Content available at: https://www.ipinnovative.com/open-access-journals

IP Journal of Nutrition, Metabolism and Health Science

Journal homepage: https://www.jnmhs.com/

Original Research Article

Factors influencing sustainability of open defecation free (ODF) status in rural India: A cross sectional study

R K Mishra[1], Ch Lakshmi Kumari[1], P S Janaki Krishna[1,*], Maschendar Goud[1]

[1] *Dept. of Sustainable Development, Institute of Public Enterprise, Hyderabad, Telangana, India*

ARTICLE INFO

Article history:
Received 17-08-2021
Accepted 28-09-2021
Available online 28-10-2021

Keywords:
Sanitation
Open Defecation
Toilet
Technology
Water availability

ABSTRACT

Tackling a simple and sensitive concern of 'Open Defecation (OD)' is such a compounded and righteous challenge that enormous efforts and resources are needed to bring in the desired changes in the villages. Towards this, attaining open defecation free (ODF) status by providing toilet facilities to every household is the foremost step in rural sanitation programme under Swachh Bharat Mission – Gramin (SBM –G) being implemented by the Government of India. The present paper aims to examine the factors that have influence in attaining ODF status in rural areas. In this study, various parameters that contribute to attaining ODF status in the villages were identified and an extensive primary survey was conducted in 32,390 households across 686 rural villages in Krishna District of Andhra Pradesh, India. The empirical analysis of the data using a multinomial logistic regression model revealed that the factors such as water availability, safe excreta disposal, technology used for toilet construction and awareness on Swachh Bharat have an influence in achieving the open defecation free status in the villages to a greater extent.

1. Introduction

Sanitation has been considered as one of the prime indices in measuring the human development indices. Availability of better sanitation facilities has also been considered as one of the basic amenities in measuring economic growth. Out of total world population 2.4 billion people still do not have access to basic sanitation facilities and 900 million are openly defecating.

As part of a global health and development agenda by the year 2030, the proportion of people without sustainable access to sanitation has been falling far short of the Sustainable Development Goals (SDGs). The major deficit has been identified in sub-Saharan Africa and South Asia.[1]

Only 68 percent of the world's population have access to basic sanitation. In Sub-Saharan African and South Asia 70 percent and 53 percent of the population do not have basic sanitation facilities. Huge amount of expenditure is required in order to provide better sanitation facilities. To mention few countries, it is equivalent to 6.4 percent of GDP in India, 6.3 percent of GDP in Bangladesh, 7.2 percent of GDP in Cambodia, 2.4 percent of GDP in Niger, and 3.9 percent of GDP in Pakistan annually.

1.1. Open defecation: global scenario

In the present day global scenario removal of OD has occupied a prime place in developing countries. According to UNICEF and WHO[2] report compared to 1990 OD has declined by ten percentage points in 44 countries and by more than 20 percent points in 23 countries in 2015. Fifteen countries have reduced open defecation by more than 25 percent. Ethiopia achieved the largest decrease in the proportion of the population practicing open defecation (from 92 per cent in 1990 to 29 per cent in 2015), a reduction over five times greater than the regional average

* *Corresponding author.*
E-mail address: janaki@ipeindia.org (P. S. Janaki Krishna).

https://doi.org/10.18231/j.ijnmhs.2021.021

for the same period. In South Asia region, where the number of open defecators is highest, has also made noteworthy progress in decreasing OD. Bangladesh, Nepal and Pakistan have registered more than 30 percent points since 1990. Reduction of OD to 31 percent in India alone represents 394 million people, and ominously influenced regional and global estimates. All other regions recorded a reduction in open defecation in population terms between 1990 and 2015.

