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Association between rural sanitation and under five survival in China: Evidence from World Bank development indicators

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Abstract

This study analysed the relationship between rural sanitation and survival rates of children less than five years in China. The data from the World Bank for the period 2000 to 2020 were obtained via the World Development Indicators (WDI). The central theme was to determine the correlation between access to basic rural sanitation and two essential child survival indicators: stunting heights and under-five mortality. The study used graphical trend analysis and statistical correlation to determine trends and correlations across time. Findings showed a high negative correlation between under-five mortality, and rural sanitation and between stunting and rural sanitation. The results indicate that with improved access to sanitation, there is reduced stunted growth and mortality among the children. Reduction in stunting growth was attributed to limited exposure to sanitation-related diseases such as diarrhoea, the common culprits of malnutrition and mortality among under five children. We conclude that increased access to rural sanitation is associated with increased child survival and should receive priority in health and development policy. Integration of sanitation efforts into maternal and child health programs and further investments in rural sanitation infrastructure can also improve health outcomes and support the attainment of global development targets. *(Afr J Reprod Health 2025; 29 [12]: 139-147).*

Keywords: Rural sanitation, China, under-five mortality, stunting heights, survival

Résumé

Cette étude analyse la relation entre l'assainissement rural et le taux de survie des enfants de moins de cinq ans en Chine. Les données de la Banque mondiale, couvrant la période 2000-2020, ont été obtenues via les Indicateurs du développement dans le monde (IDM). L'objectif principal était de déterminer la corrélation entre l'accès à l'assainissement rural de base et deux indicateurs essentiels de la survie infantile : le retard de croissance et la mortalité des enfants de moins de cinq ans. L'étude a utilisé l'analyse graphique des tendances et la corrélation statistique pour déterminer les tendances et les corrélations au fil du temps. Les résultats montrent une forte corrélation négative entre la mortalité des enfants de moins de cinq ans et l'assainissement rural, ainsi qu'entre le retard de croissance et l'assainissement rural. Ces résultats indiquent qu'un meilleur accès à l'assainissement réduit le retard de croissance et la mortalité infantile. La réduction du retard de croissance est attribuée à une exposition limitée aux maladies liées à l'assainissement, telles que la diarrhée, principales causes de malnutrition et de mortalité chez les enfants de moins de cinq ans. En conclusion, un meilleur accès à l'assainissement rural est associé à une augmentation de la survie infantile et devrait être une priorité des politiques de santé et de développement. L'intégration des efforts d'assainissement aux programmes de santé maternelle et infantile et des investissements accrus dans les infrastructures d'assainissement rural peuvent également améliorer les résultats sanitaires et contribuer à la réalisation des objectifs de développement durable. *(Afr J Reprod Health 2024; 29 [12]: 139-147).*

Mots-clés: Assainissement rural, Chine, mortalité des enfants de moins de cinq ans, retard de croissance, survie

Introduction

In the past decades, the global health community has made remarkable strides in increasing child survival, and as a result, under-five deaths have fallen remarkably in the majority of countries. Child health is a priority for global public health and an indicator of national development. Among the most common indicators of survival and child well-being are stunting prevalence and under-five mortality (U5MR), both of which reveal general healthcare system quality, living conditions, and nutritional status in a nation[1-3]. These indicators not only show the immediate health impacts of children but also broader indications of a country's environmental and socioeconomic development[4,5].

The World Health Organization (WHO) has explained under-five mortality as deaths of children between birth and five years of age per 1,000 live births[6]. It is a critical indicator used globally to assess the success of public health interventions and policies in improving maternal and child health. Stunting, another critical child development indicator, refers to impaired linear growth and is measured with a height-for-age z-score (HAZ) below two standard deviations of the WHO growth standard median[7, 8]. Growth stunting is typically the result of long-term malnutrition, recurrent infection, and unhygienic and unsanitary conditions, particularly in early childhood. It has lasting impacts on cognitive development, schooling, and adult economic productivity[9].

The world's most populous country, China, has made tremendous advances in improving child health over the last three decades. Since the early 1990s, China has witnessed a persistent and large decline in under-five mortality due to augmented coverage of healthcare, improved maternal care, and investments from the government in child survival programs[3, 10, 11]. This accomplishment is in line with worldwide agendas such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs), particularly aiming to reduce child mortality and improve access to water, sanitation, and hygiene (WASH) as key targets. SDG 6 has among its specific objectives to ensure that everyone has access to safe and equitable sanitation and hygiene by 2030 due to its vital role in securing public health[12,13].

