-age z-score (WAZ)	WAZ = (Weight of each child–the median of reference's weight) / the standard error of reference's weight.
Stunting	=1 if HAZ < -2; =0 if HAZ > -2.
Underweight	=1 if WAZ < -2; =0 if WAZ > -2.
Household per capita income	The household per capita income = annual income of the household / household size.
Male	1 = yes; 0 = no.
Han ethnicity	1 = yes; 0 = no.
Eastern region	1 = yes; 0 = no.
Central region	1 = yes; 0 = no.
Western region	1 = yes; 0 = no.
0–2 years	Whether a child's age falls into the age range of 0–2 years old, 1 = yes, 0 = no.
3–5 years	Whether a child's age falls into the age range of 3–5 years old, 1 = yes, 0 = no.
6–12 years	Whether a child's age falls into the age range of 6–12 years old, 1 = yes, 0 = no.
13–18 years	Whether a child's age falls into the age range of 13–18 years old, 1 = yes, 0 = no.
Education of household head (year)	The educational attainment of the household head.

Data source: Rural-Urban Migration in China 2008

3–5 years), group C (aged 6–12 years), and group D (aged 13–18 years). They are all dummy variables, each with a value of 1 if the child has that characteristic and 0 otherwise. Considering that children's health might be influenced by parents, and the key role that being a household head plays in Chinese families, our study includes the schooling of the household head as an important control variable, which is used to characterize the influencing factors in this respect. Please refer to Table 1 for the variables and specific definitions used in this study.

3 Methodology

This paper uses the concentration index to measure health inequality. The concentration index, proposed by Kakwani (1977, 1980), is a quantitative representation of the concentration curve and used to measure the degree of health inequality

Footnote 2 (continued)

Ningxia autonomous region, Xinjiang autonomous region, Sichuan province, Chongqing municipality, Yunnan province, Guizhou province, and Tibet autonomous region).

associated with the social-economic status. Studies have shown that the concentration index is a good indicator of the degree of health inequality (Kakwani et al., 1997). The concentration curve depicts a graph with the horizontal axis (X-axis) representing the cumulative population percentage by living standard, the leftmost side representing the poorest percentage of the population, and the percentage of the wealthier population represented as the graph progresses to the right. The rightmost side represents the percentage of the richest population. The vertical axis (Y-axis) represents the cumulative percentage of health variables. If all individuals enjoy the same level of health, the concentration curve would be a 45-degree line which is the "line of equality." The concentration index is defined as twice the area between the concentration curve and the line of equality. If there is no socioeconomically related health inequality, then the value of the concentration index is zero. When the concentration curve is above the line of equality, the concentration index takes a negative value; otherwise it takes a positive value. In general, the concentration index can be expressed by the formula as follows:

$$C = 1 - 2\int_0^1 L_h(p)d_p \tag{1}$$

The index is between −1 and 1. For discrete living standard variables, the formula can be written as:

$$C = \frac{2}{N\mu}\sum\nolimits_{i=1}^{n} h_i r_i - 1 - \frac{1}{N} \tag{2}$$

In the above formula, h_i is the health sector variable, μ is its average value, $r_i = i/N$ is the fractional rank of the individual i's distribution of living standard, $i = 1$ represents the poorest individual, and $i = N$ represents the richest individual.

In order to facilitate the calculation, we can get a more convenient formula for defining the concentration index by using the health variables and the fractional order of the living standard distribution:

$$C = \frac{2}{\mu}Cov(h, r) \tag{3}$$

It should be noted that the concentration index depends only on the relationship between the health variable and the rank of the living standard variable and not on the variation in the living standard variable itself. A change in the degree of income inequality would not have impact on the concentration index measure of income-related health inequality.

Next, we introduce the decomposition of the concentration index. Wagstaff et al. (2003) demonstrated that the health concentration index can be decomposed into the contributions of individual factors to income-related health inequality, in which each contribution is the product of the sensitivity of heath with respect to that factor and the degree of income-related inequality in that factor. In short, they showed that the concentration index could be decomposed into contributional

Table 2 Descriptive statistics of the health inequality of children in China

	Full sample		Rural sample		Urban sample	
	HAZ	WAZ	HAZ	WAZ	HAZ	WAZ
Average	−0. 6796	-0. 0626	−0.9978	−0.0643	0.1488	0. 4308
Standard error	1.7627	1.5880	1.7622	1.6080	1.4706	1.4682
Min	−4.9966	−4.9556	−4.9966	−4.9556	−4.9495	−4.7993
Max	4.9954	4.9938	4.9954	4.9910	4.9845	4.9938
Obs.	7945	8634	5740	6421	2205	2213