In 2012, Government of India has redesigned its rural sanitation program as 'Nirmal Bharat Abhiyan' (NBA) encompassing various activities towards eliminating the practice of Open Defecation in rural areas. It has come up with an innovative idea of Nirmal Gram Puraskar (Clean Village Prize) award to villages where all the households had access to toilet facilities and reach ODF status. Here, attaining ODF status has been largely correlated with the technological design, substructure component of the toilet based on updated World Health Organization (WHO) definitions of safe sanitation and past governmental efforts, the Government of India set out latrine guidelines and criteria under the Swachh Bharath Abhyan (SBA). Simple and low-cost toilets were recommended for rural setting under SBA (Gramin). In some parts of the villages, Government has been promoting improved sanitation facilities that include higher technology designs in toilet construction such as EcoSan model that separates urine and faecal matter. This model encourages clean sanitation because the human excreta can be used safely in agriculture. The urine could be used as fertilizer without treatment, while the faecal matter is decomposed by microorganisms prior to use. Wet Sanitation Technologies (flush and pour flush toilets connecting to sewers, septic tanks or pit latrines) and Dry Sanitation Technologies (ventilated improved pit latrines; pit latrines which slabs; or composting toilets) are commonly recommended for better sanitation facilities. Rural experiences with government latrine construction indicate that the government may benefit from additional options for simple superstructure design such as outer structure painting and embellishment, to help encourage usage once latrines are constructed and to combat perceptions of "poor quality".

The present study indicated that a large proportion of the rural population is aware of the importance of using toilets, implying that the key challenge is behavioral change to shift from awareness to practice. Under the given magnitude of OD, over the years wide-spread research has been carried out in various countries presenting the status of OD and the methods that are being adopted globally for improving sanitation as well.

Recent research work has been considered as influential on construction and usage of toilets; socio-cultural factors viz.,caste;[3] psychosocial stress;[4] gender norms,[5,6] habit of open defecation[7] and water governance issues. Barnard et al.[8] studied India's 'Total Sanitation Campaign' in their study and found that 47 percent of the toilets that are constructed under subsidized scheme are accessible. 33 percent of the toilets that are not having minimum facilities like roof, door, covered pit and water are in use. The study results show that the usage of toilets is no way related to their built and operations.

Many sanitation practitioners and researchers acknowledge that toilet interventions must move beyond building toilets, and instead focus on engaging the social and economic factors that would lead to toilet adoption. Scholars have highlighted that toilet adoption depends on technology used in toilet construction[9] people participation,[10] involvement of particular State Government in solving local problems associated with toilet adoption and understanding people's ideas and values around sanitation.[11–13] Rheinlander et al.[12] anchored the importance of understanding community perception towards sanitation, and accordingly suggested that new methods may be designed that are acceptable by the people. The work of Robinson[14] and Joshi et al.,[15] pointed out that people who are living in poor conditions are aware of good hygiene and sanitary conditions but they lack proper financial support and incentives to build or use toilet facilities. In another study it was observed that the major reasons for open defecation among households who have access to toilets is that they are used to age old practice with little or no stigma attached to it. OD is no way connected to their socio-economic status and family literacy rates.[16] Therefore the monitoring team from Government of India or third party may expand their focus from budget and toilet construction to effective usage.[17] Few researchers opine that the Program has been reduced to "a no-gain toilet construction scheme where India built millions of toilets, but people (did) not use them".[18] Population with access to toilets who actually use them require an insight into the determinants of use. Research into the successful adoption and sustained use of latrines has revealed a range of factors that may potentially influence use; with health considerations only play a minor role.

Further, Jenkins and Curtis[19] were of the view that toilet adoption may be motivated by a "prestige, well-being or situational drive" and that it may vary with gender, age, occupation, life-stage, travel experience, education, wealth the physical and social geography of the village environment with reference to the availability of good defecation sites around the home and/or village. Factors such as family size, privacy and safety for women and girls, peer influence, social cohesion, access to water, structural issues related to toilet construction may be the constraints for attaining sustained ODF.

The measurement of toilet usage at individual and household level has become a big challenge, though it is a robust indicator for estimating OD and for integration into

large-scale household survey.

The aim of this study is to assess the functional usage of toilets at household and village level, the technology used for their construction and the safe faecal disposal mechanisms that are in place in ODF declared villages of Krishna District.

2. Materials and Methods

2.1. Study context

The Government of Andhra Pradesh has extended financial support to the eligible Below Poverty Line (BPL), SC/ST, General and Backward community households in the districts of Andhra Pradesh for the construction of toilets. The study team has made an evaluation of the availability, accessibility and adaptability of toilets after construction across the villages in Andhra Pradesh. The Gram Panchayats that are selected have achieved almost 100 percent sanitation coverage.