Despite these advancements, there exists a knowledge gap in terms of the direct relationship between rural sanitation access and under-five mortality and stunting. While the importance of sanitation and under-five survival are well established, little empirical work has quantitatively estimated the direction and magnitude of this relationship over time in the context of China. This is particularly important in rural China, where health outcome differentials and development in infrastructure persist compared to that of urban China.

Therefore, this study sought to determine the relationship between rural sanitation and child survival in China using under-five mortality rates and the prevalence of stunting as indicators. Using data from 2000 to 2020, the study determined whether better rural sanitation is directly related to better health among children. Through trend analysis and correlation matrix, this study offers data-based assessment of the association of sanitation with child survival. The findings will be help to guide health policy, inform resource allocation, and reaffirm the value of incorporating sanitation programs into the broader child health and development strategies.

Literature review

Wong *et al.*[14] analysed maternal and under-five mortality in Xide and Mianning counties in rural China, which are largely populated by the Yi ethnic minority. Although the country had made advancements in lowering maternal and child mortality nationally, MMR and U5MR were considerably greater in these counties. Most maternal fatalities took place outside hospitals from 2012 to 2014, of which 81.81% were Yi women[14]. The causes were poor provider qualifications in health care, poor access to prenatal care, poverty of infrastructure, and cultural barriers. Only 57% of mothers received folic acid counselling, and providers scored low on obstetric knowledge tests. Prenatal care attendance was highly correlated with hospital delivery and postnatal care. The conclusion was that systemic disparities, including social norms and resource limitations, contributed to the high mortality rates. It recommended policy changes to strengthen access to healthcare, expand the training of providers, and address cultural and structural obstacles to maternal and child health in ethnic minority regions.

Xu *et al.*[3] analysed the child mortality trend and causes among children under five years of age in Xuzhou, China, from 2016 to 2020. They utilized population-based data of the Xuzhou CDC and SPSS for analysis and identified 1,949 deaths during the study period. Death had a persistent decline, from 573 in 2016 to 94 in 2020. The most deaths were seen in January, February, and May, with the lowest in July, August, and September. The most prevalent cause of death was neonatal suffocation and hypoxia, with a proportion of total cases of 16.57%. The geographically highest death was seen in Pizhou, while Kaifa had the lowest. The

research ended by determining that the lower neonatal mortality, the more, and recommended interventions aimed at addressing the top causes of death.

Zhang *et al*.[15] analysed and predicted under-five (U5MR) and maternal mortality rate (MMR) trends in China between 1991 and 2020, assessing the role of maternal health care and economic growth. Using JoinPoint regression and linear mixed-effect models, they found decreasing rates of neonatal, infant, under-five, and maternal mortality in both urban and rural areas. These rates of death were all significantly negatively related to GDP, health expenditure ratio, management rate of the system, and maternal care. ARIMA models predict continued reductions in U5MR (to 7.2‰ in 2025) and MMR (to 8.3 per 100,000). The study concluded that China attained major decreases in child and maternal mortality and emphasized the value of equitable public health services and optimal distribution of resources to combat Healthy China 2030 goals. The authors suggested that the strategies of China could be followed as an example by developing countries striving to attain Sustainable Development Goals.

Lv *et al*.[1] applied Joinpoint regression and correlation analysis to analyse trends in China's under-five mortality rate (U5MR) during 1996-2020. Significant decline in U5MR in three phases with a mean annual percentage change of −7.27% was noticed. Greater decrease in the rural U5MR was noticed as compared to the urban one, though rural areas were still more affected. Pneumonia deaths declined most steeply, and reductions in congenital heart disease and accidental asphyxia were more moderate. U5MR was inversely related to hospital delivery rates, neonatal consultations, systematic health management, and proportion of government expenditure on health, but positively with out-of-pocket health expenditure. The evidence indicated that increased government spending on health and improved maternal and child health care services contributed significantly to the decline in mortality. The study concluded that future decline in U5MR requires increased focus on health disparities in the rural communities, congenital conditions, and additional public health funding and reduced out-of-pocket payments.

Methods

Trend analysis and correlation matrix methods were employed in this study to examine the impact of rural sanitation on under-five survival in China. Using five-year interval data between 2000 and 2020 accessed from the World Bank's World Development Indicators (WDI) [16], the study explored how rural sanitation is associated with stunted growth and under-five mortality rates through graphical trend analysis and correlation tests.