Data source: Rural-Urban Migration in China 2008

factors at the individual level. For any linear additive regression model for health (y): $y = \alpha + \sum_k \beta_k x_k + \varepsilon$. The concentration index can be written as follows:

$$C = \sum\nolimits_k \left(\frac{\beta_k \bar{x}_k}{\mu} \right) C_k + GC_\varepsilon / \mu \tag{4}$$

where μ and $\bar{x}_k$ are the average of y and x_k, respectively. C_k is the concentration index of x_k, and GC_ε is the concentration index of the generalization of the error term ε. Equation (4) shows C is the weighted sum of the k indices in the explanatory variable set, and the remaining terms reflect the income-related health inequality that is not explained by systematic variation in the regressors by income. The weight of x_k is the elasticity of y with respect to x_k ($\eta_k = \beta_k \frac{\bar{x}_k}{\mu}$).

Wagstaff et al. (2003) use Eq. (4) to decompose income-related inequality in child malnutrition in Vietnam in 1993 and 1998. In their study, malnutrition is measured by the height-for-age z-scores (HAZ) of children younger than 10 years of age, and the measure of living standard is household consumption per capita. The z-scores are multiplied by −1 such that a greater value indicates more malnourishment. The specification of the regression model presented in Eq. (3) above is very similar to that used in this study.

4 Empirical Results

4.1 Descriptive Analysis

Table 2 reports descriptive statistics for HAZ and WAZ in the full, rural, and urban samples. The averages of HAZ and WAZ are −0.6796 and − 0.0626, respectively. In terms of urban and rural areas, the average value of HAZ of the rural samples is much lower than that of their urban peers, and the difference is 1.1466 (=0.1488-(−0.9978)). Meanwhile, the gap of WAZ between rural and urban samples is 0.4951 (=0.4308-(−0.0643)), which is much smaller than the gap of HAZ. Moreover, the standard deviation of HAZ and WAZ in rural samples is larger than that in urban samples. Descriptive analysis shows that the overall health level of rural children is

Table 3 Descriptive statistics on underweight and stunting of children in China

Age(year)	Gender	Full sample			Rural sample			Urban sample		
		S(%)	U(%)	Obs.	S(%)	U(%)	Obs.	S(%)	U(%)	Obs.
0–2	boy	21.51	5.59	358	25.93	7.41	243	12.17	1.74	115
	girl	17.33	6.00	300	20.51	6.67	195	11.43	4.76	105
	total	19.60	5.78	658	23.52	7.08	438	11.82	3.18	220
3–5	boy	18.94	5.48	639	23.13	7.05	454	8.65	1.62	185
	girl	19.24	3.41	499	22.93	4.14	362	9.49	1.46	137
	total	19.07	4.57	1138	23.04	5.76	816	9.01	1.55	322
6–12	boy	23.82	5.58	1650	29.91	6.57	1187	8.21	3.02	463
	girl	22.79	5.15	1360	29.97	6.87	931	7.23	1.40	429
	total	23.36	5.38	3010	29.93	6.70	2118	7.74	2.24	892
13–18	boy	17.92	10.40	2060	22.18	11.96	1628	1.62	4.40	432
	girl	14.36	10.76	1943	16.73	11.81	1524	5.73	6.92	419
	total	16.20	10.57	4003	19.57	11.89	3152	3.64	5.64	851

Data source: Rural-Urban Migration in China 2008

"S" stands for the rate of stunting, "U" stands for the rate of underweight

lower than that of urban children, and the degree of health inequality of rural children is higher than that of urban children.

Table 3 reports descriptive statistics on stunting and underweight in children by age group and gender. For the full sample, the rate of stunting for each age group was around 20%. The rate of stunting in children between the ages of 6 and 12 was significantly higher than the other age groups, with a rate of 23.36%. The age group with the highest incidence of underweight was 13 to 18 years old, reaching 10.57%, and the underweight rate of other age groups was mostly around 5%.

