

Article

Do Clean Toilets Help Improve Farmers' Mental Health? Empirical Evidence from China's Rural Toilet Revolution

Ruohan Zhang ¹, Jialan Zhang ¹, Kuan Zhang ¹, Dingde Xu ² , Yanbin Qi ¹  and Xin Deng ^{1,*} 

¹ College of Economics, Sichuan Agricultural University, Chengdu 611130, China; 202103145@stu.sicau.edu.cn (R.Z.); 2022308058@stu.sicau.edu.cn (J.Z.); 14869@sicau.edu.cn (K.Z.); qybin@sicau.edu.cn (Y.Q.)

² College of Management, Sichuan Agricultural University, Chengdu 611130, China; dingdexu@sicau.edu.cn

* Correspondence: dengxin@sicau.edu.cn

Abstract: The mental health crisis poses a major challenge to global sustainable development. In response, the United Nations has launched an ambitious plan to “reshape the environment that affects mental health”. Clean toilets are an important measure of civilization, yet it is unclear whether they are helping to alleviate the global mental health crisis. Therefore, using data from a large sample of rural Chinese households and introducing an instrumental variables approach based on the IV-Tobit model to address endogeneity, this study quantitatively discusses that clean latrines have a positive effect on the mental health of farm households. The results showed the following: (1) 89.8% of Chinese rural households had clean toilets, while the average farm household depression index was 12.568; and (2) clean toilets helped to improve the mental health of farmers, which means that the depression index of farmers with clean toilets decreased by 66.9% compared to farmers without clean toilets. The findings of this study can inform the development of policies to mitigate the global mental health crisis and contribute to the resilience of global development.

Keywords: clean toilets; mental health; toilet revolution; IV-Tobit model; China rural



Citation: Zhang, R.; Zhang, J.; Zhang, K.; Xu, D.; Qi, Y.; Deng, X. Do Clean Toilets Help Improve Farmers' Mental Health? Empirical Evidence from China's Rural Toilet Revolution. *Agriculture* **2024**, *14*, 128. <https://doi.org/10.3390/agriculture14010128>

Academic Editors: Francisco Javier Castellano-Álvarez, Rafael Robina-Ramírez and Francisco José Ferreira Silva

Received: 6 December 2023

Revised: 11 January 2024

Accepted: 13 January 2024

Published: 15 January 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Mental disorders are a major public health problem affecting patients, society, and the entire nation [1]. The World Health Organization has announced that nearly 1 billion people worldwide suffered from mental disorders in 2019, which means that 1 in 8 people suffered from a mental disorder. For individuals, mental disorders have a significant negative impact on a patient's labor force participation, with people with mental disorders losing an average of 10.52 additional years of work [2]. Mental illness can also lead to a greater likelihood of leaving school early, a lower likelihood of obtaining full-time employment, and a reduced quality of life. In addition, all people with mental disorders have an increased risk of premature death [3]. For the whole of society and the economy, mental disorders can cause an increase in total economic costs. A Canadian study suggests that the total economic costs associated with mental illness will increase six-fold over the next 30 years, and could exceed \$2.8 trillion based on 2015 Australian dollars [4]. As a result, how to effectively curb the spread of the global mental illness crisis has become a research priority for the academic community.

The lifetime prevalence of mental disorders in China is 16.6%, meaning that 230 million people will suffer from mental disorders in their lifetime. The insidious nature of mental illnesses has led to the frequent problem of Chinese patients suffering from mental illnesses and failing to recognize their illnesses or seek timely medical attention. This will lead to tragic consequences, such as a rural suicide rate of 7.04 per 100,000 in 2019, a suicide rate among China's elderly that is 2.75 to 7.08 times higher than that of the general population, and a continued rise in psychological problems among left-behind children [5]. Rutter [6]; Clark et al. [7]; Evans [8] showed that the environment can effectively improve

mental health. Therefore, this paper starts from the perspective of the toilet revolution in China's habitat improvement, quantitatively investigates whether this environmental reform can improve the level of human mental health, and proposes Hypothesis H1: The toilet revolution has a positive effect on the mental health of farmers.

Firstly, the definition of mental disorders. Current research findings have classified mental disorders into 11 conditions: panic disorder, social phobia, simple phobia, major depressive disorder, obsessive-compulsive disorder, substance abuse/dependence, alcoholism/dependence, personality disorder, schizophrenia, bipolar disorder, and dementia in those older than 65 years of age [9]. This shows that depression is an important part of mental disorders. According to a WHO analysis, a quarter of the world's population suffers from a mixture of the more common mental disorders, usually anxiety and depression [10]. Thus, the key to effectively addressing mental disorders, an important issue in global sustainable development, is how to effectively address depression, which in turn comes to significantly alleviate the global problem of mental illness. Studies by Slyepchenko et al. [11] and Yang et al. [12] have shown that the disruption of the gut microbiome is associated with Major Depressive Disorder (MDD) and that disruption of the gut microbiome will lead to MDD through some mechanism. Phillips et al. [13] believe that the living environment has a positive impact on mental health, and Li and Zhou [14] believe that living environment interventions, such as environmental improvements to indoor home facilities, are an effective way to reduce the risk of depressive symptoms in middle-aged and older Chinese people. This study hypothesizes that improving physical health and living environments can be effective in improving depression and alleviating mental disorders, ultimately contributing to sustainable global development at both individual and socio-economic levels.

The state of physical health and living conditions in rural areas are not encouraging. It is estimated that as of 2017, 880 million people were living in slum-like conditions, with approximately 50% living in rural areas where conditions still needed to continue to improve [15]. The UN Millennium Development Goals (MDGs) report suggests that global basic sanitation coverage was only 67% as of 2015, well below the 75% coverage needed to achieve the MDGs. Poor sanitation around the world has led to increased disease prevalence and environmental pollution (MFA and UN, 2015, UNICEF and WHO, 2015); 1.5 million children die from diarrhea each year [16]. This shows that the toilet revolution, which is an important measure to improve health and living conditions, cannot be delayed.