Estimation procedures

To investigate the connection between under-five survival and rural sanitation in China, indicators and proxy variables outlined in Table 1 were utilized. Given the study's scope and objectives, a graphical analysis combined with a correlation matrix approach was adopted. This method provides a visually intuitive and comprehensive overview, allowing for the clear identification of patterns, trends, and potential relationships among the variables over the study period.

Table 1: Measurement of variables

Variable	Code	Measurement	Source	Expected sign
Rural sanitation	RSN	People using at least basic sanitation services, rural (% of rural population)	WDI	-
		Variable of Interest		
Stunted Height	STH	Prevalence of stunting, height for age (% of children under 5)	WDI	NA
Under-five mortality	UFM	Mortality rate, under-5 (per 1,000 live births)	WDI	NA

Data analysis

To achieve the objectives of this research, data analysis was performed using graphical presentation and correlation matrix. Graphical presentation allows for the examination of patterns, trends, and variations in data across time, while the correlation matrix determines the direction and strength of the association between variables. These techniques have been used in health economics studies such as [17, 18, 19, 20, 21, 22.] Together, they present a clear and understandable image of the study area.

Ethical consideration

This study utilized publicly available statistical data from World Development Indicators (WDI). Data are anonymized and aggregated with no harm potential to privacy for individuals or release of personally identifying information. No sensitive or personal information was gathered or used by this research. Any analysis was within terms of use specified by the data suppliers. A strict protocol was adhered to at the time of research to keep the integrity and transparency of the results intact. As the research was not carried out on human or animal subjects, there was no need to take ethical clearance.

Results

Graphical trend

Figure 1 shows the correlation between rural sanitation (RSN) and stunting height (STH) among under-five children in China during the period from 2000 to 2020. During the 20 years, the proportion of the rural population that had access to basic sanitation services improved dramatically—from 45.0% in 2000 to 54 in 2005, in 2010, it climbed to 65.2 and in 2015, it was at 76.5 but it rose to the highest in 2020 peaking at 87.9% in 2020. At the same time, the under-five children's stunting rate followed a pattern in the opposite direction. It dropped continuously from 17.8% in 2000 to 9.4 in 2010 and reached its lowest point in 2020 at to 6.4%.

Figure 2 depicts the changing pattern of rural sanitation (RSN) and under-five mortality (UFM) in China from 2000 to 2020.