For rural children, the overall rate of stunting for all age groups is above 19%. The rate of stunting among children aged 6 to 12 is significantly higher than that among other age groups. The overall rate of stunting in this group is 29.93%, and there is almost no gender difference. This may reflect the negative impact of rural primary school mergers on the nutritional health of children in the data survey year considering that most children in this age group are in primary school (Luo et al., 2009). Children in the two age groups younger than 5 years old have a stunting rate of more than 20%, and after the age of 12, the stunting rate of children is significantly lower, especially for girls. It is worth considering that girls aged 6 to 12 years old with a stunting rate have a higher such rate than do boys in the same age range, and girls in other age groups have a lower stunting rate than do boys of those age groups. For all rural children, regardless of gender, the age group with the highest incidence of underweight is 13 to 18 years old. Both boys and girls have higher than 11% prevalence of underweight in this age group, while the underweight rates of other age groups are all lower than 8%. In terms of gender, underweight has the same characteristics as stunting rate. Girls have lower underweight rates than do boys except for girls who are aged 6 to 12 years.

For urban children, the stunting rates grouped by age group, regardless of gender, are all lower than 13%. The age group with the highest rate of stunting is those aged between 0 to 2 years old, and the stunting rate of the full sample is 11.82%. Furthermore, the gender difference is quite small. An obvious feature is that stunting rates decline with age. The group with the lowest rate of stunning within the urban sample is the eldest group, namely, the group of 13 to 18 years old. This holds for the underweight rate, and the total underweight rate was 5.64%. The gender difference is statistically significant, with 4.40% and 6.92% had by boys and girls, respectively. The underweight rates of other age groups are all lower than 5%. Investigating those indices with a gender perspective, the underweight rates of girls aged 3 to 5 years and aged 6 to 12 years is lower than those of boys, however, the underweight rates of girls in the other two age groups are higher than those of boys.

Comparing the health differences between urban and rural children, we can find that the stunting and underweight rates of urban children are significantly lower than those of rural children. For rural children, the age group with the highest stunting rate is 6 to 12 years old, and that rate is much higher than that of the other three age groups. For urban children, the age group with the highest stunting rate is 0 to 2 years old, but it is still much lower than that of rural children. An important feature is that the rate of stunting in urban children decreases significantly with age.

4.2 Stunting and Underweight: Estimation from Linear Probability Model

We will use the linear probability model (LPM) to estimate the probability equations for stunting and underweight in this section. The LPM itself has some potential limitations. One of the main limitations is that its estimated probability may be less than 0 or larger than 1. In general, to circumvent this problem, previous studies usually use the logit or probit models. However, we use LPM for estimation in this study both because the concentration index decomposition in the next part depends on linear regression and because the study does not involve probability prediction. In addition, our study shows that the results of the LPM and the logit or probit model are consistent with each other, though we have not presented the results of the logit or probit models here.

Table 4 reports the results of stunting for children by the LPM. The household per capita income has a significant mitigation effect on the stunting of rural children and has a much bigger effect on girls. In terms of gender differences, the boys' rate of stunting is 3.42% higher than that of girl's. The rate of stunting in the 13–18 age group is significantly higher than in other age groups. Children living in the western region have a stunting rate 4.11% higher than do those who live in the eastern region. This is mainly driven by girls. Meanwhile, the household per capita income and the gender of each child have no effect on the stunting rate of urban children. An increase in the schooling of the household head helps to reduce the rate of stunting in boys.

By comparing the regression results of urban and rural children, we can draw the following conclusions: the increase in household per capita income can help

Table 4 The estimation of children's stunting from linear probability model

	Rural sample			Urban sample		
	Total	Girl	Boy	Total	Girl	Boy
Household per capita income	−0.0352***	−0.0412***	−0.0307**	0.0005	0.0014	0.0011
	(0.000)	(0.004)	(0.026)	(0.958)	(0.919)	(0.929)
Boy (1 = yes)	0.0342***			−0.0135		
	(0.004)			(0.210)		
3–5 (1 = yes)	−0.0545*	−0.0201	−0.0807*	−0.0370	−0.0249	−0.0489
	(0.679)	(0.679)	(0.074)	(0.116)	(0.497)	(0.108)
6–12 (1 = yes)	−0.0452	−0.0122	−0.0702*	−0.0615***	−0.0515*	−0.0714***
	(0.120)	(0.777)	(0.076)	(0.003)	(0.099)	(0.007)
13–18 (1 = yes)	−0.1839***	−0.1756***	−0.1881***	−0.1065***	−0.0706**	−0.1417***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.024)	(0.000)
Han ethnicity (1 = yes)	0.0888*	0.0539	0.1139*	0.0292	0.0255	0.0344
	(0.088)	(0.507)	(0.094)	(0.478)	(0.704)	(0.503)
Education of household head	−0.0086***	−0.0061	−0.0104***	−0.0037**	−0.0017	−0.0055**
	(0.001)	(0.107)	(0.004)	(0.027)	(0.499)	(0.011)
Central region (1 = yes)	−0.0106	0.0103	−0.0291	0.0503***	0.0403*	0.0636***
	(0.427)	(0.591)	(0.119)	(0.000)	(0.051)	(0.000)
Western region (1 = yes)	0.0411**	0.0485*	0.0344	0.0191	0.0257	0.0136
	(0.019)	(0.053)	(0.162)	(0.208)	(0.268)	(0.492)
Constant	0.6325***	0.6697***	0.6390***	0.1362	0.0905	0.1492
	(0.000)	(0.000)	(0.000)	(0.160)	(0.547)	(0.234)
Obs.	5540	2549	2991	2168	1036	1132

