

Preplanned Studies

Improving Sanitary Latrines in Rural Areas Correlated to Decreasing the Related Disease Burden — China, 2006–2017

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Summary

What is already known on this topic?

A Latrine Revolution was conducted to promote the coverage of sanitary latrines, and this coverage has shown to increase significantly from 2006 to 2017. Sanitary latrines are an important strategy for reducing disease burdens associated with poor sanitation infrastructure.

What is added by this report?

Mortality of diarrheal diseases attributable to unsafe sanitation decreased from 7,748.05 in 2006 to 2,405.46 in 2017 and was correlated with increased use of sanitary latrines.

What are the implications for public health practice?

The coverage of sanitary latrines in rural areas of China should be further improved through the adjustment of policies and plans and by combining health education and hygiene promotion.

The improvement of obsolete latrine pits in rural areas of China was proposed as early as 1960s, and campaigns were discussed in 2015 to prioritize the improvements of latrines across the country (1). By 2015, the Chinese government announced that farmers and other rural residents needed access to sanitary latrines and subsequently launched the Latrine Revolution in rural areas (2). Following these comments, China has been promoting the Latrine Revolution meant to continuously improve sanitary latrines that have played important roles in improving rural living conditions, decreasing the rates of fecal-oral transmitted diseases, and further progressing the civilizing of society goals. There were six different sanitary latrine types promoted in rural household to improve the disposal of feces. The coverage of sanitary latrines in rural communities rose from 55.0% in 2006 to 81.8% in 2017 and were accompanied by sharp drops in the rates of diarrheal diseases and soil-transmitted helminths (STH). A correlation analysis was conducted using data on the improving coverage

of sanitary latrines and indicators of STH and diarrheal diseases caused by unsafe sanitation in China during 2006 and 2017. The human capital approach was also applied to calculate the reduction of indirect economic burden (IEB) associated with unsafe sanitation during 2006 and 2017. Both the prevalence of STH infections ($R^2 = 0.94$) and mortality of diarrheal diseases ($R^2=0.95$) due to unsafe or poor sanitation had negative correlations to increased coverage of sanitary latrines. Furthermore, in 2017, an estimated 7.60 billion CNY (1.12 billion USD in 2017) was saved in 2017 compared to 2006. This suggested that the increased coverage of these sanitary latrines significantly contributed to reducing intestinal infectious diseases and other related disease burdens, so continuing the Latrine Revolution should be a top priority and combined with health education and promotion to target affected populations.

In developing countries, controlling diseases related to sanitation facilities are vital to maintaining public health especially as fecal-oral disease burdens remain significant. In low- and middle-income countries in Southeast Asia, the lack of sanitation accounted for approximately 29% of the burden of diarrheal diseases (3). In 1993 in China, sanitary latrine coverage in rural China was only 7.5% and fecal-oral transmission of diseases accounted for more than 70% of infectious disease incidence as there were 490 million people infected with *Ascaris*, 200 million with hookworm, more than 1.13 million with schistosomiasis (4). Sanitation interventions and improvements are directly related to the protection of public health (5). This study aims at describing the health impacts from the Latrine Revolution on intestinal infectious diseases, especially diarrheal diseases, during 2006 and 2017.

Coverage of sanitary latrines in rural areas was extracted from the China Health Statistical Yearbook (6). The prevalence of STH infection was extracted from the National Surveillance System for Key Infectious Diseases and Vectors (7). Mortality and burden of diarrheal diseases attributed to unsafe sanitation were extracted from the Global Burden of

Disease Study 2017 (GBD 2017) (8). Indicators of disease burden include disability-adjusted life years (DALYs), years of life lost (YLLs), and years lived with disability (YLD). The human capital approach (9) was applied to measure IEB, and gross domestic product (GDP) per capita was collected from the China Health Planning Statistical Yearbook 2018 (6). Correlation analysis was adopted to examine the correlation of the coverage of sanitary latrines and indicators of diarrheal diseases due to unsafe sanitation and STH. Human capital approach was applied to measure indirect economic burden (IEB) using the following formula.

$$IEB = \sum_{i=1}^n DALY_i \times W_i \times GDP \text{ per capita} \quad (1)$$

In formula (1), IEB was the sum of products of age-specified DALY_i, W_i, and GDP per capita. DALY_i is DALY in age group i. W_i is weights of productivity in age group i. GDP per capita in 2017 was used in IEB in 2006 and 2017.

