# Household access to sanitation facilities in rural China

Xiaolong Li, Qihang Hu, Yanqing Miao, Wenjing Chen and Chunhui Yuan

## ABSTRACT

Access to improved sanitation is a vital part of breaking the fecal-oral pathway and preventing diarrheal diseases. Because China is one of the largest developing countries, improving sanitation in rural China could greatly reduce the number of deaths that result from poor hygiene and sanitation worldwide each year. Therefore, our study on the situation of household access to sanitation facilities in rural China can be important for policy making on sanitation improvement. A cross-sectional study was conducted in 24 villages in three provinces in 2013. These three provinces were selected to represent the eastern, central, and western regions of China. A total of 790 respondents were interviewed. Most of the respondents (89.8%) reported having improved sanitation. Factors that influenced access to improved sanitation included the number of family members, annual per capita necessities expenditures, and subsidies for sanitation improvement. Knowledge, attitude, and practice (KAP) also influenced sanitation improvement and healthy behaviors. Using the approaches of concentration index (CI) and concentration curve (CC), this study found that the equity of sanitation improvement in rural China was good (CI = 0.0292).

**Key words** | inequity, influence factors, practices, rural China, sanitation improvement

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## INTRODUCTION

Globally, approximately 2.4 million deaths (4.2% of all deaths) could be prevented each year if everyone practiced appropriate hygiene and had good, reliable sanitation and safe drinking water (Prüss-Üstün *et al.* 2008). Most of these deaths are children in developing countries and result primarily from diarrhea and subsequent malnutrition, as well as other diseases that are attributable to malnutrition. Although rarely discussed alongside HIV/AIDS, tuberculosis, and malaria, the three major diseases that attract attention from the international public health community, diarrhea alone kills more children each year than these three combined. It has been acknowledged worldwide that good sanitation plays an important role in reducing domestic 0–5 year-old child mortality (Hutton 2013). The World Health Organization estimates that 74,000 children under 5 years old die each year in China due to diarrhea (Boschi-Pinto *et al.* 2008). The keys to diarrhea disease control are access to safe water, improved sanitation and regular hygienic practices.

Sanitation improvement in rural China is worthy of close attention because China is one of the largest developing countries, and has a rural population of 971 million people. The rural population accounts for approximately 72% of the total population (National Bureau of Statistics of China 2012). The Chinese government has attached importance to sanitation improvement for more than the last decade and has incorporated the improvement of sanitation in rural areas into its national 5-year plan since the 1990s. In 2009, to promote public health service levels and equity, the Chinese government launched a 3-year health reform program and set sanitation improvement as one of the major public health services. Opinions of the Communist Party of China (CPC) Central Committee and the State Council on expanding medical and health system reforms indicated that government input on health services would be gradually increased (Zhang *et al.* 2013). In these 3 years, the Chinese government invested a total of 4,448,000,000 yuan (740,000,000 US dollar) for rural

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sanitation improvement (Ministry of Finance 2012). In addition, the coverage rate of improved sanitation in rural China rose from 50.9% in 2003 to 71.7% in 2012 (Ministry of Health P.R. China 2013). Figure 1 shows that China's rural improved sanitation coverage rate increased year by year from 2003 to 2012 (Ministry of Health P.R. China 2013).

However, only average provincial data about sanitation improvement in China is available. Therefore, the objective of this study was to better understand the sanitation conditions in rural China and identify the factors that influence sanitation improvement at the household level. This study also aimed to determine the correlation between sanitation improvement and knowledge, attitude, and practice (KAP). In addition, the implications of the findings are discussed in terms of equitable access to improved sanitation.