The toilet revolution refers to the renovation of toilets in developing countries, and discussions about a revolution in public toilets were raised in public media in China as early as the early 1990s. The Five-Year Action Proposal for the Improvement and Upgrading of the Rural Habitat Environment (2021–2025) proposes that during the implementation of the proposal, the rural toilet revolution should be promoted solidly, including important initiatives such as gradually popularizing rural sanitary toilets, effectively improving the quality of toilet conversion, and strengthening the harmless treatment and resourceful use of toilet waste. The implementation of these elements will effectively improve the living environment and deter the spread of the virus. As known from the previous content, both physical health status and the level of the living environment act as important factors affecting mental health. However, few studies have demonstrated the impact of the toilet revolution on psychological health based on the above factors. Therefore, this study will use this to investigate the impact of the toilet revolution on the psychological health of farmers and to quantify the extent of the impact.

Mental disorders are spreading globally, especially in developing countries. Therefore, this study is based on China, the world's largest developing country. While previous studies have focused on the palliation of psychiatric disorders by pharmacological treatments, this study focuses on the palliation of psychiatric disorders by non-pharmacological treatments, which is one of the contributions to the scientific value of this paper. Most existing studies have used a single indicator to measure the depression of farmers, such as Corrigan et al. [17], Hayes and Poland [18], and Makwana [19]. It is difficult for a single

indicator to reflect the overall mental state of farmers. In this study, the Likert scale method and entropy weighting method were used to measure the depression index of farmers. Existing studies have generally used simple empirical methods, such as the DID model [20], Multiple linear regression [21], or the O-probit model [22]. In this way, the endogeneity of farmers' behavioral decisions is ignored, and the results of the study may be biased. Thus, this study uses the IV-Tobit model to introduce instrumental variables to overcome potential endogeneity problems.

2. Theoretical Analysis and Research Hypothesis

Rose et al. [23] indicate that approximately 179 million farming households will still be using traditional dry latrines by 2022. However, this practice poses a significant health risk as human feces contain high levels of organic pollutants, viruses, pathogenic bacteria, and parasite eggs. For instance, diseases such as COVID-19 can be spread through the fecal-oral route as shown by Caruso and Freeman [24]. The absence of proper sanitation facilities can create an environment that promotes the spread of bacteria and viruses. Furthermore, the improper handling of manure can lead to the pollution of air, soil, water, and food, resulting in adverse effects on the living environment [25]. Research has shown that the living environment has a significant impact on mental health. Phillips et al. [13] found that a positive living environment could improve mental health. Li and Zhou [14] suggested that improving indoor home facilities could reduce the risk of depressive symptoms among middle-aged and older adults in China. Studies have also shown that older people benefit from a favorable environment [26–30]. Norling et al. [31] and Ishida et al. [32] found that some toilet environments are perceived as unsafe, dirty, smelly, and unpleasant. However, attitudes towards these environments can be changed by modifying them, such as changing the dark and damp environment, increasing privacy, and reducing exposed feces. Yang and Yuan [33] suggested that the environment has a significant impact on people's moods, behaviors, and habits, and therefore improving sanitation facilities can improve people's living conditions and overall well-being.

Ali et al. [34] and Paddy et al. [35] believe that the virus is transmitted through aerosols produced when flushing water and that the virus comes into contact with the human gut through the respiratory tract, resulting in the onset of diarrhea and malaria. Wang and Liu [36] indicated that COVID-19 transmission is associated with feces, meaning that exposed feces have the potential to transmit the virus. Some scholars believe that the lack of a toilet revolution or the poor condition of the toilets has led to a sharp increase in schistosomes and parasites through the contamination of water by exposed feces. This in turn has affected the rate of schistosomal infections, increased the rate of vector-borne organisms, and increased the number of *E. coli*, thus affecting health [37,38]. Zhou et al. [39] found that urine and excrement tend to cling to dry concrete toilets, releasing unpleasant odors and bacteria, and spreading disease, posing a threat to human health and environmental safety. Akaishi et al. [40] indicated that the restoration of toilet hygiene was associated with a reduction in the prevalence of gastrointestinal infectious diseases. The rural toilet reform significantly reduced farmers' expenditure on health care and had a significant positive impact on the health level of rural residents. Thus, a well-implemented toilet revolution can be a good way to improve people's physical health. Kiseleva and Strielkowski [41] found that the most important factor affecting well-being is health, and based on this it can be inferred that improved physical health can help reduce depression.

In summary, the toilet revolution will have a positive impact on farmers' mental health through two mechanisms: changing the living environment and improving farmers' physical health. This means that a good implementation site for the toilet revolution has a significant positive impact on farmers' mental health, as shown in Figure 1. Therefore, this paper proposes Hypothesis H1: The toilet revolution has a positive effect on the mental health of farmers.

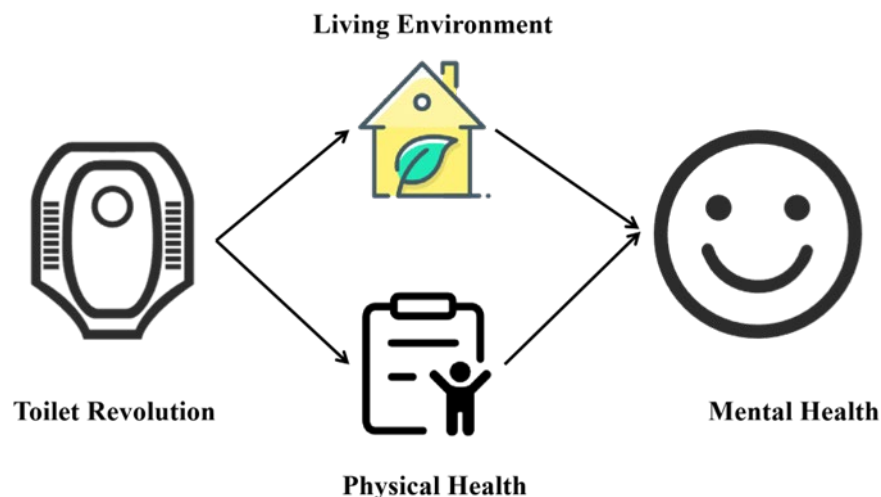


Figure 1. Mechanism diagram.

3. Data, Variables, and Method

3.1. Data

The data used in this article are mainly from the China Land Economic Survey, 2020 and 2021 (<http://jscv.njau.edu.cn>, accessed on 1 January 2022). This database survey uses the PPS sampling method to sample 52 administrative villages and 2600 farming households in 13 prefecture-level cities in the Jiangsu province, based on the establishment and survey of fixed rural observation points, covering aspects such as ecological environment, green development, poverty alleviation, rural governance, rural construction, etc. The questionnaire includes questions about the toilet revolution, such as the type of toilet and whether it can be flushed, and questions about mental health, such as whether they have felt depressed and happy recently.