During the period between 2006 and 2017, the coverage of sanitary latrines in rural areas of China increased from 55.0% to 81.8%, while deaths from diarrheal diseases attributable to unsafe sanitation decreased from 0.58/100,000 population to 0.17/100,000, and prevalence of STH infection from 20.88/100,000 reduced to 1.78/100,000 (Table 1). The result showed that the coverage of sanitary latrines in rural China was negatively correlated with both the mortality of diarrheal diseases attributable to unsafe sanitation ($R^2=0.94$) and the prevalence of STH ($R^2=0.95$). Moreover, both the infection rate of STH and the mortality rate of diarrheal diseases have decreased significantly alongside increasing coverage of sanitary latrines in rural China during the period from 2006 to 2017.

The number of deaths from diarrheal diseases attributable to unsafe sanitation decreased by 68.95% from an estimated 7,748.05 in 2006 to 2,405.46 in 2017. In the year 2017, DALYs (845,966.23 *vs.* 346,274.02, -59.07%), YLLs (531,449.12 *vs.* 115,418.89, -78.28%), and YLDs (314,517.12 *vs.* 230,855.13, -26.60%) of diarrheal diseases attributable to unsafe sanitation significantly decreased compared with those in 2006. Decreases in DALYs and YLLs were mainly found in children under 5 years old, and decreases in YLDs were mainly found in individuals over 5 years old (Table 2).

In addition, the human capital approach suggested that the weighted DALYs in 2017 decreased by 127,376.11 person-years compared with 2006, which

TABLE 1. Coverage of sanitary latrines in Rural Areas, mortality of diarrheal diseases attributable to unsafe sanitation, and prevalence of soil-transmitted helminths (STH) infection — China, 2006–2017.

Year	Coverage of sanitary latrines (%) [*]	Mortality of diarrheal diseases attributable to unsafe sanitation (per 100,000) [†]	Prevalence of STH infection (per 100,000) [§]
2006	55.0	0.58	20.88
2007	57.0	0.48	18.93
2008	59.7	0.41	16.59
2009	63.2	0.36	13.30
2010	67.4	0.31	11.25
2011	69.2	0.27	9.67
2012	71.7	0.24	6.90
2013	74.1	0.22	3.12
2014	76.1	0.20	4.49
2015	78.4	0.19	4.95
2016	80.4	0.18	— [¶]
2017	81.8	0.17	1.78

^{*} Data Source: China Health and Family Plan Statistical Yearbook (5).

[†] Data Source: Global Burden of Disease Study 2017 (GBD 2017) Results (7).

[§] Data Source: National Surveillance System of Key Infectious Diseases and Vectors (6).

[¶] Not available.

was equivalent to a reduction of 7.60 billion CNY (1.12 billion USD in 2017) in IEB (Table 3).

DISCUSSION

The findings showed that there were decreases in the mortality rate and burden of diarrheal diseases in relation to the use of unsafe sanitation facilities (mainly rural household latrines) in China during the period between 2006 and 2017. However, among children aged 1–4 years old, the YLD rate was 4.03% higher in 2017 than in 2006. It is indicated that it is worthy to promote the latrine revolution continuously due to its many health benefits as well as rich the economic benefits to China.

Previous studies in China (10–11) found that improving latrines as an intervention in rural areas was associated with lower incidence of diarrheal diseases with a relative risk of diarrheal diseases in relation to latrine improvement being 0.49; this study obtained consistent results.

Along with the development of social economy in China, the Latrine Revolution in rural areas played an important role in promoting public health, especially children's health. The under-five mortality rate of

TABLE 2. Burden of diarrheal diseases attributable to unsafe sanitation — China, 2006–2017^{*}.