Data source: Rural-Urban Migration in China 2008

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

alleviate the stunting problem of rural children, but it has no effect on urban children. In rural areas, boys have a higher stunting rate. However, there is no gender difference in stunting in urban areas. The impact of the education of the household head on the child's stunting rate is relatively weak, and it mainly affects boys; the impact of regional factors on the stunting rate of rural children and urban children is different. For rural children, living in the western region will increase the stunting rate of girls; for urban children, living in the central region has a significant tendency to increase the stunting rate, though there is no gender difference.

In Table 5, we report the estimation of the LPM for underweight in urban and rural children. The household per capita income has a significant mitigation effect on the incidence of underweight in rural children, and the mitigation effect on girls is more obvious. Regardless of whether it is for urban children or rural children, it can be seen from the regression results of the full sample that there is no

Table 5 The estimation of children's underweight from linear probability model

	Rural sample			Urban sample		
	Total	Girl	Boy	Total	Girl	Boy
Household per capita income	−0.0153**	−0.0191**	−0.0122	−0.0102	−0.0017	−0.0168*
	(0.014)	(0.037)	(0.149)	(0.138)	(0.872)	(0.060)
Boy (1 = yes)	0.0046			−0.0064		
	(0.528)			(0.424)		
3–5 (1 = yes)	−0.0225	−0.0312	−0.0154	−0.0241	−0.0470*	−0.0044
	(0.221)	(0.249)	(0.542)	(0.182)	(0.093)	(0.850)
6–12 (1 = yes)	−0.0183	−0.0090	−0.0258	−0.0201	−0.0503**	0.0075
	(0.264)	(0.710)	(0.250)	(0.203)	(0.036)	(0.720)
13–18 (1 = yes)	0.0369**	0.0440*	0.0307	0.0114	0.0048	0.0170
	(0.021)	(0.061)	(0.162)	(0.472)	(0.842)	(0.420)
Han ethnicity (1 = yes)	0.0205	0.0404	0.0061	0.0401	0.0482	0.0386
	(0.529)	(0.439)	(0.884)	(0.197)	(0.333)	(0.326)
Education of household head	−0.0022	−0.0011	−0.0032	−0.0014	−0.0026	−0.0005
	(0.175)	(0.650)	(0.155)	(0.239)	(0.176)	(0.739)
Central region (1 = yes)	−0.0271***	−0.0402***	−0.0161	−0.0015	0.0010	−0.0026
	(0.001)	(0.001)	(0.165)	(0.880)	(0.949)	(0.846)
Western region (1 = yes)	0.0152	0.0177	0.0126	−0.0141	−0.0077	−0.0188
	(0.162)	(0.268)	(0.397)	(0.213)	(0.658)	(0.206)
Constant	0.2104***	0.2126**	0.2118***	0.1255*	0.0646	0.1587*
	(0.000)	(0.017)	(0.007)	(0.081)	(0.564)	(0.088)
Obs.	6180	2846	3334	2175	1040	1135

Data source: Rural-Urban Migration in China 2008

Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

gender difference in the incidence of underweight for those children. The education of the household head has no effect on the incidence of underweight. For urban children, the household per capita income, gender, and Han ethnicity have no effect on the probability of being underweight.