The purpose of this study is to examine the impact of the toilet revolution on the mental health of farming households. Reference literature of Cheng et al. [15] and Wang and Shen [20], among the variables selected, were those related to the toilet revolution and mental health, and the remaining sample of 5039 farmers was processed by deleting missing values, and so on.

3.2. Variables

3.2.1. Explained Variables

This study uses the mental health status of farmers as the explanatory variable and aims to discuss the impact of the toilet revolution on the mental health status of farmers. The questionnaire asks respondents if they have felt anything in the past week including a low mood, struggling to do anything, not sleeping well, feeling happy, feeling lonely, living happily, feeling sad and upset, and feeling unable to go on with their lives, and the respondents complete a five-point scale depending on the level of impact. By normalizing the eight indicators through the entropy weighting method, the score is calculated by calculating the entropy value and entropy weighting, that is the depression index (0–100); the higher the index the higher the degree of depression. The process of calculating the depression index is shown in Appendix A.

3.2.2. Explained Variables

The “Availability of flushable toilet conveniences” was used as the core explanatory variable in this study. The question “type of toilet” in the China Land Economic Survey was selected, and toilets with flushing devices were assigned a value of 1, which means 1 = clean toilet, while the rest were assigned a value of 0, which means 0 = non-clean toilet. As the ‘toilet revolution’ continues, local governments are optimizing their standards and requirements, from standard to comfortable, and from tidy to beautiful. The sanitary code for

public toilets issued by the State Administration of Market Supervision and Administration and the National Standardization Administration of China (<https://openstd.samr.gov.cn>, accessed on 1 January 2022) clearly states that harmless sanitary toilets are the following: the septic tank type with three or more compartments with front-end treatment facilities, the digester type, the double and triple urn type, the urine and feces separation type, and the flush type with complete water and sewerage. Based on the above requirements, the existing toilet situation can be categorized into toilets with flushing devices and toilets without flushing devices, while the models in the normative standards all belong to toilets with flushing devices. This study focuses on sanitary toilets and therefore uses the availability of flushable toilet conveniences as a criterion for the development of a toilet revolution.

3.2.3. Control Variables

To improve the estimation power of the model, in selecting the control variables, this study refers to Al-Butmeh and Al-Khataib [42], Feng et al. [43], Zeng and Jian [44], Chang et al. [45] and Shields-Zeeman and Smit [46]. While these scholars selected age, education level, and economic income as control variables in their studies, this study added some factors affecting the mental health of farmers as control variables. These control variables include personal characteristics of the farm household (for example, age of the farm household, education level of the farm household, whether the farm household is engaged in agricultural production, self-rated health of the farm household), social and economic characteristics of the household (for example, the structure of household education level, household economic income, whether the household is located in a plain area) and environmental characteristics.

3.2.4. Descriptive Statistics

Table 1 presents the definitions of the variables and descriptive statistics for this study. The multiple variables used in the study were binary discrete variables. For example, the toilet revolution situation where it is a clean toilet took the value of 1 and the non-clean toilet took the value of 0. As can be seen from Table 1, the average depression index of respondents in the sample was 12.568, which was relatively good for depression, and 89.8% of households had completed the toilet revolution, indicating that the toilet revolution process was advancing significantly. The average age of respondents was approximately 62 years, indicating that the majority of those living in rural areas are older, middle-aged, and elderly and that middle-aged and elderly groups were more likely to suffer from mental disorders, making it significant to focus on those living in rural areas. Only 14.6% of respondents had a high school or higher degree of literacy, with a generally low level of education in rural areas. A total of 84.2% of the sample used smartphones, but only 45% used the internet. In total, 85.5% of the households in the sample were situated in the plains with relatively flat terrain, and 34.5% of them considered their villages to be polluted, thus showing the need for habitat improvement.

3.3. Method

3.3.1. Baseline Model

This study aims to discuss the quantitative impact of the toilet revolution on the psychological health of farmers. The dependent variable is the depression index of farmers, which is a two-sided restricted truncated model with 0–100, and the independent variable is the status of the toilet revolution, which is a binary variable: 1 = clean toilets, which means a toilet revolution is taking place; and 0 = non-clean toilets, which means no toilet revolution is taking place. Thus, this study uses the Tobit regression model as the baseline model for the study to analyze the quantitative relationship between the toilet revolution and farmers' mental health, with the following estimated equation:

$$y^* = \beta_0 + \beta_1 \text{Clean}_{\text{toilet}i} + \beta_2 X_i + \mu_i \quad (1)$$

$$y = \max(0, y^*) \quad (2)$$

When $y^* > 0$, $y = y^*$; others, $y = 0$. The explanatory variable y is mental health status (depression index), y^* is the observed value of mental health status, and the explanatory variable is the status of the toilet revolution. The random error term μ_i follows a normal distribution. The regression coefficient β_0 is a constant term, β_1 measures the impact of the toilet revolution on the mental health of farmers, and β_2 measures the effect of control variables on the mental health of farmers.

Table 1. Variable definitions and descriptive statistics results.

Variable Name	Meaning of Variables	Mean
Depression Index	Depression Index, (The higher the value from 0 to 100, the deeper the depression)	12.568
Clean toilet	The toilet revolution (1 = clean toilet; 0 = non-clean toilet)	0.898
Age	Age of interviewees (year)	61.572
Gender	Gender of interviewees	0.712
Education	Whether have a high school diploma or above (1 = yes; 0 = no)	0.146
Health	Household respondents' self-rated health (1 = healthy; 0 = no)	0.873
Job	Whether the household respondent is engaged in agricultural production (1 = yes; 0 = no)	0.701
Environmental perception	Whether the household respondent believes the village is polluted (1 = yes; 0 = no)	0.345
Household income	Interviewees' annual household income	11.313
Household burden	Annual Household Burden of Interviewees	39.904
Household education	Proportion of high school and above civilian employees in the household to total household size (%)	21.817
Cadre	Is a leader (1 = yes; 0 = no)	0.153
Farm asset	Assets on the farm	0.188
Smartphone	1 = use of smartphone; 0 = other	0.842
Internet use	1 = use of the Internet; 0 = other	0.450
Plain	1 = if the household is located on the plain; 0 = other	0.855
Distance	Distance from town	6.184
Variable name	Meaning of variables	Mean

The Tobit model, as a truncated-tailed regression model, is applicable to the data characteristics of this study. However, the reason for not choosing the OLS model and DID model is that these models do not fit well enough with the data in this study. For example, the OLS model is suitable for a stable linear relationship between the independent and dependent variables and the dependent variable is a continuous variable. However, the independent variable (explanatory variable) in this study is a binary variable.