2.2. Study design

The study team after interacting with the Chief Officials at SAC, (Swachh Andhra Corporation, Government of Andhra Pradesh) conducted interactive meetings with the Chief Officials and staff of the Department of Rural Water Supply and Sanitation (RWS&S) to draw upon the project inception plan. About 125 field investigators were trained in all aspects of ODF, including the collection of data through structured questionnaires furnished by SAC. A detailed questionnaire with separate schedules was used to physically verify the coverage of toilets at village, households, schools, anganwadis and public places.

2.3. Village and household selection

A cross-sectional study has been made among the identified villages. 686 villages in 47 mandals with a sample size of 32390 thousand were surveyed on access to functional toilets, toilet usage, water availability, etc. Villages were identified from ODF declared villages in the district. The sample size was selected as 10 percent of the total households in a village.

2.4. Variables used in the study

The study gathered data on the variables that are used to assess the ODF status among households and villages. The variables that are used are access to functional toilets, availability of water, model of the toilets ie; twin pit, single pit, eco-san toilets, depth of the pits, institutional mechanism to check OD spot in villages, disposal of faeces.

Quality of the toilets has also been evaluated basing on the parameters viz., distance between the twin pits, junction box, P-trap. The toilets are considered as functional if the households have toilet along with water availability. Safe disposal mechanism is being studied by verifying the disposal mechanism that is being followed i.e., into enclosed twin pits, single pits, closed drains, open pit, nallahs, The technology used in toilet construction has been assessed based on twin pit, single pit, eco-san, roof top, doors, flooring, water pipes. Schools and anganwadi toilets are assessed by interacting with the teachers and students on Swachh Bharat schemes.

2.5. Data analysis

The study has evaluated the status of ODF by using Multinomial Logistic Regression model. The qualitative data has been converted into quantitative one by assigning codes to the identified variables. Entire analyses was made using SPSS Version 22. In the present study the correlation between access to functional toilets and the other identified parameters viz., water availability, Human Excreta Disposal, Household Defecation, Child Open Defecation, Awareness on Swachh Bharat was analyzed with a multinomial logistic regression model.

2.5.1. Multinomial logistic regression

Multinomial logistic regression is used to predict the categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables. The independent variables can be either dichotomous (i.e., binary) or continuous (i.e., interval or ratio in scale). Multinomial logistic regression is a simple extension of binary logistic regression that allows for more than two categories of the dependent or outcome variable. Like binary logistic regression, multinomial logistic regression uses maximum likelihood estimation to evaluate the probability of categorical membership of independent variable[20]

Multinomial logistic regression is often considered as an attractive analysis because; it does not assume normality, linearity, or homoscedasticity. A more powerful alternative to multinomial logistic regression is discriminant function analysis which requires these assumptions are met. Indeed, multinomial logistic regression is used more frequently than discriminant function analysis because the analysis does not have such assumptions. Multinomial logistic regression does have assumptions, such as the assumption of independence among the dependent variable choices. This assumption states that the choice of or membership in one category is not related to the choice or membership of another category (i.e., the dependent variable). The assumption of independence can be tested with the Hausman-McFadden test. Furthermore, multinomial logistic regression also assumes non-perfect separation. If the groups of the outcome variable are perfectly separated by the predictor(s), then unrealistic coefficients will be estimated and effect sizes will be greatly exaggerated.

There are different parameter estimation techniques based on the inferential goals of multinomial logistic regression analysis. One might think of these as ways of applying multinomial logistic regression when strata or clusters are apparent in the data. Unconditional logistic regression[21,22] refers to the modelling of strata with the use of dummy variables (to express the strata) in a traditional logistic model. Here, one model is applied to all the cases and the data are included in the model in the form of separate dummy variables, each reflecting the membership of cases to a particular data. Conditional logistic regression[21] refers to applying the logistic model to each of the data individually. The coefficients of the predictors (of the logistic model) are conditionally modeled based on the membership of cases to a particular data.

Marginal logistic modeling[21] refers to an aggregation of the data so that the coefficients reflect the population values averaged across the data.