## METHODS AND MATERIALS

### Investigation range

This cross-sectional study was carried out in 27 rural settlements of three provinces, which were selected to represent the eastern, central, and western regions of China in 2013. Based on the national rural sanitation facility coverage rate changes and variations in economic development, geographical situations, populations, and living conditions in different areas, Shaanxi Province (rural per capita net income of US $927.5 in 2012) was chosen to represent the western region; Shanxi Province (rural per capita net income of US $1,023.1 in 2012) was chosen to represent the central region; and Jiangsu Province (rural per capita net income of US $1,963.9 in 2012) was chosen to represent the eastern region. No more than three counties were selected from each of the chosen provinces, and the investigation took place in no less than 30 households in each of four villages, which were selected randomly from the counties. The provinces, counties, and villages are listed in Table 1.

### Variable collection

A total of 790 respondents were given semi-structured questionnaires which were self-administered, and the questionnaires were collected on the spot. And all the respondents were the head of household. The variables for which data was collected included socio-demographic

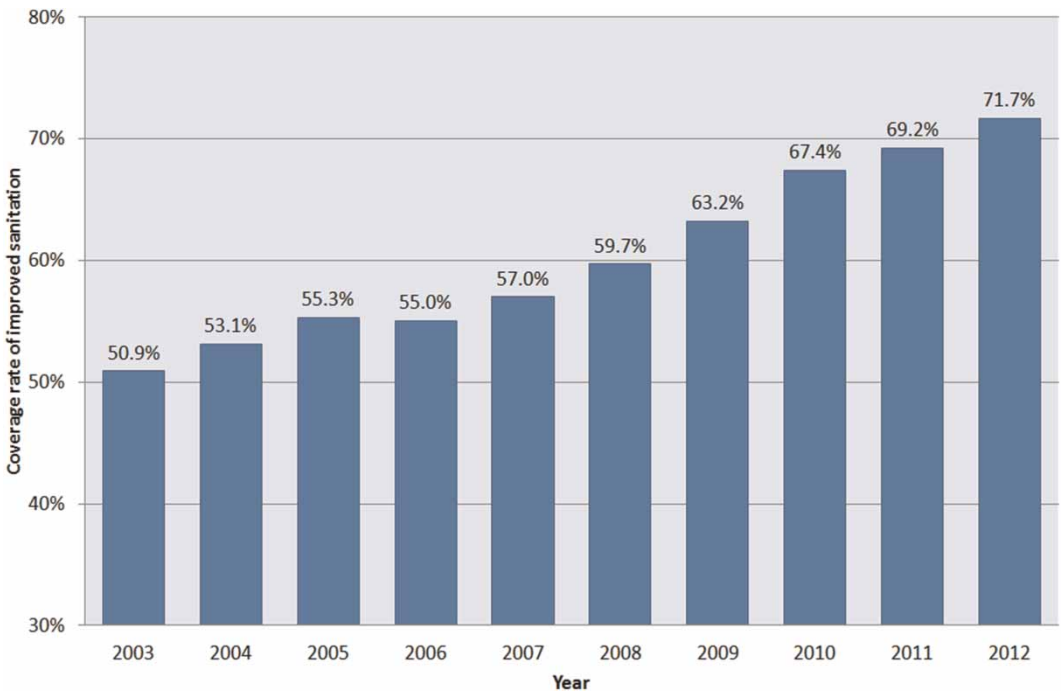


**Figure 1** | Coverage rate of improved sanitation in rural China from 2003 to 2012.

**Table 1** | Investigation range

| Province | City | County | Town | Village | Households |
|---|---|---|---|---|---|
| Shaanxi | Tongchuan | Yaozhou | Sunyan | Heju | 34 |
| | | | Guanzhuang | Mu'ao | 33 |
| | | | Zhaojin | Tianyu | 34 |
| | | | Mianyang | Shuiyu | 33 |
| | | Wangyi | Huangbao | Dujiayuan | 32 |
| | | | | Wenmingyuan | 32 |
| | | | Wangyi | Chuankou | 30 |
| | | | | Gaoyuan | 34 |
| Shanxi | Yuncheng | Ruicheng | Yangcheng | Zhaijia | 33 |
| | | | | Yangzu | 32 |
| | | | Xuezhang | Yangyuan | 33 |
| | | | Guwei | Kengtou | 31 |
| | Jinzhong | Yuci | Beitian | Xiaonanzhuang | 30 |
| | | | | Nanliu | 35 |
| | | | Dongyang | Chewang | 32 |
| | | | | Dongyang | 34 |
| Jiangsu | Xuzhou | Tongshan | Hanwang | Hanwang | 30 |
| | | | | Zhaoshan | 33 |
| | | | Liuxin | Yangchang | 38 |
| | | | | Weizhuang | 31 |
| | Yangzhou | Gaoyou | Sanduo | Nanfeng | 34 |
| | | | | Sanbailiu | 32 |
| | | | | Ergou | 35 |
| | | | Gaoyou | Xinmin | 35 |
| Total | | | | | 790 |