We can draw some interesting conclusions by comparing the results of the rural and urban samples. The increase in household per capita income is more likely to reduce the incidence of underweight for rural girls and urban boys. Rural girls in the 13–18 age group have a higher incidence of underweight, and urban girls in the 3–5 and 6–12 age groups have lower incidence of underweight. Regional factors have a heterogeneous effect on underweight in rural and urban children. For rural children, living in the central region has a significant decreasing effect on the incidence of underweight for girls; for urban children, regional factors have no effect on the incidence of underweight; for both rural and urban children, gender, Han ethnicity and the education of household head have no effect on the incidence of underweight.

Table 6 The concentration index of stunting and underweight

Health indicators	Types	Raw CI	Normalized CI
Stunting	Rural sample	−0.0609	−0.0834
	Urban sample	−0.1025	−0.1103
Underweight	Rural sample	−0.0288	−0.0318
	Urban sample	−0.1269	−0.1317

Data source: Rural-Urban Migration in China 2008

4.3 The Concentration Index and Regression-Based Decomposition

Before entering into the presentation of the results of the regression-based decomposition of the concentration index, we should first explain the calculation of the concentration index in the case of binary dependent variables. In general, when the value of the dependent variable of interest is not limited, the concentration index will be within the interval [−1, 1]. However, if the dependent variable is a binary variable, such as the stunting and underweight used in this paper, then the average value of the distribution of the variables examined will limit the possible range of the concentration index: when the average value rises, the possible range of the concentration index is narrowed.

Let μ denote the mean of the binary variable y, and n denote the sample size. For a given $\mu > 0$, the minimum value of the concentration index is equal to $\mu - 1 + (1/n)$, and the maximum value of the concentration index is equal to $1 - \mu + (1/n)$. For large samples, 1/n gradually approaches 0 and the minimum and maximum values each approach $\mu - 1$ and $1 - \mu$. If the average value approaches 1, the concentration index approaches to 0. In this paper, after calculating the concentration index of stunting and underweight in urban and rural samples, the normalization process is carried out, and the concentration index after normalization is obtained. The specific method is to use the original concentration index divided by one parameter. The average value of stunting or underweight was subtracted from 1 (Wagstaff, 2005). Table 6 reports the estimated results for the concentration index of stunting and underweight.

Table 7 reports the decomposition results of the concentration index of stunting for the rural and urban samples. It should be noted that the concentration index hereafter is the concentration index that has been normalized. In the case of rural samples, the concentration index of stunting is −0.0834, indicating that stunting is more likely to occur in children from low-income families. The overall contribution of all factors to the concentration index reaches −0.0533, and the residual is −0.0301. In terms of each influencing factors, the contribution of household per capita income to inequality of stunting is 54.72%, which is the main contributing factor. The next major contributing factors are being 13–18 years old, the education of household head, and the western region, with contributions of 18.63%, 7.54%, and 6.54%, respectively. In addition, there are three explanatory variables that have a certain attenuation effect on the inequality of stunting: namely, the central region,

Table 7 Results of decomposition of children's stunting in China

	Coefficient	Elasticity	CI	Contri. Index	Contri. Per.
Rural sample					
Household per capita income	−0.0352	−1.0711	0.0426	−0.0456	0.5472
Boy (1 = yes)	0.0342	0.0687	0.0133	0.0009	−0.0110
3–5 (1 = yes)	−0.0545	0.0252	−0.0818	−0.0021	0.0248
6–12 (1 = yes)	−0.0452	0.0543	−0.0120	−0.0007	0.0078
13–18 (1 = yes)	−0.1839	−0.3316	0.0469	−0.0155	0.1863
Han ethnicity (1 = yes)	0.0888	0.3256	0.0054	0.0018	−0.0212
Education of household head	−0.0086	−0.2423	0.0260	−0.0063	0.0754
Central region (1 = yes)	−0.0106	−0.0151	−0.1369	0.0021	−0.0249
Western region (1 = yes)	0.0411	0.0255	−0.2141	−0.0055	0.0654
Residual				−0.0301	
CI				−0.0834	
Urban sample					
Household per capita income	0.0005	0.0677	0.0397	0.0027	−0.0243
Boy (1 = yes)	−0.0135	−0.1004	0.0117	−0.0012	0.0106
3–5 (1 = yes)	−0.0370	−0.0741	0.0751	−0.0056	0.0505
6–12 (1 = yes)	−0.0615	−0.3416	0.0107	−0.0037	0.0331
13–18 (1 = yes)	−0.1065	−0.5644	−0.0486	0.0274	−0.2487
Han ethnicity (1 = yes)	0.0292	0.4087	0.0056	0.0023	−0.0207
Education of household head	−0.0037	−0.6127	0.0510	−0.0312	0.2831
Central region (1 = yes)	0.0503	0.2243	−0.2680	−0.0601	0.5451
Western region (1 = yes)	0.0191	0.0529	−0.2381	−0.0126	0.1142
Residual				−0.0922	
CI				−0.1103	

Data source: Rural-Urban Migration in China 2008

Han ethnicity, and boy. Their contributional percentages to the inequality of stunting are −2.49%, −2.12%, and − 1.10%, respectively.

