



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*



**Toward Understanding the Status of Latrine in Rural  
China: A Macro-Micro Analysis**

by Shaoping Li, Huanhuan Tang, Chengfang Liu, and Renfu Luo

*Copyright 2021 by Shaoping Li, Huanhuan Tang, Chengfang Liu, and Renfu Luo. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.*

# Toward Understanding the Status of Latrine in Rural China: A Macro-Micro Analysis

Shaoping Li<sup>1</sup>, Huanhuan Tang<sup>1</sup>, Chengfang Liu<sup>1,\*</sup>, Renfu Luo<sup>1</sup>

## Abstract

Rural latrine is a key component for China in its drive towards rural revitalization. In recent years, China has invested significantly in its rural latrine project. However, little is known about the quality status of latrines in rural China. Using macro and microdata, this paper fills the void in the literature on this topic. The purpose of this paper is to understand the status of latrine in rural China, as well as challenges that China is facing in latrines in its rural areas. We find that China has witnessed remarkable progress in the quality of rural latrine since the 1990s. However, progress has been uneven across regions. Compared to other developing countries with a similar level of GDP per capita, China still has a long way to go.

**Keywords:** Latrine, Status, Rural China, Macro-micro analysis

JEL code: H41, H50, H54

**Acknowledgments:** The authors would like to acknowledge the financial support of the National Natural Science Foundation of China (grant number 71861147003).

---

<sup>1</sup> China Center for Agricultural Policy, School of Advanced Agricultural Sciences, Peking University, Beijing 100871, China

\* To whom correspondence may be addressed. Email: cfliu.ccap@pku.edu.cn

Access to sanitation and hygiene conditions are crucial to human health and wellbeing. A large body of literature has linked sanitation to the environment, health, and education (Caulfield et al., 2004; Kulabako et al., 2007; Buttenheim, 2008; Mara et al., 2010; Wu et al., 2013; Adukia, 2017). Without proper sanitation systems, excreta have become one of the major causes of water pollution in some areas (Kulabako, 2007; Katukiza et al., 2012). Poor sanitation is also responsible for 10 percent of the global burden of diseases (Mara et al., 2010). In addition, improved sanitation and hygiene can increase children's educational attainment (Zhang and Xu, 2016). Therefore, Sustainable Development Goals (SDGs) call for achieving access to adequate and equitable sanitation and hygiene for all and end open defecation by 2030 (United Nations, 2015).

However, even in 2017, half of the world's population still did not have access to basic sanitation services (World Bank, 2018). More than 61 percent of the population (4.5 billion people) lacked safely managed sanitation; 2.4 billion people lacked of access to basic sanitation services, such as toilets or latrines, and 892 million people still were practicing open defecation (WHO and UNICEF, 2017). Not surprisingly, most of these people are disproportionately concentrated in developing countries (WHO, 2017).

As the biggest developing country in the world, China also faces sanitation challenge, especially in its rural areas. In 2017, more than 37 percent of, or 98.8 million rural households still did not have access to innocuous-sanitary latrines (National Health Commission, 2018). Studies have shown that safe and adequate sanitation plays a key role in preventing diarrhea, which is one of the leading causes of death in children younger than 5 years in China (Rudan et al., 2010; He et al., 2017). Thus, improving sanitation has important implications for the wellbeing of children in China.

Being aware of the importance of sanitation very early, China started the Patriotic Health

Campaign with a focus on latrine improvement in the 1950s. The latrine improvement has evolved into the so-called *toilet revolution* in 1993. Since then, a lot of money has been invested in this campaign. Indeed, during 2004 and 2013, China invested about 8.27 billion yuan in its latrine improvement. In addition, the Rural Revitalization Strategy recently calls for more resources being allocated to toilet revolution in rural China (State Council, 2018).

Given lots of efforts have been put into latrine improvement, one may ask: “what is the status of latrine in rural China?” In recent years, there is a growing body of literature examining the status of latrines in rural China. For example, using macro data from statistical yearbooks, some authors explored the dynamics of distribution of different kinds of toilets in rural China (Lin and Liu, 2016; Cheng et al., 2018; Zhang, 2018). All studies have shown that the coverage of sanitary latrines and innocuous-sanitary latrines in China are far from satisfactory, with significant disparities across regions. Using micro survey data from Chongqing, Luo et al. (2009) find that the proportion of sanitary latrines and fecal harmless treatment was only 26 percent in 2007, which was lower than the national average rate of sanitary latrines.

However, a close examination of the existing studies reveals a couple of limitations. First, studies using micro data are mostly limited to one specific area and hence are lack of national representativeness. Second, even among those studies using macro data, few has examined the types of latrines that had been used in rural China. Finally, none of the them have made international comparisons. The absence of rigorous evidence on the status of latrines in rural China hampers policymakers to effectively invest in toilet revolution (as well as determine how much to invest) and improve the quality of latrines.

In this study, we contribute to the literature by combining macro data with micro data to

document the status of latrine in rural China. Specifically, using macro data, we first examine the coverage of sanitary latrines and innocuous-sanitary latrines, fecal harmless treatment rate, and regional disparity. We then compare China with other countries and regions in rural latrine development. Using micro data, we assess the distribution of different types of latrine types across provinces and their development over time.