factors (number of family members, education level of the head of household, annual per capita income, and annual per capita necessities expenditures), sanitation situation, source of income (farming or other), and policy support (welfare supported for low income, subsidy of sanitation improvement).

Furthermore, the investigation included a section about KAP, which is commonly used in sanitation improvement studies (Beyene & Hailu 2013; Joshi *et al.* 2013; Sibiya & Gumbo 2013) to enhance the comprehensiveness of the research. The KAP was applied by asking three groups of questions about health knowledge, attitude toward health knowledge, and personal health behavior. The questions were designed to solicit information about sanitation use and health status in rural households.

## Data processing and analysis

The data gathered were rechecked and collated before being delivered to analysts for further study. The data were analyzed with IBM SPSS Statistics Version 19 for statistical generation of frequencies, percentages, medians, and associations. To illustrate the correlation of the independent variables and sanitation improvement, cross-tabulations were used.

In the binary logistic regression, the 'forward: condition' method was chosen. It is important that the method of entering variables in the model was 'forward: condition' which was a stepwise method. A mathematical criterion of the software can decide the order of independent variables entering into the regression model. In this method, all related variables are entered into the model to compute their significance to the output, and eliminations are made based on less relativity between the independent variables and the dependent variable. At each step, one new independent variable is added into the model at a time and the compound significances are computed by the software to determine whether the newly added independent variable will be saved or eliminated. In addition, correlation analysis was used to refine the KAP section of our research.

The equality of sanitation improvement in rural China was determined by calculating the concentration index (CI) (Kakwani *et al.* 1997; O'Donnell & Wagstaff 2008). The CI is defined on the basis of the concentration curve (CC) (O'Donnell & Wagstaff 2008). The CC plots the cumulative percentage of a variable against the cumulative percentage of population, ranked from poorest to richest by economic index (O'Donnell & Wagstaff 2008). Two variables were included in the CC, an improved sanitation variable and an economic status variable, against which the distribution of improved sanitation was plotted.

The CI is defined as twice the area between the CC and the 45-degree line. The CI of the improved sanitation in the model is:

$$\mathrm{CI} = \frac{2}{K \cdot \mu} \sum_{i=1}^{K} y_i R_i - 1 \quad (1)$$

where $y_i$ is the sanitation situation of *ith* household. The number 1 indicates *ith* household has improved sanitation and 0 indicates *ith* household does not have improved sanitation. $\mu$ is the mean of $y$, and $R_i$ is the fractional rank of the *ith* household in the income distribution.

## RESULTS AND DISCUSSION

### General characteristics of respondents

A total of 790 respondents were given semi-structured questionnaires; five were eliminated because the questionnaires were incomplete.

The standard for improved sanitation in this study was secure access to a hygienic latrine with a roof and walls and timely management of sewage and wastewater as defined by the Office of the National Patriotic Health Campaign Committee. This standard conforms with WHO/UNICEF Joint Monitoring Programme on Water Supply and Sanitation (JMP) indicators (Flores & Giné 2013) and Gunawardana's definition of improved sanitation (Gunawardana & Galagedara 2013). Unimproved sanitation in rural China included pit latrines without covers, pit latrines with covers, public toilets, shared toilets, cesspits, manure buckets and ditches.