Further reading on multinomial logistic regression is limited. Several authors[23–25] provided discussions of binary logistic regression in the context of graduate level textbooks, which provides insight into a multinomial because it is a direct extension. However; other authors provide either direct examples of multinomial logistic regression,[20] or a full discussion of multinomial logistic regression,.[26–29]

While the regression analysis is used in social sciences when the number of dependent variable categories are two, multinomial logistic regression is employed when dependent variables involve three or more categories. This explains the correlation between the dependent variable and the independent variable when their values are obtained with rating scales[30]

In this study, the correlation between access to functional toilets and the study variables like open defecation, child defecation, water availability, safe excreta disposal techniques was analyzed with multinomial regression model by employing the data collected through primary questionnaire in Krishna District of Andhra Pradesh, India.

Multinomial logistic regression models were used for estimations where the dependent variable had more than two categories that are discrete, have nominal characteristics, and were not ordered; the dependent variable of which exhibit multinomial distribution, while there are constraints over independent variables.[28]

3. Materials and Methods

The variables that are used in the study like between Access to functional toilets and the study variables like open defecation, child defecation, water availability, safe excreta disposal techniques was analyzed with multinomial regression model by employing the data collected through a primary questionnaire in Krishna District of Andhra Pradesh, India. The questionnaire was addressed to 33,000 respondents at village level and mandal level of Krishna district. Six independent variables were examined using the chi-square test of independence, and after excluding a variable that was not significant, the subsequent analyses were conducted using the remaining variables. Using the maximum likelihood estimator of the model examined in the research, the odd ratios of the variables that compose the model were obtained. The validity of the model was tested with the likelihood ratio test. The data obtained from the study were analyzed with the aid of SPSS package software.

The nominal dependent variable of the study was access to functional toilets. Access to functional toilets was organized as follows: 1: households who have own functional toilets, 2: households who have shared toilets; and 3. households who use community toilets. The variables that are believed to have impact on access to a toilet facility depends on fly proof arrangements, open defecation, child defecation, water availability, safe excreta disposal techniques.

Table 1: The level of independent variables used in the study

Independent variables	Level of independent variables
1. Water availability	1. Yes, 2. No
2. Fly Proof Arragements	1. Yes 2. No
3. SafeExcreta Disposal Techniques	1. Drains/Nallahs 2. rivers/canals 3. open pit 4. enclosed single pit 5. enclosed twin pit 6. enclosed twin pit with p-trap
4. Household Open Defecation	1. Yes 2. No
5. Child Open Defecation	1. Yes 2. No
6. Awareness on Swachh Bharat	1. Yes 2.No

(Source: Study Questionnaire)

The multinomial logistic regression model in which dependent variables are more than two, discrete and non-ordered categories that have nominal properties, and exhibit multinomial distribution, is an expansion of the binomial logistic distribution for the category. A multinomial logistic regression with a dependent variable that has a single category must have "J-1" logistic regression model is expressed as given in Equation.[31] (Liao, 1994)

$$\pi_j = \frac{exp(\sum_{k=1}^{k} \beta j_k x_k)}{1+\sum_{j=1}^{J-1} \sum_{k=1}^{k} \beta_{jk} x_k} \qquad j=1,2\ldots J-1 \qquad \ldots\ldots\ldots(1)$$

It is possible to write this definition in equation 2 as well:

$$\pi_j = \frac{1}{1+\sum_{j=1}^{J-1} exp-(\sum_{k=1}^{k} \beta_{jk} x_k)} \qquad \ldots\ldots\ldots\ldots\ldots(2)$$

While the subscript k in. . . .coefficient in equation 2 denotes the dependent variable, the subscript j is used to denote the dependent variable category. The sum of probabilities of categories that belong to the dependent variable should

be "1" as in binary. For example, in a multinomial logistic regression in which the number of dependent variable categories (D) has 3 levels, the sum of probabilities of each category is equal 0 "1".