The rest of the paper is structured as follows. Section 2 briefly reviews the evolution of policies aiming at improving quality latrine in rural China. Sections 3 and 4 describe the changes in the quality of rural latrines in China over time and by regions using macro data and survey data. Finally, conclusions and implications are drawn in Section 5.

### **Evolution of policies aiming at improving latrines in rural China**

Many authors have argued that the improvement in rural latrine in China is mostly driven by government policies (Zhou and Zhou, 2018). Generally speaking, the policies aiming at improving latrines in rural China over the past seven decades can be categorized into four stages: 1949-1977, 1978-2001, 2002-2011, and 2012 to date. Appendix 1 gives the main policies on improving rural latrines in China in detail. We briefly describe each stage below.

#### ***1949-1977: Rural latrine improvement in the Patriotic Health Campaign***

Immediately after it was founded in 1949, China started to improve its quality of rural latrines aiming at improving the health of its people. In 1952, to prevent the damage of potential germ warfare, President Mao Zedong called for paying more attention to hygiene, and the National Patriotic Health Campaign Committee (NPHCC) started the Patriotic Health Campaign (PHC) to improve sanitation and hygiene. In the 1960s, the practice of “Two Management and Five Retrofitting” (*Liang Guan Wu*

*Gai*)<sup>1</sup> which included management of excrement and improvement of latrine was adopted in rural areas, which led to substantial progress in the quality of sanitation facilities and reduction of incidence of infectious diseases (Xiao, 2005; Zhang, et al., 2018). In short, the PHC substantially awakened the public awareness in the need for better hygiene in the country, however, sanitation facilities continued to remain poor due to lack of funding during the 1970s (Zhang et al., 2018).

### ***1978-2001: Rural Latrine Improvement in the National Economic and Social Development Plan***

In 1978, to further improve rural latrine, the State Council released the Notice on Adhering to the Patriotic Health Campaign, which asked to continue to improve latrine and water in rural areas. Latterly, in the Planning for Realizing “Health Care for All in 2000” in China’s Rural Areas, the definition of sanitary latrines was firstly proposed in China, and the coverage of sanitary latrine was also included in as one indicator of primary health care.

Shortly afterwards, in 1991, the goal of coverage of sanitary latrines in rural China was set in the National Ten Year Plan for Patriotic Health Work and Outline of the Eighth Five-Year Plan. This is the first time that coverage of sanitary latrine as one target of development was included in the National Economic and Social Development Plan. To monitor the progress of latrine improvement in rural areas, NPHCC established a national annual statistical report system for rural sanitary latrines in 1995 (Zhang, 2018). Moreover, China also included the rural latrine improvement in its Ninth Five-Year Plan in 1996 (Miao et al., 2012). Since then, rural latrine improvement has gained increasing attention.

### ***2002-2011: Rural Latrine Improvement in the Rural Reform and New Rural Construction***

Entering the 21<sup>st</sup> century, the State Council released the Decision on Further Strengthening Rural

---

<sup>1</sup> The two managements include management of human manure and water supply, and the five retrofitting are retrofitting of water well, toilet, animal pen, stove and living environment in rural areas (Cheng et al., 2018).

Sanitation Work in 2002, which demanded that more emphasis should be placed on improving hygiene and sanitation in rural areas. In 2004, to encourage local governments to improve rural latrines, the central government started to finance the rural latrine improvement project through transfer payments. The transfer payments increased the motivation of local government.

In order to develop rural areas, in 2005, the New Rural Construction was proposed in the Fifth Plenary Session of the 16th CPC Central Committee. Therefore, NPHCC demanded that rural latrine improvement should be speed up and the coverage of sanitary latrine should reach 65% by 2010. Furthermore, rural latrine improvement was included into the list of National Public Health Services in 2009. In 2010, the first of National Urban and Rural Sanitation Campaign started, with the goal of increasing the coverage of sanitary latrine by 10 percent.

### ***2012 to date: Rural Latrine Improvement in the Rural Revitalization Strategy***

Since the 18<sup>th</sup> National Congress of the Communist Party of China, China started to set goals for rural latrine improvement (Zhang et al., 2018). In April 2014, the National Health and Family Planning Commission set a goal of achieving 85 percent of coverage of sanitary latrines by 2020. Meanwhile, government leaders also started to put more emphasis on rural latrine improvement. In his visit to Jiangsu Province in December 2014, President Xi Jinping emphasized that rural latrine improvement is an important component of the New Rural Construction. One year later in Jilin Province, President Xi called for a toilet revolution and increasing the use of sanitary latrines amongst rural populations.

The Healthy China 2030 Plan was released in 2016. The Plan set a lofty goal to ensure all rural residents have access to innocuous-sanitary latrine by 2030 (State Council, 2016).

Over the past two years, multiple policies directed at rural sanitation have been announced by



the Government. In the 19<sup>th</sup> CPC National Congress in 2017, China launched the Rural Revitalization Strategy. One of the five general goals of the Strategy is “Pleasant Living Environment”, with improvement in rural latrines as an important component.