The concentration index calculated using the urban sample is −0.1103, similar to that of the rural sample, which also indicates that stunting is more likely to occur in children from low-income families. The overall contribution of all factors to the concentration index reaches −0.0181, and it can be found that the explanatory power of the existing explanatory variables is weak. According to the influencing factors, the contribution of this regional variable to the inequality of stunting in the central region reaches 54.51%, which is the most important contributing factor. The next major contributing factors are the education of the household head and the western region, with contributions of 28.31% and 11.42%, respectively. In addition, the 3–5 age group, the 6–12 age group, and boy have a slight increase in the inequality of the probability of stunting. In addition, there are three explanatory variables that have a certain attenuation effect on the inequality of stunting, which are the 13–18 age

Table 8 Results of decomposition of children's underweight in China

	Coefficient	Elasticity	CI	Contri. Index	Contri. Per.
Rural sample					
Household per capita income	−0.0153	−1.3453	0.0426	−0.0573	1.8025
Boy (1 = yes)	0.0046	0.0269	0.0133	0.0004	−0.0113
3–5 (1 = yes)	−0.0225	−0.0301	−0.0819	0.0025	−0.0776
6–12 (1 = yes)	−0.0183	−0.0636	−0.0120	0.0008	−0.0240
13–18 (1 = yes)	0.0369	0.1925	0.0469	0.0090	−0.2836
Han ethnicity (1 = yes)	0.0205	0.2176	0.0054	0.0012	−0.0372
Education of household head	−0.0022	−0.1799	0.0260	−0.0047	0.1469
Central region (1 = yes)	−0.0271	−0.1117	−0.1369	0.0153	−0.4809
Western region (1 = yes)	0.0152	0.0273	−0.2141	−0.0058	0.1839
Residual				0.0068	
CI				−0.0318	
Urban sample					
Household per capita income	−0.0102	−2.7200	0.0397	−0.1079	0.8194
Boy (1 = yes)	−0.0064	−0.0926	0.0117	−0.0011	0.0082
3–5 (1 = yes)	−0.0241	−0. 0940	0.0751	−0.0071	0.0536
6–12 (1 = yes)	−0.0201	−0. 2175	0.0107	−0.0023	0.0177
13–18 (1 = yes)	0.0114	0.1179	−0.0486	−0.0057	0.0435
Han ethnicity (1 = yes)	0.0401	1.0914	0.0056	0.0061	−0.0462
Education of household head	−0.0014	−0.4645	0.0510	−0.0237	0.1797
Central region (1 = yes)	−0.0015	−0.0132	−0.2680	0.0035	−0.0268
Western region (1 = yes)	−0.0141	−0.0759	−0.2381	0.0181	−0.1373
Residual				−0.0116	
CI				−0.1317	

Data source: Rural-Urban Migration in China 2008

group, household per capita income, and Han ethnicity. Their contributions to the concentration index inequality are −24.87%, −2.43% and − 2.07%, respectively.

Based on the above analysis, we can find that in rural samples, household per capita income is the main contributor to the concentration index of stunting. The age group of 13–18 years old, the education of the household head, and the western region also contribute significantly to the concentration index of stunting. In the urban sample, household per capita income is not the main contributor to the concentration index of stunting, but has a weak mitigation effect. The household's location and the education of the household head are the main contributors to the concentration index of stunting for urban children.

We report the decomposition of the concentration index of underweight for rural and urban children in Table 8. The concentration index of underweight for rural samples is −0.0318, and children in low-income families have a higher incidence of underweight. The overall contribution of each influencing factor to the concentration index reaches −0.0386, with a residual of 0.0068. In terms of influencing factors, the contribution of household per capita income to the concentration index of stunting reaches 180.25%, which was the most important contributor. The next major contributing factors are the western region and the education of the household head, with contributions of 18.39% and 14.69%, respectively. In addition, there are three factors that have a greater attenuating effect on children's inequality of underweight, including the central region, the age group of 13–18 years and the age group of 3–5 years, each contributing to the concentration index by −48.09%, −28.36%, and − 7.76%, respectively.