3.3.2. Description of Model Endogeneity

This study notes that the status of the toilet revolution and the mental health of farmers may be causal, which can lead to endogeneity problems in the above model setting. Specifically, the toilet revolution may affect the mental health status of farmers, which is the area that this study focuses on. However, the state of the toilet revolution may also be influenced by the mental health of the farmers.

For example, a farmer with a mental disorder may need more care and attention from family, friends, and others. The cleaner the toilet, the closer people will be to the household and thus to the farmer with a mental disorder who needs care and attention. Further, to a certain extent, the farmer with a mental disorder can influence the behavior of others and thus contribute to the progress of the toilet revolution. Of course, another possibility exists: because OCD is one of the obvious symptoms of depression, depression and anxiety are the real causes of OCD [47]. Therefore, patients suffering from depression tend to be more compulsive and will have stricter requirements for their living environment, such as rubbish must be in the trash, and so on. Similarly, they will have a stronger desire to renovate unclean toilets as a way of promoting a toilet revolution.

In conclusion, either of the above scenarios implies that the toilet revolution is a self-selected behavior of the farmers rather than a random occurrence. This would lead to the inability of this study to properly infer the impact of the toilet revolution on the mental health of the farmers.

3.3.3. Selection of Tool Variables

To solve the endogeneity problem, this study proposes to introduce instrumental variables to the IV-Tobit model. The criteria require that the instrumental variables are correlated with the endogenous variables and uncorrelated with the explanatory variables. Existing studies chose the amount of investment in rural toilet conversion as an instrumental variable to explain the endogeneity problem, but no relevant data were available in the China Land Economic Survey and could not be used in this study. This study, therefore, uses another more commonly used instrumental variable, the proportion of behavioral occurrences of other people within the same village, by calculating the proportion of behavioral occurrences of other people within the same area. The behavior of others in the same village may influence the person's choice. For example, if people in the same village have renovated the exterior of their houses to make the whole village look neat and tidy, the person may also involuntarily choose to renovate the exterior of their house, either because they are influenced by the herd mentality or because they do not want their house to be out of harmony with the overall environment. Similarly, when the number of farmers who choose to build clean toilets increases throughout the village, it will lead to the rest of the people choosing to build clean toilets as well, that is, it will lead to a toilet revolution for others. The proportion of toilet construction occurring in the same area is not related to mental health and is an exogenous variable for mental health. Thus, the proportion of other people's behavior occurring in the same village was chosen as the instrumental variable for this study, which allows for good control of endogeneity issues.

4. Results

4.1. Tobit Empirical Results

Table 2 presents the estimated results of the impact of the toilet revolution on the level of depression of farmers. Since the level of depression among farmers is a multivariate discrete variable, models (1) to (6) in Table 2 are estimated using the IV-Tobit model. Further, considering that the IV-Tobit model is a non-linear model, model (7) is an estimate of the marginal effect based on model (6) for ease of interpretation of the estimation results. In addition, to maximize the accuracy of the estimation results, a stepwise variable addition strategy was used in this study. That is, based on model (1), model (2) to (6) progressively control for farm household characteristics, household characteristics, and village characteristics. As can be seen from Table 2, all models were significant at the 1% level of significance, which showed that this model was significant.

According to the estimation results in Table 2, the clean toilet variables in models (1) to (6) were all significant at the 1% level, indicating that the toilet revolution does reduce the level of psychological depression of farmers, which means that clean toilets help reduce the depression index of farmers. According to the estimation results of model (7), the depression index of farm households with clean toilets will decrease by 66.9% relative to households without clean toilets.

Current research scholars are more likely to conclude that rural latrine conversion has a significant positive impact on the health of rural residents. Cao [38], Liu and Liu [48], Chai and Liu [49], and Dong et al. [50] found that, by controlling the sources of infection and reducing the density of vector organisms, the rate of schistosomiasis infection and vector organism transmission will significantly reduce, which will, in turn, improve the health level. Consequently, the health level will lead to the improvement of the residents' mental outlook, which will, in turn, lead to the improvement of the appearance and mental health condition of the Chinese countryside, consistent with the theory of this study. However, this study considers that not only is the transmission of the virus blocked, but

the population will be healthier, lighter, and happier without illness. The improvement of the human environment can also improve the psychological well-being of farmers; when the environment is better, the mood is naturally better.

Based on this, this study hypothesizes that the reason for the difference in findings is mainly due to the following two aspects. Firstly, there are geographical limitations in the findings. This study focuses on rural areas, where the overall living environment is worse compared to urban areas, and the degree of influence of the human environment on the mental health of farming households is greater than that of urban areas. Hence, the difference in the mechanisms of influence of the toilet revolution on the mental health of farmers. Secondly, the focus of the study is different. Previous scholars have focused more on people's physical health, while mental health, or only "good mental outlook" is reflected in the article as a co-benefit. Whereas, this study focuses on the mental health of farmers, with more emphasis on the psychological aspect. That is, farmers with clean toilets will experience a 66.9% decrease in the depression index relative to households without clean toilets.