Item	2006	2017	Change	
Mortality	7,748.05	2,405.46	−5,342.59	−68.95%
Mortality rate, per 100,000				
Under 5 years	7.36	1.13	−6.23	−84.65%
<1 year	30.78	4.20	−26.58	−86.35%
1 to 4 years	1.59	0.22	−1.37	−86.16%
DALYs (person years)	845,966.23	346,274.02	−499,692.21	−59.07%
Age-Standardized DALY rate, per 100,000	100.99	31.38	−69.61	−68.93%
DALY rate, per 100,000				
Under 5 years	731.65	185.00	−546.65	−74.71%
<1 year	2,869.32	501.27	−2,368.05	−82.53%
1 to 4 years	205.55	91.01	−114.54	−55.72%
YLLs (person years)	531,449.12	115,418.89	−416,030.23	−78.28%
Age-Standardized YLL rate, per 100,000	72.49	11.58	−60.91	−84.03%
YLL rate, per 100,000				
Under 5 years	640.76	98.68	−542.08	−84.60%
<1 year	2,691.17	367.48	−2,323.69	−86.34%
1 to 4 years	136.13	18.79	−117.34	−86.20%
YLDs (person years)	314,517.12	230,855.13	−83,661.99	−26.60%
Age-Standardized YLD rate, per 100,000	28.50	19.79	−8.71	−30.56%
YLD rate, per 100,000				
Under 5 years	90.89	86.33	−4.56	−5.02%
<1 year	178.15	133.79	−44.36	−24.90%
1 to 4 years	69.42	72.22	2.80	4.03%

* Data source: Global Burden of Disease Study 2017 (GBD 2017) results.

Abbreviations: DALYs=disability-adjusted life years, YLLs=years of life lost, YLD=years lived with disability.

TABLE 3. The age-specified indirect economic burden of diarrheal diseases attributable to unsafe sanitation — China, 2006–2017.

Age group(years)	W _i	2006		2017	
		DALY _i [*] (person years)	IEB [†] (100,000 CNY)	DALY _i [*] (person years)	IEB [†] (100,000 CNY)
≥ 0	0.15	88,682.45	52,907.95	27,096.68	16,165.88
≥ 15	0.75	91,918.96	54,838.85	36,219.17	21,608.36
≥ 45	0.8	41,354.20	24,671.92	31,498.47	18,791.99
≥ 60	0.1	8,049.85	4,802.54	7,815.03	4,662.45
Total		230,005.47	137,221.26	102,629.36	61,228.67

Note: W_i means the weights of productivity in age group.

* DALY_i was collected from Global Burden of Disease Study 2017 (GBD 2017) results (7).

† GDP per capita in 2017 was used in IEB both 2006 and 2017, in order to avoid the impact of economic development.

Abbreviations: DALY=disability-adjusted life year, IEB=indirect economic burden.

diarrheal diseases attributable to unsafe sanitation in China during 2006 and 2017 dropped by 84.65%; during the same period, the overall under-five mortality rate in China declined by 56.08% (12). Diarrheal diseases have been known to cause malnutrition and affect the growth and development of children. Although the overall burden of diarrheal

diseases has declined, the YLD rate in children aged 1–4 years in 2017 was higher than that in 2006. Therefore, it is necessary to take and develop comprehensive sanitation improvement policies and plans and combine them with health education, hygiene promotion, and improving socioeconomic conditions and living environments to achieve further

success. Previous studies found that increasing coverage of sanitary latrines in rural areas was accompanied by enhanced health awareness of local residents, and the elimination of fecal pollution was accompanied by decreases in incidence of related intestinal infectious diseases that improved overall health and family life quality and promoted the development of the countryside to eliminate poverty. Meanwhile, the safe treatment of human excreta is an important environmental protection measure as it provides good organic fertilizer resources for farmland and is of great benefit to the development of agricultural ecology. This is a sound policy basis to benefit individual, societal, and environmental health.