For urban samples, the concentration index of underweight is −0.1317, which also indicates that children in low-income families have a higher incidence of underweight. The overall contribution of each influencing factor to the concentration index reaches −0.1201 with a residual of −0.0116. According to the results, the contribution of household per capita income to the concentration index of stunting reaches 81.94%, which is the most important contributing factor. The next major contributing factor is the education of the household head, which has a contribution percentage of 17.97%. Variables of all age groups have a weak contribution to the concentration index of underweight, and the total contribution of the three age groups to the concentration index is more than 11%. In addition, three explanatory variables have a weakening effect on children's inequality of underweight, and these are western region, Han ethnicity, and the central region, with their contribution to the concentration index of underweight being −13.73%, −4.62%, and − 2.68%, respectively.

To summary the decomposition results of the rural and urban samples' concentration index of underweight, we can conclude that the household per capita income is the most important contributor to the inequality of children's underweight, regardless of living in a rural or urban area, and the education of the household head has a similar contribution to concentration index of underweight for rural and urban children. In terms of urban and rural areas, the contribution of age group to the concentration index of underweight is different in direction of effect. In the rural sample, all three age group variables had a negative contribution to the concentration index of underweight; however, in the urban sample, the three age groups all contributed positively to the concentration index of underweight.

5 Conclusion and Discussion

This paper analyzes children's health inequality by using Rural-Urban Migration in China 2008, and uses the regression-based decomposition method to decompose the health inequality. First, we calculate the HAZ and WAZ indicators, and then generate binary variables that indicate stunting and underweight. The LPM is used to estimate the probability of stunting and underweight in urban and rural areas. Then, the concentration index is calculated for stunting and underweight. Last, the concentration index is decomposed. Regarding our primary Hypothesis, the empirical results of this study verify them. In this section we will provide a brief summary of the empirical results and discuss further policy implications.

The increase in household per capita income help to decrease the probability of stunting in rural children, but it has no effect on urban children, showing the different effects of household income on the relief of stunting in urban and rural children which is consistent with previous studies (da Silva et al., 2018). Regardless of whether it is for rural children or urban children, the 13–18 age group has a significant decrease in stunting rate. In a certain sense, the growth and development of this age group can alleviate the early-life lags suffered therein. The impact of the education of the household head on children's stunting rate is relatively weak, and mainly helps reduce the rate of stunting for boys as it increases. The impact of regional factors on the stunting rate of rural and urban children is heterogeneous. Specifically, in the rural sample, girls in the western region have higher rates of stunting; in the urban sample, living in the central region significantly increase the rate of stunting in children, and there is no gender difference. Many studies suggest that there exist obvious son preferences in rural China (Bo, 2018; Chen et al., 2013). The preference for boys in rural or western region may lead to higher rates of stunting for girls.

The increase in household per capita income has a significant positive effect on reducing the incidence of underweight among rural girls and urban boys. Compared to other age groups, urban girls in the 3–5 and 6–12 age groups have relatively lower rates of underweight, and rural boys in the 13–18 age group have relatively lower rates of underweight. Household location has different effects on the incidence of underweight for rural and urban children. For rural children, living in the central region has a significant decreasing effect on the underweight of girls; for urban children, living region has no significant effect on the underweight rate of children. Regardless of rural or urban children, the education of household head, gender, and Han ethnicity have no effect on the incidence of underweight. This study cannot yet give a reasonable explanation for these results and it needs further empirical analysis in the future.

Household per capita income is the most important contributor to the concentration index of stunting for rural children. The 13–18 age group, the education of the household head and living in the western region have a significant contribution to the concentration index of stunting. Household per capita income is not the main contributor to the urban children's concentration index of stunting, but has a weak mitigation effect. Regional factors and the education of the household head are the main contributors to urban children's concentration index of stunting. Regarding rural and urban children, household per capita income is the most important contributor to the concentration index of underweight. This is consistent with previous studies (Bhagowalia et al., 2011; Rahman et al., 2018; Ueda et al., 2015). The education of the household head has a similar contribution to the concentration index of underweight for urban and rural children. In terms of urban and rural areas, the contribution of age group to the concentration index of underweight is different in its direction of effect. The three age groups have negative contributions to the concentration index of underweight for rural children, while they have positive contributions to that of urban children.