Table 2. Tobit empirical results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Clean toilet	−28.961 *** (−9.091)	−26.839 *** (−8.675)	−45.508 *** (−6.146)	−40.278 *** (−5.592)	−38.610 *** (−5.180)	−38.147 *** (−5.079)	−0.669 *** (−5.064)
Age				−0.083 *** (−2.933)	−0.064 ** (−1.996)	−0.063 ** (−1.972)	−0.001 ** (−1.974)
Gender				−3.989 *** (−6.006)	−3.651 *** (−5.536)	−3.636 *** (−5.520)	−0.064 *** (−5.550)
Education				−1.318 * (−1.669)	−0.141 (−0.152)	−0.144 (−0.156)	−0.003 (−0.156)
Health				−11.058 *** (−9.928)	−10.293 *** (−9.648)	−10.316 *** (−9.694)	−0.181 *** (−9.888)
Job				−0.702 (−1.134)	−0.873 (−1.400)	−0.873 (−1.403)	−0.015 (−1.403)
Environmental perception				2.810 *** (4.812)	2.708 *** (4.738)	2.679 *** (4.703)	0.047 *** (4.722)
Household income					−1.398 *** (−5.010)	−1.402 *** (−5.039)	−0.025 *** (−5.073)
Household burden					−0.041 *** (−3.572)	−0.041 *** (−3.588)	−0.001 *** (−3.595)
Household education					−0.008 (−0.532)	−0.008 (−0.541)	−0.000 (−0.541)
Cadre					−2.494 *** (−3.513)	−2.490 *** (−3.524)	−0.044 *** (−3.535)
Farm asset					0.402 (0.497)	0.488 (0.601)	0.009 (0.601)
Smartphone					0.946 (0.825)	0.922 (0.807)	0.016 (0.807)
Internet use					−0.598 (−0.857)	−0.614 (−0.881)	−0.011 (−0.881)
Plain						1.104 (0.942)	0.019 (0.942)
Distance						−0.040 (−0.741)	−0.001 (−0.741)
Constant	36.065 *** (12.358)	30.563 *** (10.691)	42.490 *** (7.138)	55.641 *** (8.827)	69.409 *** (11.923)	68.123 *** (11.219)	
Year dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
City Dummies	No	No	Yes	Yes	Yes	Yes	Yes
ll	−18,386.84	−18,290.34	−18,191.56	−17,927.71	−17,828.94	−17,827.45	−17,827.45
χ^2	54.773 ***	48.195 ***	29.960 ***	25.470 ***	22.631 ***	21.727 ***	21.727 ***
Obs.	5039	5039	5039	5039	5039	5039	5039

Note: *t* statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In addition, Ali et al. [34] and Paddy et al. [35] believe that the virus is transmitted by aerosols produced during flushing that come into contact with the human gut through the respiratory tract, causing illness. However, the difference between this study and the one in which schistosomes contaminate water sources is speculated to be due to the fact that China is still in the stage of the toilet revolution where flushing toilet waste treatment is still popular, and most of the unreformed rural areas are open defecation and cleaned up by emptying. Therefore, discussing the influencing factors, beyond the actual situation before flushing toilet waste treatment, is popular and is not in line with the actual situation in China, hence, the difference between the findings of this study and others.

4.2. Robustness Tests

The omission of variables may affect the estimation results [51]. To verify the robustness of the baseline regression results, this study replaced the IV-Tobit model with an IV-Probit model to test the estimates of the impact of the toilet revolution on the mental health of the farmers. The explanatory variables were also replaced and each of the eight questions indicating indicators of depression was used as explanatory variables for robustness testing, Table 3 presents the estimation results.

Table 3. Robustness tests.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Clean toilet	−2.091 *** (−6.574)	−1.637 *** (−4.446)	−0.861 ** (−1.976)	2.434 *** (6.767)	−1.337 *** (−3.290)	2.051 *** (3.855)	−1.871 *** (−5.234)	−0.701 (−1.048)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ll	−3640.34	−3691.58	−3985.70	−1619.74	−3411.62	−1439.48	−3284.62	−1870.34
χ^2	21.034 ***	12.840 ***	3.921 **	17.826 ***	8.143 ***	7.448 ***	15.374 ***	0.796
Obs.	5039	5039	5039	5039	5039	5039	5039	5039

Note: *t* statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The explanatory variables in models (1) to (8) were whether they felt low in mood, struggled to do anything, did not sleep well, felt happy, felt lonely, were happy in life, felt sad and upset, and felt life could not go on in the past week.

In model (1), the coefficient on clean toilets was negative and significant at the 1% level, suggesting that clean toilets help reduce the likelihood of farmers falling into depressed moods.

In model (2), the coefficient on clean toilets was negative and significant at the 1% level, suggesting that clean toilets help reduce the likelihood that farmers are struggling to do anything.

In model (3), the coefficient on clean toilets was negative and significant at the 5% level, indicating that clean toilets help to improve the likelihood of poor sleep.

In model (4), the coefficient on clean toilets was positive and significant at the 1% level, indicating that clean toilets contribute to the likelihood that the farmers feel pleasure.

In model (5), the coefficient on clean toilets was negative and significant at the 1% level, suggesting that clean toilets help to reduce the likelihood of falling into loneliness.

In model (6), the coefficient on clean toilets was positive and significant at the 1% level, suggesting that clean toilets help increase the likelihood of farmers feeling happy in their lives.

In model (7), the coefficient on clean toilets was negative and significant at the 1% level, suggesting that clean toilets help to reduce the likelihood of falling into sadness and grief.

In model (8), the coefficient on clean toilets was negative, indicating that clean toilets help to reduce the likelihood of falling into the emotion of being unable to continue in life.

Feeling low in mood in model (1) was more affected by a clean toilet than by a bad mood in the other models. Feeling happy in model (4) and feeling good about life in model (6) was more affected by a clean toilet.

In summary, clean toilets help to reduce the likelihood of farmers falling into depression. In other words, clean toilets help to improve the mental health of farmers, which also suggests that the estimates are robust.

5. Conclusions and Implications

Based on more than 5000 data from Jiangsu Province, China, this study introduced an instrumental variables approach to address endogeneity in the IV-Tobit model to test the impact of the toilet revolution on the psychological well-being of farm households and conducted a marginal effects analysis. The results showed that clean toilets had a positive impact on the mental health of farmers; farmers with clean toilets experienced a 66.9% decrease in the depression index relative to households without clean toilets. This corroborates the recommendation of this study to encourage rural areas to promote a toilet revolution to improve the mental health of farmers.