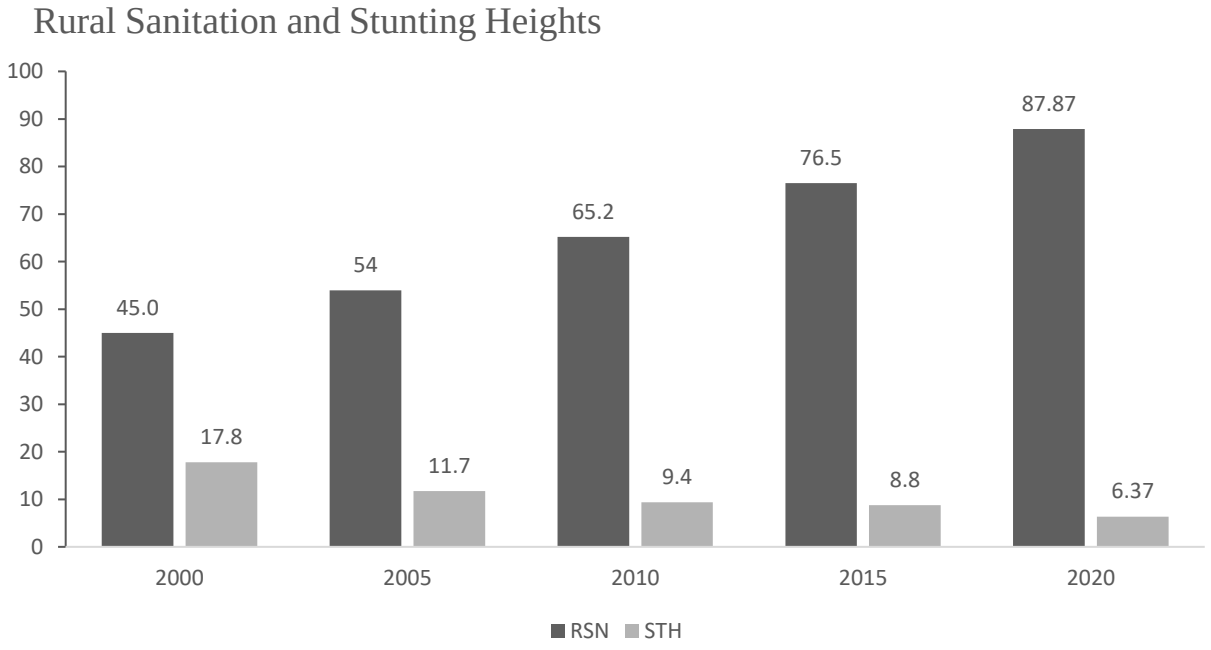

Figure 1: Rural sanitation and stunting heights among under-five in China

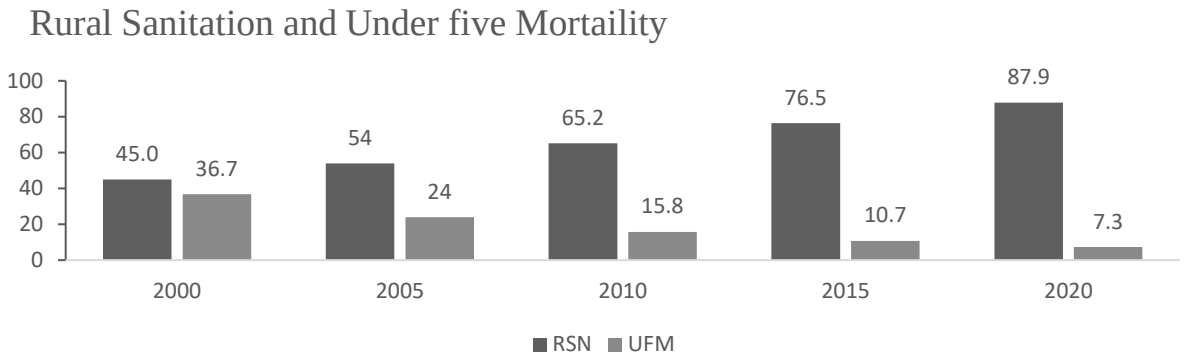

Figure 2: Rural sanitation and under-five mortality in China

Table 2: Correlation matrix

	STH Coefficient	Probability	UFM Coefficient	Probability
RSN	-0.8	0.0	-0.9	0.0

During the years, basic rural sanitation coverage rose continuosly from 45.0% in 2000 to 54% in 2005 and then in 2010, it rose to 65.2 with no fall in 2015 and finally it peaked at 87.9% in 2020, whereas under-five mortality dropped considerably from 36.7 to 7.3 deaths per 1,000 live births.

Correlation matrix

Table 2 presents the correlation between rural sanitation (RSN) and two indicators of child health: stunting height (STH) and under-five mortality (UFM). It shows that the two measures have strong negative relationships with RSN. The correlation coefficient between RSN and STH is -0.8 (p = 0.0), which indicates that as the level of access to rural sanitation is higher, the proportion of stunting among children under five years becomes lower. Similarly, the correlation between RSN and UFM is stronger at -0.9 (p = 0.0), suggesting higher rural sanitation coverage is significantly associated with lower under-five mortality.

Discussion

The findings of research on rural sanitation and child health outcomes in China between 2000 and 2020 unequivocally confirm the significance of basic sanitation in enhancing the survival and development of children. Over these two decades, increased access to basic sanitation by the rural population occurred step by step with a corresponding sizable reduction in stunting among children under the age of five. This negative correlation points to a high negative correlation between rural sanitation improvement and child stunting levels. As sanitation facilities increased and hygiene conditions were better, the prevalence of children with growth impairment resulting from environmental contamination and frequent infections due to poor sanitation declined. The graph and statistical data combined show that access to basic sanitation has a great impact on healthier physical growth among children.

The same pattern is observed when examining under-five mortality. Rural sanitation coverage increased steadily with falling mortality rates, supporting the evidence that improving sanitation has been a key driver of reducing child mortality in rural China. Increased access to safe sanitation facilities likely shortened the occurrence of waterborne and hygiene-related diseases -e.g., diarrhoeal infections- that are leading causes of death for children under five. The steady declining trend in mortality rates with rising access to sanitation emphasizes the overall public health gain of sanitation investments, particularly when healthcare infrastructure is poor in rural settings. Statistical evidence corroborates these trends. Rural

sanitation was strongly negatively related to child stunting with a coefficient of -0.8 (p = 0.0), while that with under-five mortality was even more robust at -0.9 (p = 0.0). These coefficients confirm that sanitation gains are highly correlated with abrupt declines in stunting and mortality. The channels are well established: improved sanitation lessens contact with contaminated water, lowers rates of diarrhoeal and parasitic infections, and retards chronic nutrient losses that erode child growth and survival.