Meanwhile, the Guidelines on Promoting the Special Implementation of the Rural Toilet Revolution released in 2019 calls for effective treatment of toilet waste in the suburbs of the eastern, central and western cities. Furthermore, it calls for long-term mechanisms for management and protection to be established by 2022. For remote regions, the plan aims to increase the coverage of sanitary latrines and the innocuous treatment of fecal. In March 2019, the Minister of Agriculture and Rural Affairs, Mr. Han Changfu, noted that the central government will invest 7 billion yuan to promote rural latrine improvement in 30,000 villages, reaching more than 10 million rural residents (Peoples Network, 2019). To increase the quality of rural latrine improvement, Notice on Effectively Improving the Quality of Rural Toilet Restoration Work was released by multiple ministries.

### **Status of latrines in rural China: a macro perspective**

To understand the status of rural latrines in China, we first draw on macro data from China Sanitation Statistical Yearbook<sup>1</sup>. We focus on the coverage of sanitary latrines, types of sanitary latrines, coverage of innocuous-sanitary latrines, as well as fecal harmless treatment rate.

#### ***Coverage of sanitary latrines***

Statistics show that the coverage of sanitary latrines in China has increased steadily over the past two decades (Figure 1). Between 1996 and 2017, the number of households with sanitary latrines increased from 54 million to 217 million, with an average annual growth rate of 6.9 percent. In other words, the coverage of sanitary latrines, which is defined as the proportion of households with

---

<sup>1</sup> Since 2002, the China Sanitation Statistical Yearbook has been renamed the China Sanitation and Health Statistical Yearbook.

sanitary latrines, increased nearly 60 percentage points during this period, from 20.9 percent to 81.8 percent.

However, the increase in aggregate numbers might have masked the variations across regions. Between 2001 and 2017, disaggregated data show that the coverage of sanitary latrines in rural China varies significantly across the four regions (Figure 2). Coverage in the eastern and western areas had always been the highest and lowest, respectively. Before 2010, the coverage in the central areas was slightly higher than that in the northeast. After 2010, the coverage in the central areas and the northeast areas have almost been the same, with the latter outperformed the former in 2016. Moreover, the disparities across regions peaked in 2005 and since then the difference has remained stable. By 2016, the coverage in the east reached over 90 percent for the first time, surpassing the “85 percent by 2020” target that was set by the Health and Family Planning Commission. While the coverage of sanitary latrines in the central and northeast is still about 80 percent. Finally, while there is still a low coverage rate, the west has had a higher coverage growth rate. The region’s coverage rate increased from 33 percent in 2001 to 75 percent in 2017, with an average annual growth rate of 5.3 percent.

Compared with the east, the west has continued to be left behind by about 20 percentage points. Meanwhile, since 2001, the gap between the west and central and northeast regions has shrunk by about 10 percentage points. However, the gap between the east and central has increased from 2 percentage points in 2001 to 14 percentage points in 2016. This implies that there has been uneven progress in increasing sanitary coverage in rural China. Therefore, more emphasis should be placed on increasing coverage in the west (Lin and Liu, 2016; Zhang et al., 2018).

### ***Types of sanitary latrines***

Statistics show that the composition of different types of sanitary latrines in rural China has

changed during 2002 and 2017 (Figure 3)<sup>1</sup>. Specifically, the proportion of three-septic-tank toilets has increased steadily and become the dominant type of sanitary latrines, from 26.36 percent to 37.59 percent. The proportion of water flushing toilets has also increased from 6.2 percent to 17.67 percent. However, the proportions of biogas-linked toilets and urine-faeces linked toilets first saw increase before they began to decrease in 2015 and 2016, respectively.

In addition to composition by type, we also look at the composition by utilization of different types of sanitary latrines. In 2017, the utilization of three-septic-tank toilet ranked the highest (37.59 percent), followed by water flushing toilet (17.67 percent), biogas-linked toilet (12.00 percent), dual-pit alternate toilet (7.09 percent), urine-faeces linked toilet (1.45 percent), and dual-pit alternate toilet (0.83 percent).

Similar to its coverage, the composition of sanitary latrines by type also sees obvious disparities by region (Table 2). The rural residents in the east mostly rely on the three-septic-tank toilet and water flushing toilet, and we can also see a steady increase in their coverages, from 26.4% and 6.2% to 37.6% and 17.7%, respectively. However, during the same period, rural residents in the central have switched from dual-urn toilet to biogas-linked toilet and three-septic-tank toilet. In the west, biogas-linked toilet, three-septic-tank toilet, and water flushing toilet are the most three common types of sanitary latrines used by rural residents. These results are very similar to Yao et al. (2009). In contrast, rural residents living in the northeast are more likely to use water flushing toilet (from 5.4% to 19.3%) due to the poor moisture resistance of the three-septic-tank toilet (He and Fu, 2016).

---

<sup>1</sup> Based on China Health and Family Planning Statistical Yearbook, sanitary latrines can be classified into 7 types: three-septic-tank toilet, biogas-linked toilet, urine-faeces linked toilet, water flushing toilet, dual-pit alternate toilet, dual-urn toilet and other types of sanitary latrines. However, after careful systematic study of each type of latrine types, Fan et al. (2018) found out that only three-septic-tank toilet by flushing water and water flushing toilet meet the requirements of modern civilized life/lives on sanitation, comfortability and convenience of latrines. In contrast, other types of latrines are still susceptible to some shortcomings in use. It reminds us that we should not only take the local geographical environment and villagers' behavior habits into consideration in the improvement of rural latrine with practical conditions (He and Fu, 2016; Li et al., 2017), but also pay attention to developing new latrine technologies in the process of latrine construction.