Mental disorders such as depression can have varying degrees of impact on individuals, families, and society. A low social climate is detrimental to the country's economic development, and depression is detrimental to family collaboration and personal development. Many studies show that people who have suffered from mental illness have a history of rejection at work, resulting in poor personal and family finances, or that the side effects of the illness, such as obesity, low self-esteem, extreme sensitivity, and other negative emotions that are detrimental to personal development, can lead to self-imposed isolation and a lack of communication with society over time. This study shows that clean toilets help to improve the mental health status of farmers, in that the depression index of farmers with clean toilets will decrease relative to households without clean toilets. Thus, the toilet revolution is a non-pharmacological and effective way to improve mental health problems, which will not only have an impact on the individual farmer but will also have a positive impact on the family atmosphere, economic situation, and neighborhood relations. A healthy mind reduces the amount of money people need to spend on mental health treatment, such as counseling costs and medication costs. At the same time, people with mental disorders lose an average of 10.52 additional years of working time [2], and a healthy mind can help people reduce the loss of work hours and thus have a better economic situation. Based on this, this study will make the following four recommendations to government departments to improve the promotion of the toilet revolution.

Firstly, the government has increased the publicity of the toilet revolution. Rural residents have less access to smartphones and the internet than urban residents, and their ability to access information is weaker due to the terrain and nature of their work. Therefore, they are relatively uninformed and have little understanding of the significance of the toilet revolution and the impact of toilet conversion on them. Great publicity helps to change farmers' stereotypes from a conceptual point of view, which helps to achieve smooth progress of the toilet revolution. This publicity includes but is not limited to, policy advocacy for the toilet revolution, the benefits of the toilet revolution, the significance of the toilet revolution to the farmers themselves, and the significance of the toilet revolution to the villages.

Secondly, the implementation of policy subsidies and the establishment of model households for the toilet revolution. Subsidies for latrine conversion are an important factor in encouraging the implementation of latrine conversion. The implementation of subsidies to households and people, and the elimination of the phenomenon of refusal or under-allocation of funds after conversion, will help to reduce the problem of decreased motivation to convert latrines due to the lack of implementation of policy subsidies. Thus, in addition to improving the distribution of subsidies for the toilet revolution, government departments can also set up relevant working groups to go to the grassroots level to listen to the opinions and questions of household toilet conversion and answer their questions

about subsidies and toilet conversion on time. In addition, a model household for toilet revolution can be set up, and the title of the model household for toilet revolution can be awarded every month to those households that meet the standards and maintain excellence after toilet conversion.

Thirdly, government departments assist farmers to choose a reasonable mode of toilet conversion and promote the toilet revolution. The Five-Year Action Plan for the Improvement and Upgrading of Rural Habitat (2021–2025) calls for water where appropriate and drought where appropriate. For farmers with little knowledge, they need concise, rather than vague, requirements from the government. Thus, it is recommended that the government selects a reasonable model of toilet conversion according to the actual situation in the region, specifies the specific objectives and standards of toilet reform, and provides farmers with precise and clear requirements for conversion. The requirements for conversion include, but are not limited to, the size of the toilet space, whether ventilation facilities such as windows are installed, whether to choose a flush type of toilet waste treatment or other standard waste treatment methods, and the requirement to achieve the simultaneous promotion of toilet waste treatment at the same time as the conversion. In addition, government departments can also introduce water-saving and waterless flushing facilities, which on the one hand will respond to the national call for water conservation, and on the other hand, will reduce farmers' concerns about not using flushing toilets because they are distressed by the water bill. This will greatly contribute to the popularity of clean toilets.

Fourthly, it is essential to address the issue of responsibility for implementation. Although toilets may seem small, they reflect significant aspects of people's livelihoods. The implementation of the toilet revolution should not be merely a slogan or a formal task assigned to government departments. Instead, it requires the active participation of every household. Unfortunately, there are instances in some areas where slogans are shouted without any practical work being performed, and formalism is prevalent at the grassroots level. Thus, to make progress with the toilet revolution practically, it is crucial to address these undesirable phenomena thoroughly. To ensure practical implementation, the government can use performance appraisal to assign each household to a specific staff member and implement a system of checking one household at a time. Additionally, an anonymous reporting channel can be established to encourage farmers to report the existence of problems and urgent issues boldly.

Author Contributions: Conceptualization, R.Z. and X.D.; methodology, X.D.; software, X.D.; formal analysis, R.Z.; investigation, D.X.; resources, D.X.; writing—original draft preparation, R.Z., J.Z., K.Z., D.X., Y.Q. and X.D.; writing—review and editing, R.Z. and X.D.; visualization, R.Z.; funding acquisition, D.X. and X.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Social Science Fund of China (Grant No. 22CJY046), the Institute of Chinese Liquor History, Sichuan, China (Grant No. ZGJS2023-03), and the National Training Program for Undergraduate Innovation, China (Grant No. 202310626049).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Dataset available on request from the authors.

Acknowledgments: We gratefully acknowledge financial support from the National Social Science Fund of China (Grant No. 22CJY046), the Institute of Chinese Liquor History, Sichuan, China (Grant No. ZGJS2023-03), and the National Training Program for Undergraduate Innovation, China (Grant No. 202310626049). The authors also extend great gratitude to the anonymous reviewers and editors for their helpful review and critical comments. Additionally, all authors are very grateful to the National Natural Science Foundation of China (Grant No. 71773052, Zhou Li at Nanjing Agricultural University) for providing the data.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Appendix A.1. Entropy Method

The entropy weight method is a method to determine the weight of indicators. The principle is to use the information entropy to calculate the entropy weight of each indicator according to the degree of variation of the value of each indicator, and then correct the weight of each indicator through the entropy weight. Compared with other subjective assignment methods, this method can make full use of the original data, avoid errors caused by human factors, and have higher credibility and accuracy.

The depression index in question in this study was then calculated by the entropy method, mainly as follows:

(1) Standardized data

Use as positive indicators whether you feel depressed, whether you find it hard to do anything, whether you feel you do not sleep well, whether you feel lonely, whether you feel sad and upset, whether you feel you can't go on with your life.

Positive indicators:

$$X'_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \quad (A1)$$

Negative indicators of whether or not you feel happy, and whether or not you feel happy with your life.