In rural China, where health infrastructure remains uneven, sanitation improvements are a cheap and scalable public health intervention. These findings corroborate the need to continue investing in rural sanitation as a strategic pathway towards the attainment of Sustainable Development Goal 3 (Good Health and Well-being). They further agree with global empirical evidence that links poor sanitation and unhygienic conditions to undernutrition and child mortality. Sinking money into rural sanitation facilities in the poorest and highest child mortality districts would not only enhance child health gains but also enhance the overall foundation for sustainable rural development.

Evidence from China further supports the associations identified in this study. Rural service disparities affect child development outcomes, underscoring the importance of sanitation in improving child health[23]. Health-system structures influence mortality patterns, aligning with our findings on environmental determinants of under-five survival[24]. Travel burden limits timely care and increases vulnerability in rural areas[25]. Poverty-alleviation programmes reduce health risks and strengthen household resilience[26]. Technological improvements in hospitals enhance service delivery[27]. Family dynamics also shape care decisions[28]. Biological and epidemiological evidence highlights population susceptibilities relevant to sanitation-related diseases[29]. Genetic factors further reinforce this vulnerability[30].

Laboratory-based findings emphasise reproductive health risks in infectious contexts[31]. Additional immunological evidence shows how underlying susceptibility compounds environmental exposure[32]. Broader Global South evidence reinforces the relevance of our findings, showing that health-financing conditions, gender dynamics, women's empowerment, household wealth, public spending, financial stress, insurance coverage, and medical costs all shape maternal and child health outcomes in similar ways[33–41].

Study strengths and weakness

One of the strengths of this research is that it uses a holistic methodology, spanning two decades of data to analyse rural sanitation's connection to under-five stunting and the trends in mortality in China. The application of universally accepted data sources, i.e., the World Bank's World Development Indicators (WDI), adds to the validity of the results and facilitates comprehensive cross-country comparisons. Use of graphical as well as statistical methods offers unequivocal graphical representation and quantitative analysis of the observed relationship.

The study is not free from limitations, though. Strong relationships are determined, but causality cannot be conclusively established in the absence of more advanced techniques such as multivariate regression or time-series analysis. Also, the data available for stunting heights had some years missing and the study extrapolated for those missing years. However, despite these limitations, the research provides an invaluable point of entry for subsequent studies within this topic especially in light of the scarcity of research on the impacts of rural sanitation on outcomes in child health within comparable settings.

Policy implications

To hasten the decline in under-five mortality and stunting, based on the findings of the study, governments must prioritize the expansion of access to basic rural sanitation infrastructure. More public investment in financing clean water supply, latrines, and waste disposal systems is required to reduce the transmission cycle of sanitation-borne disease. Sanitation interventions must be integrated into maternal and child health programs through the inclusion of hygiene education in prenatal and postnatal care visits. Targeted subsidies or fiscal incentives need to be provided to help low-income rural households construct and maintain sanitary

facilities. It is also necessary to reinforce community-led total sanitation programs to enhance local ownership, behaviour change, and use of sanitation facilities over the long term. Capacity building for rural health workers on hygiene promotion and environmental health is also necessary. Finally, robust monitoring and evaluation mechanisms must be established to gauge the success of sanitation policy, ensure equitable access, and enable evidence-based decision-making for the improvement of child health outcomes in rural communities.

Conclusion

The objective of this study was to show the relationship between rural sanitation and under-five survival in China. This study reconfirmed the robust negative association between rural sanitation and under-five health outcomes in China from 2000 to 2020. With the improvement of basic sanitation coverage, both stunting and under-five mortality decreased significantly, demonstrating the critical role of improved sanitation in promoting child survival and development. Statistical analysis indicated that better rural sanitation is closely linked to lower chronic malnutrition and child mortality rates, mainly through lower exposure to waterborne diseases and unhygienic conditions. The findings stress the need for long-term investment in rural sanitation infrastructure, coordination with maternal and child health services, and community participation to achieve long-term health benefits. These results offer practical advice for policymakers who aim to improve child health and achieve Sustainable Development Goals, especially in rural and poor settings.

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