Based on the data collected, the majority of households (89.9%) used improved sanitation. The median number of family members was 4 (minimum 1; maximum 8). The median education level of the head of household was junior high school, which accounted for approximately half of the respondents (48.3%). A large number of those polled had sources of income other than farming (72.1%). Most did not get welfare support for low income (89.9%). Over half of the households (69.9%) received a subsidy for sanitation improvement of 500 to 1,000 yuan (approximately US $80 to 160), and some families (16.9%) received no subsidy or welfare support. The median annual per capita income was 5,000 to 10,000 yuan (approximately US $800 to 1,600). More than two-thirds of the respondents (68.8%) reported that their annual per capita necessities expenditure was 0 to 5,000 yuan (approximately US $0 to 800). More information about the respondents' social demographic characteristics is listed in Table 2. Details about types of sanitation facilities reported by the respondents are listed in Table 3.

### Binary logistic regression

Binary logistic regression was applied to determine the factors influencing the sanitation improvement process. The results listed in Table 4 show the significant factors and the overall explained variance (adjusted $R^2 = 0.51$). Variables such as education level of the head of household, household farming status, welfare support for low income, and annual per capita income were not significant.

The regression progressed step-by-step. In each step, a new variable was added into the regression function calculating its significance, combining with the previous variables. All of the variables might be kept or eliminated based on their significance to the regression process, where the standard in this model was set at 0.05. As shown in Table 4, from step 1 to step 4, a new variable was included at each step; from step 4 to step 5, however, the factor 'Annual per capita income' was excluded because it had a greater significance (0.079) in the regression model. In addition, 'B' array represented the weight of each variable in the final logistic regression functions.

The results show that the more members there were in a family, the more likely they were to have improved

**Table 2** | Basic respondent characteristics based on questionnaire responses

| Variable | | Frequency | | Percentage |
|---|---|---|---|---|
| | | Households with improved sanitation | Households without improved sanitation | |
| **Sanitation situation** | | 705 (89.8%) | 80 (10.2%) | 100% |
| **Number of family members** | 1 | 31 (86.1%) | 5 (13.9%) | 4.6% |
| | 2 | 96 (85.7%) | 16 (14.3%) | 14.3% |
| | 3 | 148 (88.1%) | 20 (11.9%) | 21.4% |
| | 4 | 195 (87.4%) | 28 (12.6%) | 28.4% |
| | 5 | 157 (94.6%) | 9 (5.4%) | 21.2% |
| | 6 | 69 (97.2%) | 2 (2.8%) | 9.0% |
| | 7 | 8 (100.0%) | 0 (0.0%) | 1.0% |
| | 8 | 1 (100.0%) | 0 (0.0%) | 0.1% |
| **Education level of head of household** | Pre-school | 93 (86.1%) | 15 (13.9%) | 13.8% |
| | Primary | 149 (90.9%) | 15 (9.1%) | 20.9% |
| | Junior high school | 341 (90.0%) | 38 (10.0%) | 48.3% |
| | Senior high school | 86 (87.8%) | 12 (12.2%) | 12.5% |
| | Vocational college | 32 (100.0%) | 0 (0.0%) | 4.1% |
| | Bachelor's degree | 4 (100.0%) | 0 (0.0%) | 0.5% |
| **Farmers/agriculturalists** | Yes | 201 (91.8%) | 18 (88.2%) | 27.9% |
| | No | 504 (89.0%) | 62 (11.0%) | 72.1% |
| **Welfare support for low income** | Yes | 72 (91.1%) | 7 (8.9%) | 10.1% |
| | No | 633 (89.7%) | 73 (10.3%) | 89.9% |
| **Subsidy for sanitation improvement (yuan)** | 0 | 65 (48.9%) | 68 (51.1%) | 16.9% |
| | 1 to 500 | 54 (100.0%) | 0 (0.0%) | 6.9% |
| | 500 to 1,000 | 537 (97.8%) | 12 (2.2%) | 69.9% |
| | 1,000 to 2,500 | 49 (100.0%) | 0 (0.0%) | 6.2% |
| **Annual per capita income (yuan)** | 0 to 5,000 | 148 (84.6%) | 27 (15.4%) | 22.3% |
| | 5,000 to 10,000 | 247 (89.5%) | 29 (10.5%) | 35.2% |
| | 10,000 to 15,000 | 166 (91.7%) | 15 (8.3%) | 23.1% |
| | 15,000 to 50,000 | 135 (94.4%) | 8 (5.6%) | 18.2% |
| | 50,000 to 300,000 | 9 (90.0%) | 1 (10.0%) | 1.3% |
| **Annual per capita necessities expenditure (yuan)** | 0 to 5,000 | 478 (88.5%) | 62 (11.5%) | 68.8% |
| | 5,000 to 10,000 | 172 (93.0%) | 13 (7.0%) | 23.6% |
| | 10,000 to 15,000 | 37 (92.5%) | 3 (7.5%) | 5.1% |
| | 15,000 to 50,000 | 16 (88.9%) | 2 (11.1%) | 2.3% |
| | 50,000 to 300,000 | 2 (100.0%) | 0 (0.0%) | 0.3% |