$$P(D=0|x)+P(D=1|x)+P(D=2|x)=1 \qquad .(3)$$

In models with dependent variables that have more than 2 categories, a baseline category should be determined in order to make comparisons or analyses. The baseline category (j) can be selected arbitrarily by the package software. For instance, the baseline category can be selected as 0 for a dependent variable that consists of 1 and 2, categories. Therefore, in the comparison, two different logistic models are obtained that comprise 1 and 2. Hence, for a model, the dependent variable of which has two categories, two likely hood ratios are calculated each category is compared with these ratios, the model is linearized by taking the natural logarithms of these ratios to obtain logistic models.

$$\pi_j = p\,(y=J) = \frac{1}{1+\sum_{j=1}^{J-1}\sum_{k=1}^{k}\beta_{jk}x_k} \qquad j=1,2\ldots J-1 \qquad \ldots\ldots\ldots(4)$$

Furthermore, the probability to lie within the baseline category can be computed with the help of other probabilities as given in equation 5, if the other probabilities are known. In multinomial logistic regression model, the logit transformation is obtained by taking the logarithms of the odds ratios after selecting the baseline category, the logarithms of odds ratios can be obtained as given in equation 6, equation 7 and equation 8.

As is seen the baseline category is taken as 'y=0' in all three odds ratios. The notation of the model can be generalized as in equation 9 with all these given.

$$\pi_j = P(y=J) = 1-\left[(P(y=1)+P(y=2)+\cdots+P(y=J-1)\right] \quad \ldots..(5)$$

$$ln\left[\frac{p(y=1(x_1)}{p(y=0(x_1)}\right] = \beta_1+\beta_{11}\chi_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

$$ln\left[\frac{p(y=1(x_2)}{p(y=0(x_1)}\right] = \beta_2+\beta_{21}\chi_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

$$ln\left[\frac{p(y=1(x_3)}{p(y=0(x_1)}\right] = \beta_3+\beta_{31}\chi_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$ln\left[\pi_j/\pi_J\right] = ln\left[\frac{p(y=j)}{p(y=J)}\right] = ln\left[\frac{exp\left(\sum_{k=1}^{K}\beta_{jk}\right)(x_k)}{\frac{1+\sum_{j=1}^{J-1}exp\left[\sum_{k=1}^{K}\beta_{jk}x_k\right]}{1+\sum_{j=1}^{J-1}exp\left[\sum_{k=1}^{K}\beta_{jk}x_k\right]}}\right]$$

$$ln\left[\pi_j/\pi_J\right] = ln\left[\frac{p(y=j)}{p(y=J)}\right] = ln\left[exp\left(\sum_{k=1}^{K}\beta_{jk}x_k\right)\right]$$

$$ln\left(\pi_j/\pi_J\right] = ln\left[\frac{p(y=j)}{p(y=J)}\right] = \left(\sum_{k=1}^{K}\beta_{jk}x_k\right) \quad \ldots\ldots(9)$$
$$j=1,\ldots..,J-1$$

4. Descriptive Statistics on The Identified Variables Considered in The Survey

4.1. Access to toilet facility

'Access to toilet facility' is defined in relation to the toilet that could be used by the majority of the household members, irrespective of whether it was being used or not. Under Swachh Bharat Mission it is mandatory that every household in the village should have an access to functional toilet avoiding open defecation. In the entire district 96.9 percent (31402 households) have access to own toilet facility and 1.2 percent (375 households) are using shared toilets. However, 75 households are still using public toilets.

4.2. Water availability

Lack of water for household uses (other than drinking) like washing utensils, bathing, etc., impedes total sanitation achievement. Though the households have access to toilets, they may not use it for a variety of reasons, the important reason being lack of water facility. In the context of use of toilets, availability of water is essential. Lack of adequate water in the toilets or in the vicinity of the toilets affects the usage of toilets. In the present study it is observed that water is the major constraint for effective usage of toilets. 83.1 percent (27185 households) have water facilities and 16.9 percent (5205 households) do not have water facilities which has hampered the usage of toilets

4.3. Fly proof arrangements

Proper fly proof arrangements are necessary for maintaining good hygienic conditions in and around the toilets. The study found that while constructing the toilets 30.4 percentage of house holds (9835 households) have functional water seal and 37.1 percent (12010 households) have other fly proof arrangements. It was further observed that 2.1 percent (667 households) have Eco-san toilets. However, 28.5 percent (9249 households) of the households do not have fly proof arrangements