### ***Coverage of innocuous-sanitary latrine***

As the coverage of sanitary latrines increases, so does the proportion of innocuous-sanitary latrines. However, the coverage of innocuous-sanitary latrines in rural China is still very low (Figure 4). In 2017, coverage of innocuous-sanitary latrine was only 62.70 percent. Again, this aggregate number masks variations across regions. The coverage of innocuous-sanitary latrine in the east is the highest. Interestingly, since 2010, the central region has lagged behind the west. However, the central and the west are left behind by the national average by 7 percentage points and 10 percentage points, respectively. The northeast still has the lowest coverage of innocuous-sanitary latrines, despite that its coverage increased from 5.2 percent in 2002 to 30.68 percent in 2017, a level equivalent to that of the central in 2002.

### ***Fecal harmless treatment rate***

Similar to the coverage of sanitation latrines, the fecal harmless treatment rate in rural latrines has also witnessed a substantial increase in the last two decades. The fecal harmless treatment rate has increased from 21 percent in 1996 to 93.12 percent in 2017, with an average annual growth rate of 7.35 percent (Figure 5).

The fecal harmless treatment rate also varies amongst the four regions, while the disparities are not as obvious as their coverages. The east is far ahead of the rest of the country, with fecal harmless treatment rate increasing from 57.3% in 2001 to 99.98% in 2016. Both the central and northeast have had a very similar trajectory in the fecal harmless treatment rate, from about 52% in 2001 to 90% in 2017. The fecal harmless treatment rate in the west was about 35.1% in 2001. The region has already surpassed the northeast region in 2012, with an annual growth rate of 5.92 percent.

## **International comparison**

Some authors argued that the status of latrine in one country is a good indicator of its development level (Zhou and Zhou, 2018). To the best of our knowledge, there has been no study that has compared the status of latrines in rural China with other countries. In this section, using data from WHO, UNICEF, and the World Bank, we compare China with other countries to further understand the status of rural latrines in China in the context of the world community. Appendix Table 2 gives those definitions of terms used in this section.

There was a big gap between the sample developed countries and China (Figure 6). As early as 2000, nearly all (99% and above) rural residents in developed countries, such as Germany, France, UK, and the US, had already access to at least basic sanitation services and no one practiced open defecation, while the coverage rate of at least basic sanitation services among rural people in China was only 52% and there still was 4% of rural people practicing open defecation. Among all countries, India performed worst, with only 11% of rural people having access to at least basic sanitation services and 82% of rural people still practicing open defecation. Although China outperformed South Africa, Vietnam, Indonesia, and India, it was left behind by Thailand, Chile, and Philippines.

During 2000 to 2015, although there was still a gap between the sample developed countries and developing countries, a great progress has been made in sample developing countries (Figure 7). In China, the coverage rate of at least basic sanitation services increased from 52% in 2000 to 61% in 2015, and the percentage of people practicing open defecation decreased from 4% in 2000 to 3% in 2015. Among all sample countries, Chile made the biggest achievement. The coverage rate of at least basic sanitation services in Chile has risen from 67% in 2000 to 99% in 2015, which has reached the level of developed countries. India, Indonesia, Vietnam, and South Africa also witnessed 20-

percentage point increase, however, more than half (56%) of the rural population in India still practiced open defecation in 2015. In addition, in 2015, although China's per capita was higher than that of Philippines, Thailand, and Vietnam, all three later countries have higher proportions of people using at least basic service in rural areas than China. Specifically, in 2000, the proportion of people using at least basic service in rural Vietnam was lower than that of China, however, in 2015, the proportion of people using at least basic service in rural Vietnam was higher than that of China by 11 percentage points. This implies that the improvement of rural latrine is not guaranteed by GDP growth, while it needs government intervention.

### **Progress in the status of latrines in rural China: a micro perspective**

To better understand the status of latrines in rural China from micro perspective, we draw data from the China Health and Nutrition Survey (CHNS). CHNS was designed and implemented by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Health at the Chinese Center for Disease Control and Prevention. Using a multistage, random cluster process, CHNS draw a sample of about 7,200 households with over 30,000 individuals in 15 provinces that vary substantially in geography, economic development, public resources, and health indicators. In addition, data on sanitation facilities were collected.

From 1989 to 2015, nine waves of CHNS have been conducted, which helps us describe the dynamics of distribution of different kinds of sanitation facilities. The urban samples were removed as our study focused on the status of latrines in rural China. Those kinds of sanitation facilities in this paper are defined based on the survey question answered by the households: "What kind of toilet facilities does your household have?" The possible options include no bathroom, flush toilets (in house), no flush (in house), flush (outside house, public restroom), no flush (outside house, public

restroom), cement open pit, earth open pit, and others.

### ***By latrine type***

Thanks to the nature of panel data from CHNS, we can examine the change of distribution of different kinds of latrines at household level. Similar to the results from macro data, the results from micro data also show that China had made a great achievement in sanitation services in rural areas (Table 4). For example, there was nearly 80% of rural households using open pit (cement or earth) in 1989, while it decreased to 36.75% in 2015. Meanwhile, the proportion of rural household with flush toilets (in house) increased from 0.75% in 1989 to 47.68% in 2015.