Furthermore, several interventions related to sanitation and hygiene should be more targeted to children and their caregivers in rural areas in order to develop their health habits, and the financial support for such interventions should be further strengthened at the policy level by the government. In addition, universal access to sanitary latrines is gradually being introduced, which will produce significant effects for public health and environmental and economic benefits.

This study was subject to at least several limitations. First, the national prevalence of STH infection and national mortality of diarrheal diseases were used in this study as data focusing on rural areas was not available. This may have resulted in an overestimation of the reduction of the burden of diarrheal diseases related to the Latrine Revolution and underestimating the correlation between sanitary latrine coverage and indicators of STH and diarrheal diseases. Second, costs of patient healthcare were not included in the IEB due to data unavailability. The contribution of economic growth to GDP per capita also played an important role in the reduction of IEB. Third, the data sources used in this study were collected beginning in 2006 and GBD 2017 was the most updated version to be used in this study. This range limited the years in which the impact of the Latrine Revolution, having begun in 2015, could be examined, but the effects of gradual improvements are noticeable.

The findings of this study provided evidence for further developing the rural Latrine Revolution and plans for health education and hygiene promotion, which represent good practice and play a key role in

advancing further rural social and economic development.

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REFERENCES

1. Luo YS. Mao Zedong and the establishment of the rural health system in new China. *General Rev Commun Party China* 2020;(4):4–9. <http://d.wanfangdata.com.cn/periodical/dsbl202004002>. (In Chinese).
2. Huanqiu. Xi Jinping : The villages also want a " toilet revolution". <https://china.huanqiu.com/article/9CaKrnK5Sco>. [2020-11-10]. (In Chinese).
3. Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC, et al. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: an updated analysis with a focus on low- and middle-income countries. *Int J Hyg Environ Health* 2019;222(5):765–77. <http://dx.doi.org/10.1016/j.ijheh.2019.05.004>.
4. Pan SC, Xu GH, Wu YZ, Li JH, Yan WA, Wang GX, et al. A background survey and future strategies of latrines and nightsoil treatment in rural in China. *J Hyg Res* 1995;34(S3):1-10. (In Chinese). <http://kns.cnki.net/KCMS/detail/detail.aspx?FileName=WSYJ5S3.000&DbNameCJFQ1995>.
5. World Health Organization. Sanitation safety planning: manual for safe use and disposal of wastewater, greywater and excreta. Geneva: World Health Organization. http://apps.who.int/iris/bitstream/10665/171753/1/9789241549240_eng.pdf?ua=1.
6. National Health Commission of the People's Republic of China. China Health Statistical Yearbook-2018. Beijing: Peking Union Medical College Press; 2019. (In Chinese).
7. Zhou XN. Investigation Report on the status of major human parasitic diseases in China in 2015. Beijing: People's Medical Publishing House; 2018. (In Chinese).
8. Global Burden of Disease Collaborative Network. Global burden of disease study 2017 (GBD 2017) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018. <http://ghdx.healthdata.org/gbd-results-tool>. [2020-5-27].
9. Zhuang RS, Wang SY. How to evaluate the economic burden of diseases. *Chin Prev Med* 2001;2(4):245–7. <http://dx.doi.org/10.3969/j.issn.1009-6639.2001.04.002>. (In Chinese).
10. Li HX, Tao Y, Liu KT. Control effects of water improvements and sanitation interventions on diarrhea incidences in China: a meta-analysis. *J Environ Health* 2014;31(5):438–41. <http://dx.doi.org/10.16241/j.cnki.1001-5914.2014.05.024>. (In Chinese).
11. Wang S, Zhang R, Tao Y. Burden of diarrheal in typical rural areas with water supply and latrines improvement. *J Environ Health* 2014; 31(2):159–62. <http://dx.doi.org/10.16241/j.cnki.1001-5914.2014.02.022>. (In Chinese).
12. National Bureau of Statistics of China. China statistical yearbook-2019. Beijing: China Statistics Press, 2019. <https://www.chinayearbooks.com/tags/china-statistical-yearbook>. (In Chinese).