4.4. Safe excreta disposal and technology used for construction of toilets

In the context of cleanliness another important aspect under ODF is safe excreta disposal. It is observed that various practices are being followed at village level in disposing of the faeces i.e., directly into nallahs, drains, open pit, ponds or rivers and septic tanks. In olden days direct disposal into pits, ponds or rivers has been followed. But in recent times with the growing importance of Swachh Bharat the Government has been focusing more on the technological aspect in toilet construction. The system of septic tanks with twin pit, single pit was followed at all places. In the present study while 66.6 percent (21578 households) have enclosed

twin pit technology for safe disposal of excreta, 22.5 percent (7276 households) have closed septic tank with soak pit and 4.1 percent (1338 households) have enclosed single pit. More than 5 percent of the households are still disposing the excreta into drains, nallahs, open pit and ponds .

4.5. Open defecation

It was found that 75 percent (513 villages) have no traces of open defecation. In the remaining 25 percent (173 villages) it was observed that people are defecating in the open places.

4.6. Management of household garbage

One of the important factors in ensuring cleanliness at the micro environment of the households is the garbage collection system. Garbage collection arrangement means the arrangement which usually exists to carry the refuse and waste of households to a final dumping place away from the residential areas. Information was collected regarding the garbage dumping within 10 feet perimeter of the house. It was observed that out of the total sample households 31.83 percent (10310 households) of the respondents said that the garbage is being dumped with in 10 feet perimeter of the house and the remaining 68.17 percent (22080 households) are not dumping the garbage within 10 feet perimeter of the house.

4.7. Availability and use of community / Public toilets

Information was collected from the villagers in sample villages on the availability of community toilets for defecation. Further probing was done on the use and cleaning of the community toilets. Out of 686 villages six villages were found to have community toilets. Most of the villages do not have community toilets.

5. Findings

In the study, the third category of the dependent variable "Community Toilets" was taken as baseline category, while the first category of the independent variables was taken as the baseline category and the results were interpreted accordingly. The validity of the multinomial logistic regression model was examined with the Odds Ratio Test, the model was found to be significant for $\chi 2 = 364.966$ and ($p<0.05$) values as shown in table 3. Therefore, the odds ratios of variable for each category varies.

The likelihood ratio test shows the contribution of each variable to model. Table 4 shows that the independent variables like water availability, open defecation, children open defecation and awareness on Swachh Bharat are significant independent variables relating to the access to functional toilets.

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

The effect of each independent variable on the dependent variable in the multinomial logistic regression model is different from each other for each category. While the effect of the independent variable in the logit that compares the first (Own toilets) and third levels (public toilets) of the dependent variable was denoted with β_1, the effect of the independent variable in the logit that compares second (shared toilets) and third (public toilets) level of the dependent variable was denoted with β_2. Here, the categories that include significant coefficients can be interpreted in terms of the how much they increase or decrease the odds ratios with respect to the third category, which was taken as the baseline category. The results of multinomial logistic regression analysis are given in tables 5&6.

5.1. Categorical comparison for public toilets vis-à-vis those having own toilets

1. **Water Availability (WA)**: This variable was significant among the factors that influenced access to own toilets. The probability of access to own toilets with respect to access to public toilets was 0.376 times lower.
2. **Fly proof arrangements (FP)**: The variable fly proof arrangements was significant among the independent variables. Fly proof arrangements in own toilets with respect to public toilets was 0.232 times lower.
3. **Human Excreta Disposal Technology (HED)**: This variable was significant and the safe excreta disposal techniques that are adopted in own toilets with respect to public toilets was 1.430 times higher.
4. **Human Open Defecation (HOD)**: This variable is also significant and its impact on having own toilets with respect to public toilets was 3.724 times higher.
5. **Child Open Defecation (COD)** : Child Open Defecation is highly significant that have impact on own toilet and it is 5.059 times higher than with public toilets.
6. **Awareness on Swachh Bharat (ASB)**: Awareness on Swachh Bharat is highly significant on access to own toilets and it is 0.311 times lower with respect to public toilets.