However, there is still a lot of work needed to be done to further improve latrine in rural China. Even in 2015, more than one in three rural households still used open pit, and half of rural households did not have access to flush toilets (in-house or outside-house). That may explain why under-five mortality rate in some rural places in China was still higher than that of Bangladesh (Wang et al., 2015). Improper handling of manure can have an adverse effect on the health of rural residents. In fact, one key purpose of rural latrine improvement is the innocent treatment of manure (Wen and Yang, 2005). Flushing the excrement with water can reduce fecal bacteria contact with the body and prevent the spread of bacteria in the latrine. One study shows that the incidence of diarrhea among under-5 children in Philippine decreased by 10 percent among those with their own flush toilets (Capuno et al., 2015). So, if possible, open pit should be replaced by flush toilet in rural China.

### ***By regions***

The trend emerging from each region also shows similar pattern of dynamics of distribution of different kinds of latrines in rural China (Figure 8). For example, the proportion of rural households using open pit

Table 5 describes the composition of latrine types in four regions in rural China from 1989 to 2015. Trends by region in different latrine types show that latrine type has shifted from cement open pit and earth open pit toilet to in-house flushing toilet over the recent 2.5 decades. The percentage of in-house flushing toilets are increasing steadily in all region in CHNS sample and the cement open pit and earth open pit toilet are gradually decreased. However, unlike the east region, the proportion of in-house flushing toilets in the western region and its growth rate is the highest, while in the east region, this indicator is lower than the west and central regions, which is exactly the opposite of the previous macro data.

From the specific data, the proportion of in-house flushing toilets in the east region increased from 0.84% in 1989 to 34.76% in 2015, and the cement open pit and earth open pit toilet decreased from 69.41% to 47.24%. The proportion of in-house flushing toilets in the west increased from 1.47% in 1989 to 67.74% in 2015, while the cement open pit and earth open pit toilets decreased from 79.41% to 28.22%, although there is still a small percentage of rural residents without bathroom. The ratio in the central region is just between the east and the west regions. Finally, the northeast region is the worst performer. Until recently, the latrine type of its cement open pit and earth open pit toilets still accounted for 73.55%.

## **Discussion and conclusions**

### ***Discussion***

Using macro data and microdata, we report the status of latrines in rural China over the past two decades. From the macro perspective, our results show that latrine improvement is progressing at a relentless pace. However, many challenges still remain. For example, there are huge disparities across regions and provinces. In addition, compared with other countries with similar per capita GDP, China



is far left behind in terms of coverage of basic sanitation facilities. Therefore, attention needs to be paid to reduce regional disparity. To do so, lessons must be drawn from experiences of developed and developing countries that have had made rapid progress in this regard.

Our micro-analysis using CHNS data reveals that less than half of the rural households have flush toilets, and more than 30 percent of households still use dry toilets such as cement open pit and earth open pit. In addition, our micro results show that sanitary latrines coverage in most of the sampling areas has not reached the levels recorded in the macro data in 2015, even if we consider in-house flush latrines and outside the flush house as sanitary latrines. Finally, since the 1990s, latrines in rural China have indeed undergone a process of gradual improvement, however, the current situation is far from satisfactory.

Moreover, many rural households in China still use dry latrines, or in some cases there no latrines are available. One possible explanation is that some households fail to convert their income into the investment to family sanitation and health facilities, therefore, more attention needs to be paid to improvement in sanitation conditions, especially in poor areas.

### ***Conclusions***

The latrine is a vital sanitation facility as it is a key factor in human health and the environment. Our study contributes to the literature on the status of latrine in rural China by combining the macro with the micro perspective, to enhance the understanding of latrines among different provinces, regions, and countries. To improve overall latrine level, provincial and international discrepancy need to be reduced, and more attention should be put on the implementation of latrine improvement and the strengthening of sanitation and health awareness of rural residents. Furthermore, our results provide evidence for a more targeted poverty alleviation strategy in China.

Nevertheless, there are also some limitations to our study. First, the macro data contains very limited information. These include data on whether there is no open defecation, location of rural latrines (indoor or outdoor), manure disposal methods (Zang, 2011; Wang et al., 2017), the number of latrines with households (Fu et al., 2005), area of household latrine and whether there have hand washing facilities and disinfection measures in the latrine (Tian et al., 2010). Second, CHNS only asked questions about the types of toilets in rural households. Further, the classification of these toilet types was limited. Hence, it is difficult to compare macro data with microdata directly. Thus, more studies are needed to better understand the quality status of latrine in rural China. Lastly, given tremendous resources invested to improve the status of rural latrine in China, rigorous evaluation of the effect of this sanitization improvement on rural residents are also urgently needed.