Negative indicators:

$$X'_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)} \quad (A2)$$

(2) Calculate the value of individual contribution to the total

$$Y_{ij} = \frac{x'_{ij}}{\sum_{i=1}^m x'_{ij}} \quad (A3)$$

(3) Calculate the entropy value

$$e_i = -\frac{\sum_{i=1}^m y_{ij} \ln y_{ij}}{\ln m} \quad (A4)$$

(4) Calculation of entropy weights

$$w_i = \frac{1 - e_i}{\sum 1 - e_i} \quad (A5)$$

(5) Calculation of scores

$$score_i = \sum_{i=1}^m w_i x'_{ij} \times 100 \quad (A6)$$

References

1. Ustün, T. The global burden of mental disorders. *Am. J. Public Health* **1999**, *89*, 1315–1318. [[CrossRef](#)] [[PubMed](#)]
2. Plana-Ripoll, O.; Weyer, N.; Knudsen, A.K.; Hakulinen, C.; Madsen, K.B.; Christensen, M.K.; Agerbo, E.; Laursen, T.M.; Nordentoft, M.; Timmermann, A. The association between mental disorders and subsequent years of working life: A Danish population-based cohort study. *Lancet Psychiatry* **2023**, *10*, 30–39. [[CrossRef](#)] [[PubMed](#)]
3. Harris, C.; Barraclough, B. Excess mortality of mental disorder. *Br. J. Psychiatry* **1998**, *173*, 11–53. [[CrossRef](#)]
4. Doran, C.M.; Kinchin, I. A review of the economic impact of mental illness. *Aust. Health Rev.* **2017**, *43*, 43–48. [[CrossRef](#)]
5. Hou, H.; Pei, Y.; Yu, B.; Gao, X.; Wang, W. Age-period-cohort modeling of suicide death trends in a rural Chinese population, 2004–2019. *Med. Health Sci.* **2022**, *26*, 34–39+111. [[CrossRef](#)]
6. Rutter, M. How the environment affects mental health. *Br. J. Psychiatry* **2005**, *186*, 4–6. [[CrossRef](#)]
7. Clark, C.; Myron, R.; Stansfeld, S.; Candy, B. A systematic review of the evidence on the effect of the built and physical environment on mental health. *J. Public Ment. Health* **2007**, *6*, 14–27. [[CrossRef](#)]
8. Evans, G.W. The built environment and mental health. *J. Urban Health* **2003**, *80*, 536–555. [[CrossRef](#)]

9. Eaton, W.W.; Martins, S.S.; Nestadt, G.; Bienvenu, O.J.; Clarke, D.; Alexandre, P. The burden of mental disorders. *Epidemiol. Rev.* **2008**, *30*, 1–14. [\[CrossRef\]](#)
10. Thornicroft, G. Most people with mental illness are not treated. *Lancet Psychiatry* **2007**, *370*, 807–808. [\[CrossRef\]](#)
11. Slyepchenko, A.; Maes, M.; Jacka, F.N.; Köhler, C.A.; Barichello, T.; McIntyre, R.S.; Berk, M.; Grande, I.; Foster, J.A.; Vieta, E. Gut microbiota, bacterial translocation, and interactions with diet: Pathophysiological links between major depressive disorder and non-communicable medical comorbidities. *Psychother. Psychosom.* **2017**, *86*, 31–46. [\[CrossRef\]](#)
12. Yang, J.; Zheng, P.; Li, Y.; Wu, J.; Tan, X.; Zhou, J.; Sun, Z.; Chen, X.; Zhang, G.; Zhang, H. Landscapes of bacterial and metabolic signatures and their interaction in major depressive disorders. *Sci. Adv.* **2020**, *6*, eaba8555. [\[CrossRef\]](#)
13. Phillips, D.R.; Siu, O.-L.; Yeh, A.G.; Cheng, K.H. The impacts of dwelling conditions on older persons' psychological well-being in Hong Kong: The mediating role of residential satisfaction. *Soc. Sci. Med.* **2005**, *60*, 2785–2797. [\[CrossRef\]](#)
14. Li, C.; Zhou, Y. Residential environment and depressive symptoms among Chinese middle-and old-aged adults: A longitudinal population-based study. *Health Place* **2020**, *66*, 102463. [\[CrossRef\]](#)
15. Cheng, S.; Li, Z.; Uddin, S.M.N.; Mang, H.-P.; Zhou, X.; Zhang, J.; Zheng, L.; Zhang, L. Toilet revolution in China. *J. Environ. Manag.* **2018**, *216*, 347–356. [\[CrossRef\]](#)
16. Prüss-Ustün, A.; Bartram, J.; Clasen, T.; Colford Jr, J.M.; Cumming, O.; Curtis, V.; Bonjour, S.; Dangour, A.D.; De France, J.; Fewtrell, L. Burden of disease from inadequate water, sanitation and hygiene in low-and middle-income settings: A retrospective analysis of data from 145 countries. *Trop. Med. Int. Health* **2014**, *19*, 894–905. [\[CrossRef\]](#)
17. Corrigan, P.W.; Druss, B.G.; Perlick, D.A. The impact of mental illness stigma on seeking and participating in mental health care. *Psychol. Sci. Public Interest.* **2014**, *15*, 37–70. [\[CrossRef\]](#)
18. Hayes, K.; Poland, B. Addressing mental health in a changing climate: Incorporating mental health indicators into climate change and health vulnerability and adaptation assessments. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1806. [\[CrossRef\]](#)
19. Makwana, N. Disaster and its impact on mental health: A narrative review. *J. Fam. Med. Prim. Care* **2019**, *8*, 3090. [\[CrossRef\]](#)
20. Wang, D.; Shen, Y. Sanitation and work time: Evidence from the toilet revolution in rural China. *World Dev.* **2022**, *158*, 105992. [\[CrossRef\]](#)
21. Liu, S.P. *Study on the Factors Influencing Farmers' Satisfaction with Rural Toilet Renovation in the Context of Rural Revitalization*; Yunnan University of Finance and Economics: Kunming, China, 2022.
22. Ao, X. *Study on the Impact of the "Toilet Revolution" on the Health of Rural Residents*; Jiangxi Agricultural University: Nanchang, China, 2022. [\[CrossRef\]](#)
23. Rose, C.; Parker, A.; Jefferson, B.; Cartmell, E. The characterization of feces and urine: A review of the literature to inform advanced treatment technology. *Crit. Rev. Environ. Sci. Technol.* **2015**, *45*, 1827–1879. [\[CrossRef\]](#)
24. Caruso, B.A.; Freeman, M.C. Shared sanitation and the spread of COVID-19: Risks and next steps. *Lancet Planet. Health* **2020**, *4*, e173. [\[CrossRef\]](#)
25. Phuc, P.-D.; Konradsen, F.; Phuong, P.; Cam, P.; Dalsgaard, A. Practice of using human excreta as fertilizer and implications for health in Nghean Province, Vietnam. *Southeast Asian J. Trop. Med. Public Health* **2006**, *37*, 222.
26. Eisendorfer, C.E.; Lawton, M. *The Psychology of Adult Development and Aging*; American Psychological Association: Washington, DC, USA, 1973.
27. Lawton, M.P. Environment and other determinants of well-being in older people. *Gerontologist* **1983**, *23*, 349–357. [\[CrossRef\]](#)
28. Magaziner, J.; Cadigan, D.A. Community resources and mental health of older women living alone. *J. Aging Health* **1989**, *1*, 35–49. [\[CrossRef\]](#)
29. Brown, V. The effects of poverty environments on elders' subjective well-being: A conceptual model. *Gerontologist* **1995**, *35*, 541–548. [\[CrossRef\]](#)
30. Brown, V.S. *The Elderly in Poor Urban Neighborhoods*; Routledge: London, UK, 2017.
31. Norling, M.; Stenzelius, K.; Ekman, N.; Wennick, A. High school students' experiences in school toilets or restrooms. *J. Sch. Nurs.* **2016**, *32*, 164–171. [\[CrossRef\]](#)
32. Ishida, Y.; Vyas, R.; Chauhan, G.; Delgado, L.; Kourai, H. Bacterial Contamination Analysis of Residential Toilet Room Environment and Delivery of Residual Bacterial Growth Prevention Efficacy on Residential Toilet Permeable Surfaces Using Toilet Air Freshener Product. *Biocontrol Sci.* **2021**, *26*, 85–93. [\[CrossRef\]](#)
33. Yang, J.; Yuan, C. Application of Cognitive System Model and Gestalt Psychology in Residential Healthy Environment Design. *Comput. Intell. Neurosci.* **2022**, *2022*, 5661221. [\[CrossRef\]](#)
34. Ali, W.; An, D.-Z.; Yang, Y.-F.; Cui, B.-B.; Ma, J.-X.; Zhu, H.; Li, M.; Ai, X.-J.; Yan, C. Comparing bioaerosol emission after flushing in squat and bidet toilets: Quantitative microbial risk assessment for defecation and hand washing postures. *Build. Environ.* **2022**, *221*, 109284. [\[CrossRef\]](#)
35. Paddy, E.N.; Afolabi, O.O.; Sohail, M. Toilet plume bioaerosols in healthcare and hospitality settings: A systematic review. *Am. J. Infect. Control.* **2022**, *51*, 324–333. [\[CrossRef\]](#)
36. Wang, Q.; Liu, L. On the critical role of human feces and public toilets in the transmission of COVID-19: Evidence from China. *Sustain. Cities Soc.* **2021**, *75*, 103350. [\[CrossRef\]](#)
37. Liang, H.S.; Zhang, Y.; Jiang, H.J. The impact of retrofitting sanitary toilets on the quality of rural sanitation in Tongbai County. *Henan J. Prev. Med.* **2002**.
38. Cao, J.G. Effectiveness and factors influencing the retrofitting of sanitary toilets in rural areas. *China Health Ind.* **2019**, *16*.