Table 2: Access to toilet facility

Indicators	**No of Respondents**	**Percentage**
Own Toilet	31402	96.9
Shared Toilet	375	1.2
Public Toilet	75	0.2
No Toilet	538	1.7
Total	32390	100
Water Availability		
Yes	27185	83.1
No	5205	16.9
Total	32390	100
Fly Proof Arrangements		
No Toilets	629	1.9
Functional Water Seal	9835	30.4
Other Fly Proof Arrangements	12010	37.1
Eco-San Toilets	667	2.1
No Fly proof arrangement	9249	28.5
Total	32390	100
Household excreta disposal		
No Toilets	552	1.7
Drain	447	1.4
Nallahs	562	1.7
Open Pit	333	1
Ponds or River	124	0.4
Closed Septic Tank with Soak Pit	7276	22.5
Enclosed Twin Pit	21578	66.6
Enclosed Single Pit	1338	4.1
Closed Drain	167	0.6
Biogas System	13	0
Total	32390	100
ODF	No of Respondents	Percentage
Yes	173	24.9
No	513	75.1
Total	686	100.0

(Source: Compiled from Primary Data Collected through Questionnaires)

Table 3: Model Fit Summary

Model	**Model Fitting Criteria** -2 Log Likelihood	**Likelihood Ratio Test**		
Intercept Only	942.510	Chi-Square	df	Sig
Final	577.544	364.966	12	.000

Table 4: Likelihood ratio test

Effect	**Model Fitting Criteria**	**Likelihood Ratio Test**		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig
Intercept	577.544	.000	0	.
WA	648.689	71.145	2	.000
FP	585.085	7.542	2	.023
HED	580.546	3.002	2	.223
HOD	648.687	71.143	2	.000
COD	695.329	117.785	2	.000
ASB	591.266	13.722	2	.001

Table 5: 5 Results of multinomial logistic regression model

AFa		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
1.00	Intercept	7.765	.659	138.664	1	.000			
	[WA=1.00]	-.979	.517	3.586	1	.058	.376	.136	1.035
	[WA=2.00]	0b	.	.	0	.	.	.	.
	[FP=1.00]	-.289	.242	1.430	1	.232	.749	.466	1.203
	[FP=2.00]	0b	.	.	0	.	.	.	.
	[HED=1.00]	.357	.272	1.733	1	.042	1.430	.840	2.434
	[HED=2.00]	0b	.	.	0	.	.	.	.
	[HOD=1.00]	1.315	.725	3.288	1	.070	3.724	.899	15.422
	[HOD=2.00]	0b	.	.	0	.	.	.	.
	[COD=1.00]	1.621	.726	4.986	1	.026	5.059	1.219	20.989
	[COD=2.00]	0b	.	.	0	.	.	.	.
	[ASB=1.00]	-1.170	.464	6.340	1	.012	.311	.125	.772
	[ASB=2.00]	0b	.	.	0	.	.	.	.

5.2. Categorical comparison for public toilets vis-à-vis those using shared toilets

1. **Water Availability (WA)**: This variable was significant among the factors that influenced access to own toilets. The probability of access to shared toilets with respect to access to public toilets was 0.132 times lower.
2. **Fly proof arrangements (FP)**: The variable fly proof arrangements was significant among the independent variables. Fly proof arrangements in shared toilets with respect to public toilets was 0.547 times lower.
3. **Human Excreta Disposal Technology (HEDT)**: This variable was significant and the safe excreta disposal techniques that are adopted in shared toilets with respect to public toilets was 1.617 times higher.
4. **Human Open Defecation (HOD)**: This variable is also significant and its impact on having shared toilets with respect to public toilets was 9.971 times higher.
5. **Child Open Defecation (COD)**: Child Open Defecation is highly significant that have impact on shared toilet and it is 18.200 times higher than with public toilets.
6. **Awareness on Swachh Bharat (ASB)**: Awareness on Swachh Bharat is highly significant on access to shared toilets and it is 0.233 times lower with respect to public toilets.

6. Conclusion

Krishna district is one of the most developed districts in Andhra Pradesh. The district is giving paramount importance to keep the district clean and safe as part of Swachh Bharat Mission (Gramin). In view of the growing number of households in the district there is an increasing demand for construction of individual household and community toilets. Consequently, focused attention on improving the rural sanitation in the district assumed greater importance. The combination of basic individual household toilet units with community sanitary complexes has substantially improved both provision and access to rural sanitation facilities.