## Reference

- [1] Adane, M., Mengistie, B., Kloos, H., Medhin, G., and Mulat, W. (2017), “Sanitation facilities, hygienic conditions, and prevalence of acute diarrhea among under-five children in slums of Addis Ababa, Ethiopia: baseline survey of a longitudinal study”, *PloS One*, Vol. 12 No. 8, pp. e0182783.
- [2] Adukia, A. (2017), “Sanitation and education”, *American Economic Journal: Applied Economics*, Vol. 9 No. 2, pp. 23-59.
- [3] Baker, T. (2016), “Burden of community diarrhoea in developing countries”, *Lancet Global Health*, Vol. 4 No. 1, pp. e25-e25.
- [4] Buttenheim, A. M. (2008), “The sanitation environment in urban slums: implications for child health”, *Population and Environment*, Vol. 30 No. 1/2, pp. 26-47.
- [5] Capuno, J. J., Tan, C. A. R., and Fabella, V. M. (2015), “Do piped water and flush toilets prevent child diarrhea in rural Philippines?”, *Asia-Pacific Journal of Public Health*, Vol. 27 No. 2, pp. NP2122-NP2132.
- [6] Caulfield, L. E., de Onis, M., Blössner, M., & Black, R. E. (2004), “Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles”, *The American Journal of Clinical Nutrition*, Vol. 80 No. 1, pp. 193-198.
- [7] Cheng, S., Li, Z., Uddin, S.M.N., Mang, H., Zhou, X., Zhang, L., Zhang, J. and Zheng, L. (2018), “Toilet revolution in China”, *Journal of Environmental Management*, Vol. 216, pp. 347-356.
- [8] China Daily (2015), “Xi Jinping's attend to the appointment to inspect Yanbian: taking off his shoes and entering the house and engaging in the toilet revolution”, available at: [http://china.chinadaily.com.cn/2015-07/17/content\\_21311571.htm](http://china.chinadaily.com.cn/2015-07/17/content_21311571.htm) (accessed 17 July 2015). (in Chinese)
- [9] China News (2017), “Why is the toilet revolution so important?”, available at: <http://www.chinanews.com/gn/2017/11-30/8389125.shtml> (accessed 30 November 2017). (in Chinese)
- [10] China Sanitation and Health Statistical Yearbook, Peking Union Medical College Publishing House, Beijing. (in Chinese).
- [11] China Sanitation Statistical Yearbook, People’s Health Publishing House, Beijing. (in Chinese)
- [12] China Weekly (2018), “Toilet Revolution in China”, available at: <http://www.chinaweekly.cn/7519.html> (accessed 8 October 2019) . (in Chinese)
- [13] Fan, B., Wang, H.L., Zhu, S.K. and Zhang, Y. (2018), “Reviews and reflection on ‘toilet revolution’ in the countryside of China”, *China Water & Wastewater*, Vol. 34 No. 22, pp. 19-24. (in Chinese)
- [14] Fu, Y.F., Yao, W., Liu, B.H., You, M.K., Qu, X.G., Yao, J.Y., Chen, X., Sun, J.G., Bai, X.T. and Tao, Y. (2005), “Survey on latrine improvement in five provinces of rural China”, *Journal of Hygiene Research*, Vol. 34 No. 2, pp. 219-220. (in Chinese)
- [15] He, C., Liu, L., Chu, Y., Perin, J., Dai, L., Li, X., ... & Guo, S. (2017). National and subnational

all-cause and cause-specific child mortality in China, 1996–2015: a systematic analysis with implications for the Sustainable Development Goals. *The Lancet Global Health*, 5(2), e186-e197.