1 yuan = 0.1628 US dollar (28th June, 2013).

sanitation. Some researchers have indicated that the number of households sharing a sanitation facility is a factor that influences improved sanitation use (Tumwebaze & Lüthi 2013). However, few households share a sanitation facility in rural China because of traditional customs. Instead, this study found that the number of family members played an important role in influencing improved sanitation.

In addition, the effect of subsidies on sanitation improvement reveals that government programs and policies, such as financial support, play a very important role in sanitation improvement in rural China.

**Table 3** | Types of sanitation facilities

| Sanitation situation | Frequency (N) | Percentages (%) |
|---|---|---|
| **Households with improved sanitation** | 705 | 89.8 |
| Double-vat funnel | 426 | 60.4 |
| Septic tank with three cells | 143 | 20.3 |
| Septic tank with four cells | 78 | 11.1 |
| Sanitation with complete sewer | 24 | 3.4 |
| Triple biogas tanks | 17 | 2.4 |
| Urine-directing toilet | 15 | 2.1 |
| Double alternating pits | 2 | 0.3 |
| **Households without improved sanitation** | 80 | 10.2 |
| Pit latrine without cover | 42 | 52.5 |
| Public toilet | 17 | 21.3 |
| Pit latrine with cover | 12 | 15.0 |
| Shared toilet | 3 | 3.8 |
| Cesspit | 3 | 3.8 |
| Manure bucket | 2 | 2.5 |
| Ditch | 1 | 1.3 |

**Table 4** | Binary logistic regression on factors in sanitation improvement

| | Variables | B | Sig. (*P* value) |
|---|---|---|---|
| Step 1 | Subsidy of sanitation improvement | 0.006 | 0.000 |
| | Constant | 0.086 | 0.614 |
| Step 2 | Annual per capita income | 0.000 | 0.001 |
| | Subsidy of sanitation improvement | 0.007 | 0.000 |
| | Constant | −0.703 | 0.016 |
| Step 3 | Number of family members | 0.351 | 0.003 |
| | Annual per capita income | 0.000 | 0.000 |
| | Subsidy of sanitation improvement | 0.007 | 0.000 |
| | Constant | −2.065 | 0.000 |
| Step 4 | Number of family members | 0.445 | 0.000 |
| | Annual per capita necessities expenditure | 0.000 | 0.013 |
| | Annual per capita income | 0.000 | 0.079 |
| | Subsidy of sanitation improvement | 0.007 | 0.000 |
| | Constant | −2.802 | 0.000 |
| Step 5 | Number of family members | 0.445 | 0.000 |
| | Annual per capita necessities expenditure | 0.000 | 0.000 |
| | Subsidy of sanitation improvement | 0.007 | 0.000 |
| | Constant | −2.631 | 0.000 |

Adjust $R^2 = 0.51$, N = 785.