The research findings in this paper have certain policy implications. Childhood is one of the most important periods in a person's life cycle. The accumulation of health-related human capital during this period will affect lifelong health, income, and welfare. As the saying goes, inequality begins in the first 1000 days; it is difficult to make up for the insufficient accumulation of health-related human capital from this period later in life. Policy makers should divert attention to entire growth period of children and support children in a more comprehensive way, rather than mainly focusing on children in compulsory education. As such, they should be better off paying attention to provide awareness about the importance of proper nutrition and more efficient health care system for children. Breaking the chain of intergenerational transmission of poverty therefore requires efforts to improve children's health. From a macro perspective, improving children's nutritional status and health are important measures for China to successfully cross the "middle-income trap" and enter the high-income stage. According to the empirical results of this paper, improving household per capita income and raising the educational attainment of parents can help alleviate children's health inequalities and promote the accumulation of children's health-related human capital.

Only when the household income is improved will the budget constraints that hinder the improvement of children's nutritional levels be alleviated, thereby reducing the rates of stunting and underweight. Improving the health of children and promoting the development of children's health also requires improving the educational attainment for all. Since the empirical analysis of this paper shows that the education of household head has a significant effect on the improvement of children's health, a feasible way to improve children's health is to raise the education of the household head, and to disseminate knowledge about children's nutritional health. Some previous studies show that there exists intergenerational transmission of education in China (Dong et al., 2019a). In the interest of having a further contribution to the literature, we have found that parent's education also plays an important role in children's health. Improvement in parents' educational attainment may be one of the micro reasons for the narrowing of health inequality of gender, occurring through the following three main channels. First, more schooling of parents results in a higher income level, thus helping to ease the budget constraints of access to health. As such, the preference for nurturing a boy over a girl is lessened. Second, higher levels of parental educational attainment make them accept attitudes toward gender equality. Third, more educated parents may have more knowledge on how to raise children in accordance with each child's specific situation.

Considering the difficulty of improving household income and parents' education in the short-run, in order to improve the health status of children and promote the accumulation of health-related human capital, the most applicable strategy is to improve the health status of children by implementing public policies targeting improvement of their education and overall health. In this way, it may help to increase their educational attainment and thus help to improve the health status of their children in the next generation.

In South Asia and Africa, as well as in other less developed countries, health inequality of children is still very serious. This is similar to the situation China had many years ago. The findings of this study on China may help understand the health inequality of children in other less developed countries. With the development of the economy and the progress of society, the health inequality of children is narrowing. Some measures intending to narrow the health inequality of children in China may be extended to other less developed countries and may help to narrow their own health inequality of children. On the other hand, the social development of different regions in China is very uneven. So, results of this study could also be applied to less developed regions in China.

This paper, to the best of our knowledge, has made at least three significant contributions to the literature. First, we used China's data to decompose the concentration index of children's health inequality and analyze the influencing factors and contribution of children's health inequality. The research on children's health inequality is still relatively scarce in China. Second, we employed health indicators of HAZ and WAZ to measure children's health status. They are more appropriate indicators for China in recent years and the child mortality and morbidity rates which were used in previous studies were somewhat outdated. Finally, we verified the health inequality of children in China and there existed heterogeneity in the contributions to children's health inequality between rural areas and urban areas. The result has enriched the academic community's understanding of the health inequality of children in China.

Despite significant contributions to the literature, we acknowledge at least two limitations to our study. First, we did not control for variables of commune level in the estimation due to data limitation. The results may be affected to some extent. Second, the data used in this study was collected more than ten years ago. So, it is a little temporarily out of date and does not seem appropriate to use that diagnosis for the proposed political action. This study can also extend some meaningful issues, such as the health inequality between migrant and non-migrant children, the heterogeneous health inequality at different income levels. These are worth researched in the future. In further studies, we will attempt to investigate these problems by searching for more appropriate data and using more advanced approaches.

Acknowledgements The authors would like to acknowledge the financial support of the Humanity and Social Science Youth foundation of Ministry of Education (Grant Numbers 20YJC790020) and China Postdoctoral Science Foundation (Grant Numbers 2019 M651046 and 2019 T120188).

Declarations

Conflict of Interest The author declare that they have no conflict of interest.

Human and Animal Rights This paper does not contain any studies with human participants or animals performed by the author.

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