- [16] He, Y.Z. and Fu, Y.F. (2016), “Types and characteristics of sanitary latrines in rural areas”, *Chinese Journal of Public Health Engineering*, Vol. 15 No. 2, pp. 191-193+195. (in Chinese)
- [17] Liu, Y.D. (2017), “Carrying forward the fine traditions, building a healthy China, writing a new chapter in the patriotic health movement”, *Health News*, 19 May, pp. 3. (in Chinese)
- [18] Katukiza, A. Y., Ronteltap, M., Niwagaba, C. B., Foppen, J. W. A., Kansime, F., & Lens, P. N. L. (2012), “Sustainable sanitation technology options for urban slums”, *Biotechnology Advances*, Vol. 30 No. 5, pp. 964-978.
- [19] Kulabako, N. R., Nalubega, M., and Thunvik, R., (2007), “Study of the impact of land use and hydrogeological settings on the shallow groundwater quality in a Peri-urban area of Kampala, Uganda”, *Science of the Total Environment*, Vol. 381 No. 1, pp. 180-199.
- [20] Li, H., Fu, K.M., Zhou, H.T. and Qiu F.G. (2017), “Current situation and problems of rural dry toilet renovation in China”, *China Water & Wastewater*, Vol. 33 No. 22, pp. 13-18. (in Chinese).
- [21] Li, Q. and Zang, W.B. (2011), “The Health of Left-Behind Children in Rural China”, *China Economic Quarterly*, Vol. 10 No. 1, pp. 341-360. (in Chinese).
- [22] Lin, L. and Liu, D.S. (2016), “Study on distribution equity of rural sanitary latrines”, *Chinese Journal of Public Health Management*, Vol. 32 No. 3, pp. 285-289. (in Chinese).
- [23] Lou, X.Q. (2015), “toilet revolution that I have experienced”, *People's Daily (overseas version)*, 1 August, pp. 8. (in Chinese).
- [24] Luo, H., Mu, N. and Wang, G. (2009), “Rural area resident drinking water and toilet hygiene situation and their economy throws into analysis”, *Chinese Rural Health Service Administration*, Vol. 29 No. 12, pp. 886-889. (in Chinese).
- [25] Mara, D., Lane, J., Scott, B., and Trouba, D. (2010), “Sanitation and health”, *PLoS Medicine*, Vol. 7 No. 11, 2010, pp. e1000363.
- [26] Miao, Y.Q., Yang, Z.B. and Zhou, H.Y. (2012), “Study on the willingness to pay and the influencing factors of rural residents' environmental sanitation improvement—Taking latrine improvement as an example”, *Management World*, No. 9, pp. 89-99. (in Chinese).
- [27] Ministry of Agricultural and Rural Affairs (2019), “Central Agricultural Office, Ministry of Agriculture and Rural Affairs and eight other departments jointly deployed to promote the rural toilet revolution”, available at: [http://www.moa.gov.cn/xw/zwdt/201901/t20190122\\_6170498.htm](http://www.moa.gov.cn/xw/zwdt/201901/t20190122_6170498.htm) (accessed 22 January 2019). (in Chinese)
- [28] Ministry of Agricultural and Rural Affairs (2019), “Ministry of Finance and Ministry of Agriculture and Rural Affairs: Notice on Carrying out the Work of Supplementing the Financial Prize for the Whole Village in the Rural Toilet Revolution”, available at: [http://www.shsys.moa.gov.cn/zcjd/201905/t20190515\\_6305459.htm](http://www.shsys.moa.gov.cn/zcjd/201905/t20190515_6305459.htm) (accessed 3 April 2019). (in Chinese)
- [29] Ministry of Finance (2018), “Reply of the Ministry of Finance to the recommendation No. 3451 of the First Session of the 13th National People's Congress”, available at: [http://sbs.mof.gov.cn/jytafwgk\\_8395/2018jytafwgk\\_9212/2018rddbgyfwgk/201809/t20180929\\_3032235.html](http://sbs.mof.gov.cn/jytafwgk_8395/2018jytafwgk_9212/2018rddbgyfwgk/201809/t20180929_3032235.html) (accessed 17 July 2018). (in Chinese)

- [30]Ministry of Industry and Information Technology (2014), “Guidance opinion of the General Office of the State Council on improving rural living environment”, available at: <http://www.miit.gov.cn/n1146290/n1146392/c3298314/content.html> (accessed 29 May 2014). (in Chinese)
- [31]National Health and Family Planning Commission (2014), “Coverage rate of sanitary latrines in rural China reached 74.09”, available at: [http://www.gov.cn/xinwen/2014-04/03/content\\_2652878.htm](http://www.gov.cn/xinwen/2014-04/03/content_2652878.htm) (accessed 3 April 2014). (in Chinese)
- [32]National Tourism Administration and Ministry of Construction. (1994), “Notice on implementing the opinions on solving the problem of toilets in tourist spots in China”, available at: [http://www.pkulaw.cn/fulltext\\_form.aspx?Db=chl&Gid=edfa4fc2ef44fcb1](http://www.pkulaw.cn/fulltext_form.aspx?Db=chl&Gid=edfa4fc2ef44fcb1) (accessed 25 June 2019). (in Chinese)
- [33]Pan, X., Wang, H., Zhang, B., Liu, Y., Qi, S., and Tian, Q., (2019), “Plain water intake and association with the risk of overweight in the Chinese adult population: China Health and Nutrition Survey 2006–2011”. *Journal of Epidemiology*, pp. 1-8.
- [34]People.com.cn (2002), “Decision on Further Strengthening Rural Sanitation Work”, available at: <http://www.people.com.cn/GB/shizheng/19/20021029/853905.html> (accessed 29 October 2002). (in Chinese)
- [35]People's Daily (overseas version) (2017), “Patriotic Health Campaign in China”, 27 May, p. 9. (in Chinese)
- [36]Peoples Network. (2019), “Han the : Promoting latrine improvement of 30,000 villages across the country this year”, available at: <http://lianghui.people.com.cn/2019npc/n1/2019/0305/c425476-30958782.html> (accessed 5 March 2019).
- [37]Rudan, I., Chan, K. Y., Zhang, J. S., Theodoratou, E., Feng, X. L., Salomon, J. A., ... & Campbell, H. (2010). Causes of deaths in children younger than 5 years in China in 2008. *The Lancet*, 375(9720), 1083-1089.
- [38]State Council, (2018), “the Plan for Rural Revitalization Strategy (2018-2022)”, Beijing. (in Chinese)
- [39]State Council. (2016), “Health China 2030 Program Planning”, Beijing. (in Chinese)
- [40]State Council (2018), “Rural Revitalization Strategic Plan (2018-2022)”, available at: [http://www.gov.cn/gongbao/content/2018/content\\_5331958.htm](http://www.gov.cn/gongbao/content/2018/content_5331958.htm) (accessed 26 September 2018). (in Chinese)
- [41]State Council (2018), “Three-Year Action Plan for Rural Residential Environment Improvement”, available at: [http://www.gov.cn/zhengce/2018-02/05/content\\_5264056.htm](http://www.gov.cn/zhengce/2018-02/05/content_5264056.htm) (accessed 5 February 2018). (in Chinese)
- [42]State Council (2016), “Healthy China 2030 Plan”, available at:[http://www.mohrss.gov.cn/SYrlzyhshbzb/zwgk/ghcw/ghjh/201612/t20161230\\_263500.html](http://www.mohrss.gov.cn/SYrlzyhshbzb/zwgk/ghcw/ghjh/201612/t20161230_263500.html) (accessed 30 December 2016). (in Chinese)
- [43]The National Health Commission of the People’s Republic of China, (2012), “the Hygienic specification for rural household latrine”, available at: <http://www.nhc.gov.cn/wjw/pgw/201410/5a294a72c0914d99aa672f9750b6b9b5.shtml> (accessed 29 October 2014). (in Chinese)