Moreover, annual per capita necessities expenditure is also a factor. This agrees with a number of studies that revealed that economic status is a major determinant of sanitation improvement (Whittington *et al.* 1993; Evans *et al.* 2009; Chen *et al.* 2013; Xiaolong *et al.* 2014).

Due to the limitation of sample space, the binary logistic regression cannot show some phenomena clearly. Based on the results of previous studies in China and other countries, it can be concluded that the education level of the head of household is the main factor that affects sanitation improvement (Zhang & Zhang 2003; Niu & Zu 2004; Kar & Pasteur 2005; Zhang *et al.* 2005; Evans *et al.* 2009; Chen *et al.* 2013). However, this factor is not clearly shown in this binary logistic regression study.

## KAP correlation analysis

Correlation analysis was used to analyze the KAP questionnaire, which included sections about health knowledge (P5), attitude toward health knowledge (P6), and personal health behavior (P7) and is included in the supplementary material (available online at http://www.iwaponline.com/washdev/005/141.pdf). To distinguish the significance of each question in terms of the contribution to sanitation facility

**Table 5** | Correlation analysis on KAP

| Question number | Character | Index |
|---|---|---|
| P5Q2S1 | Pearson Correlation | 0.070* |
| | Sig. (2-tailed) | 0.049 |
| | N | 785 |
| P5Q2S2 | Pearson Correlation | 0.099** |
| | Sig. (2-tailed) | 0.005 |
| | N | 785 |
| P6Q4 | Pearson Correlation | 0.084* |
| | Sig. (2-tailed) | 0.018 |
| | N | 785 |
| P6Q7 | Pearson Correlation | 0.106** |
| | Sig. (2-tailed) | 0.003 |
| | N | 785 |
| P7Q2 | Pearson Correlation | 0.265** |
| | Sig. (2-tailed) | 0.000 |
| | N | 785 |

a. Correlation is significant at the 0.01 level (2-tailed), which is represented by **.
b. Correlation is significant at the 0.05 level (2-tailed), which is represented by *.
c. Correlation is not very significant, and is excluded in this table.

improvement, the result was divided into three groups, as shown in Table 5. The content of the questions that significantly correlated to the behavior of sanitation improvement is listed below.

P5Q2S1*: Do you know that high doses of certain elements (like fluorine and arsenic) in drinking water may be toxic?
P5Q2S2**: Do you know that drinking unsanitary water could cause diarrhea?
P6Q4*: Is it true that as long as the source of water is safe, the way of obtaining and storing water will not affect health?
P6Q7**: Is it true that the sanitation of toilets will not affect health?
P7Q2**: How often do you clean your toilet?

Based on the results of the KAP questionnaire, it appeared that knowledge, attitude, and practice could all influence sanitation improvement and healthy behavior. Therefore, in addition to improving economic status and subsidies for sanitation improvement, as some scholars also mentioned (Denning *et al.* 2009), it is important to improve factors that cannot be quantified, such as socio-cultural practices and beliefs. These factors cannot be ignored in the goal of sanitation improvement in rural China.

## Equity focus

As shown in Figure 2, the CC of improved sanitation and the CC of net income of rural residents were plotted together. The purpose of plotting the latter was to provide a reference.

Although the CC of improved sanitation lay between the curve of absolute equality and the CC of income, it was very close to the curve of absolute equality. This means that the distribution of improved sanitation was quite equitable and the disparity in terms of sanitation improvement between the poor and rich was low.

The CI of improved sanitation was 0.0292 and that of net income of rural residents was 0.4128. The CI of net income of rural residents in this study was very close to