39. Zhou, Y.; Chen, G.; Ma, J.; Li, Y.; Cao, X.; Xu, Y.; Song, J.; Liu, X. Slippery concrete for sanitation. *Prog. Org. Coat.* **2022**, *171*, 107022. [\[CrossRef\]](#)
40. Akaishi, T.; Morino, K.; Maruyama, Y.; Ishibashi, S.; Takayama, S.; Abe, M.; Kanno, T.; Tadano, Y.; Ishii, T. Restoration of clean water supply and toilet hygiene reduces infectious diseases in post-disaster evacuation shelters: A multicenter observational study. *Heliyon* **2021**, *7*, e07044. [\[CrossRef\]](#)
41. Kiseleva, L.S.; Strielkowski, W. Perception of happiness by Russians. *Sotsiologicheskie Issled.* **2016**, 86–91.
42. Al-Butmeh, S.; Al-Khataib, N. Mental health and quality of life of elderly people in the Bethlehem district: A cross-sectional study. *Lancet Planet. Health* **2018**, *391*, S46. [\[CrossRef\]](#)
43. Feng, S.; Yang, Y.; Xia, N. Associations between healthy lifestyles and depressive symptoms among adults in China: A longitudinal study. *Lancet Planet. Health* **2018**, *392*, S59. [\[CrossRef\]](#)
44. Zeng, J.; Jian, W. Income-related inequality and its effect on depression prevalence in China: A longitudinal, population study. *Lancet* **2018**, *392*, S22. [\[CrossRef\]](#)
45. Chang, T.-Y.; Liao, S.-C.; Chang, C.-M.; Wu, C.-S.; Huang, W.-L.; Hwang, J.-J.; Hsu, C.-C. Barriers to depression care among middle-aged and older adults in Taiwan's universal healthcare system. *Lancet Reg. Health-West. Pac.* **2022**, *26*, 100501. [\[CrossRef\]](#)
46. Shields-Zeeman, L.; Smit, F. The impact of income on mental health. *Lancet Public Health* **2022**, *7*, e486–e487. [\[CrossRef\]](#)
47. Demal, U.; Lenz, G.; Mayrhofer, A.; Zapotoczky, H.-G.; Zitterl, W. Obsessive-compulsive disorder and depression. *Psychopathology* **1993**, *26*, 145–150. [\[CrossRef\]](#)
48. Liu, C.m.; Liu, Y. A study on the impact of rural toilet reform on farmers' health care expenditure. *Agric. Econ.* **2020**, *10*, 89–102. [\[CrossRef\]](#)
49. Chai, Z.Z.; Liu, Y.P. A study on the mechanism of the impact of rural latrine conversion on the health level of rural residents in the central and western regions. *J. Agron.* **2022**, *12*, 85–91.
50. Dong, J.; Yin, X.; Zhang, K.; Li, H. The "toilet revolution" and the health of rural minors: Micro-evidence and mechanisms of action. *Agric. Technol. Econ.* **2022**, 128–144. [\[CrossRef\]](#)
51. Wooldridge, J.M. *Introductory Econometrics: A Modern Approach*; Cengage Learning: Boston, MA, USA, 2015.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.