- [44] Tian, H.C., Zhang, F.N., Zheng, D.F., Tang, M., Wu, Q. and Zhang, L.P. (2010), "Survey of current sanitary status of public latrines in urban and rural areas in Sichuan province", *Journal of Preventive Medicine Information*, Vol. 26 No. 2, pp. 111-115. (in Chinese)
- [45] UN (2015), "Goal 6: Ensure access to water and sanitation for all", available at: <https://www.un.org/sustainabledevelopment/water-and-sanitation/> (accessed 25 June 2019).
- [46] Wang, J.Y., Li, S., Li, S.Y., Chang, X.H., Wang, Y.H., Jia, Q., Wang, L.Q., Cheng, Z.X., Yu, J.L. and Zhang, Y. (2017), "Survey on the current situation of rural environmental sanitation in Lanzhou city from 2013 to 2015", *Journal of Environment and Health*, Vol. 34 No. 4, pp. 359-361. (in Chinese)
- [47] Wang, Q. and Miao, Y.Q. (2014), "Evaluation analysis on economic and social effects of important public health services during three-year plan for medical reforming: taking rural toilet improvement as example", *Chinese Health Economics*, Vol. 33 No. 9, pp. 59-61. (in Chinese)
- [48] Wen, Z.K. and Yang, Y. (2005), "Disease prevention effect and benefit analysis of three kinds of septic tanks", *Chinese Journal of Public Health*, Vol. 21 No. 9, pp.1127. (in Chinese)
- [49] WHO (2017), "2.1 billion people lack safe drinking water at home, more than twice as many lack safe sanitation", available at: <https://www.who.int/news-room/detail/12-07-2017-2-1-billion-people-lack-safe-drinking-water-at-home-more-than-twice-as-many-lack-safe-sanitation> (accessed 12 July 2017).
- [50] WHO (2018), "Guidelines on sanitation and health guidelines", World Health Organization, Geneva.
- [51] WHO and UNICEF (2017), "Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines", World Health Organization and the United Nations Children's Fund (UNICEF), Geneva.
- [52] World Health Organization and the United Nations Children's Fund (2019), WASH in health care facilities: Global Baseline Report 2019, WHO and UNICEF, Geneva.
- [53] Wu, L.Q., Zhou, X.M., Yu, X.M. and Guan, T. (2013), "Investigation on reproductive health of young female migrant workers in Shenzhen", *Chinese Journal of Family Planning*, Vol. 21 No. 12, pp. 820-823. (in Chinese)
- [54] Xiao, A.S. (2005), "A preliminary study on the patriotic health campaign 1960s to the 1990s", *Contemporary China History Studies*, Vol. 12 No. 3, pp. 55-65+127. (in Chinese)
- [55] Xu, X.H., Wen, C.C., Zhao, Z.Z., Wang, X.Q., Wang, M.Z., and Zhang, Q. (2016), "Survey on current status of sanitary latrines in rural areas, Fengxian county, 2016", *Preventive Medicine Tribune*, Vol. 22 No. 6, pp. 428-430. (in Chinese)
- [56] Yao, W., Qu, X.G., Li, H.X. and Fu, Y.F. (2009), "Investigation of latrines improvement and excreta utilization in rural areas, China", *Journal of Environment and Health*, Vol. 26 No. 1, pp. 12-14. (in Chinese)
- [57] Zang, Z.F., Liu, B.H., Tan, J.B., Wei, H.C., Dong, G.Q., Ju, P., Chen, D.J. and Fu, Y.F. (2011), "Investigation and analysis on household latrine in the earthquake-stricken rural areas in Sichuan province", *Modern Preventive Medicine*, Vol. 38 No. 8, pp. 1415-1416+1418. (in Chinese)
- [58] Zhang, H.P., Li W., Zhao X.Z., Liu F. (2018), The Effectiveness and Challenges of Toilet Improvement in Rural China. *Chinese Primary Health Care*, Vol. 32 No. 6, pp. 70-71+84. (in Chinese)

- [59]Zhang, M.J. (2018), “Disparity analysis of household latrine improvement in rural China”, Chinese Center for Disease Control and Prevention. (in Chinese)
- [60]Zhou, X. and Zhou, C. (2018), “The origin, present situation and statements of the “toilet revolution” in China”, The Central Plains Culture Research, Vol. 6 No. 1, pp. 22-31. (in Chinese)
- [61]Zhu, J.M. (1988), China: Need toilet revolution, Shanghai Branch of Sanlian Bookstore, Shanghai. (in Chinese)