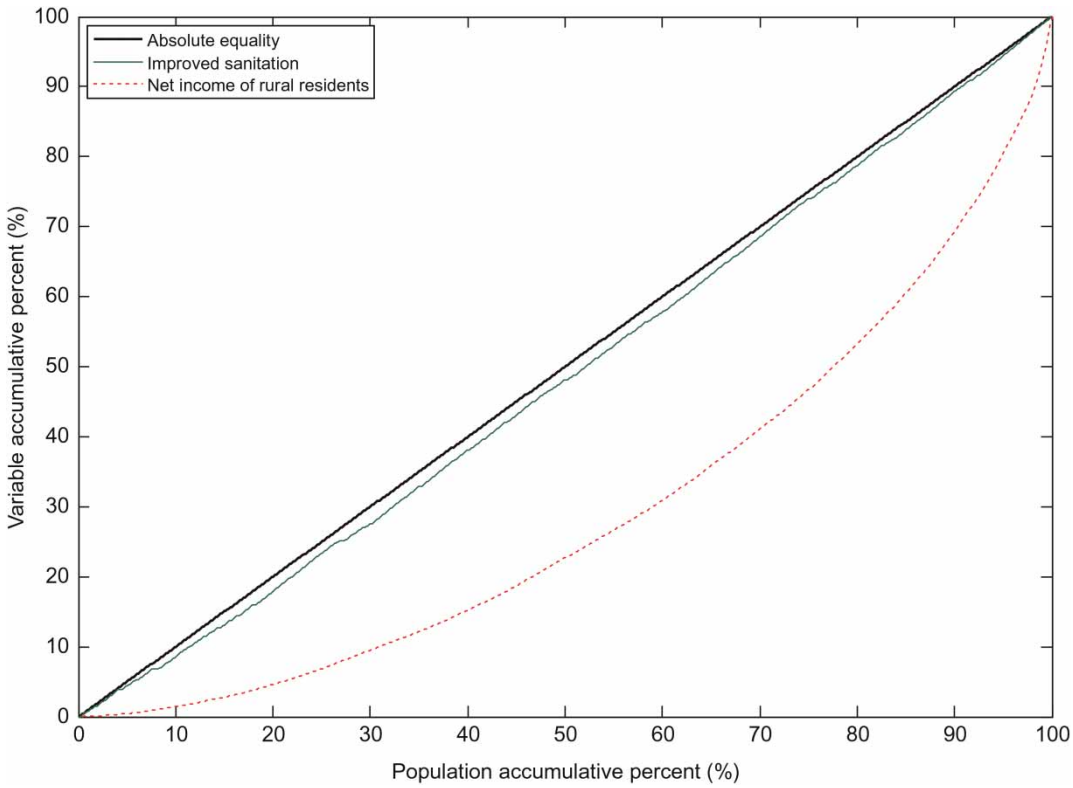


**Figure 2** | Concentration curves of improved sanitation and net income of rural residents.

the rural Gini coefficient of China, which is 0.3949 (Central China Normal University 2012). This implies that this study did not deviate from the actual situation, despite the limited sample size.

By comparing the CI of improved sanitation and the CI of income, this study also observed the relative equity of sanitation improvement in rural China. This encouraging result seems attributable mainly to the government's pro-poor policy on sanitation improvement in recent years. As Margaret Satterthwaite (Satterthwaite 2012) pointed out, improvement, whether in water supply or in sanitation, should be established in terms of substantive equality rather than formal equality. Substantive equality does not simply mean that everyone is treated equally; it means that governments (or their relevant departments) treat those who are relatively vulnerable or disadvantaged with distinction or preference so that equity can be achieved in a better way.

## CONCLUSIONS

This study found that economic status, number of family members, and amount of subsidy were the objective factors that influenced the access to improved sanitation. In addition, this study determined that subjective factors like health knowledge, attitude toward health knowledge, and personal health behavior could also influence building and using improved sanitation facilities. It is encouraging that equality of sanitation improvement was found to be satisfactory. This study is expected to contribute to a more targeted policy for sanitation improvement in rural China to increase the coverage rate of improved sanitation, eliminate open defecation, and reduce morbidity caused by diarrhea and related diseases.

## AUTHOR CONTRIBUTIONS

X.L. conceived the idea for the paper and performed part of the analysis. Q.H. contributed to processing the data and performed part of the analysis. Y.M. contributed to the investigation and provided guidance and overall quality control. W.C. and C.Y. contributed to the investigation and design of questionnaire. All authors read and approved the final manuscript.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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