The main purpose of this study was to analyze the relationship between access to toilet facilities and the variables that have impact, using multinomial logistic regression. It is believed that analyzing the usage of toilet facilities which is very important in the present day socio-economic scenario with a statistical perspective adds a different dimension to the current literature. The statistical results prove that there is a significant relationship between access to toilets and the variables viz.,water availability, fly proof arrangements, human excreta disposal techniques, human open defecation, child open defecation and awareness on Swachh Bharat. The categorical comparison of having own toilet with community public toilets proves that water availability is a major impacting factor in the usage of toilets. In some places where water availability is minimum people depend on public toilets and the fly proof arrangements are well constructed for public toilets compared to own and shared toilets. In case of human excreta disposal techniques, households have taken special care in constructing twin pits with p-trap and junction box technology. This is not so in case of public toilets. Child open defecation is highly significant with respect to own and shared toilets compared to public toilets keeping in view the safety the hygiene conditions of the children from 1-5 years of age.

The District Rural Water Supply and Sanitation (RWS&S) Department being responsible for rural sanitation in India is engaged in construction of toilets to make villages ‘Open Defecation Free’. Various Gram Panchayats having met the target of 100 percent toilets construction declared

Table 6: Results of multinomial logistic regression model

	Intercept	**3.833**	**.674**	**32.355**	**1**	**.000**			
	[WA=1.00]	-2.027	.531	14.581	1	.000	.132	.047	.373
	[WA=2.00]	0b	.	.	0	.	.	.	.
	[FP=1.00]	-.603	.274	4.842	1	.028	.547	.320	.936
	[FP=2.00]	0b	.	.	0	.	.	.	.
2.00	[HED=1.00]	.479	.294	2.663	1	.013	1.615	.908	2.870
	[HED=2.00]	0b	.	.	0	.	.	.	.
	[HOD=1.00]	2.300	.734	9.813	1	.002	9.971	2.365	42.037
	[HOD=2.00]	0b	.	.	0	.	.	.	.
	[COD=1.00]	2.901	.735	15.576	1	.000	18.200	4.308	76.883
	[COD=2.00]	0b	.	.	0	.	.	.	.
	[ASB=1.00]	-1.463	.482	9.197	1	.002	.232	.090	.596
	[ASB=2.00]	0b	.	.	0	.	.	.	.

a. The reference category is: 3.00.
b. This parameter is set to zero because it is redundant.

the villages as 'Open Defecation Free'. As part of ODF verification process the District and Mandal administration extended support to Institute of Public Enterprise (IPE) in providing the relevant data and effectively facilitated the field survey. However, the support at GP level may be strengthened for proper monitoring. Additional manpower may be appointed at GP level for effective implementation of ODF scheme.

7. Source of Funding

This work was supported by Swachh Andhra Corporation, Government of Andhra Pradesh, India. The funders had no role in the analysis, decision to publish or preparation of the manuscript.

8. Conflict of Interest

None.

Acknowledgments

The authors thank all the study participants who contributed to this study. We also thank the field team for supporting data collection, the rest of the team based at Institute of Public Enterprise, Hyderabad, India, for providing data entry, administrative and other logistic support.

References

1. Monitoring Achievement of the Health Related Millennium Development Goals; 2013. p. 1–6. Available from: https://apps.who.int/iris/bitstream/handle/10665/78916/A65_14-en.pdf?sequence=1&isAllowed=y.
2. Progress on Sanitation and Drinking Water-2015 update and MDG assessment; 2015. Available from: file:///C:/Users/ram/Downloads/Progress-on-Sanitation-and-Drinking-Water_234.pdf.
3. Routray P, Schmdt WP, Boisson S, Clasen T, Jenkins MW. Socio-cultural and behavioural factors constraining latrine adoption in rural coastal Odisha: An exploratory Qualitative study. *BMC Public Health*. 2015;15(1):880. doi:10.1186/s12889-015-2206-3.
4. Hirve S, Lele P, Sundaram N, Chavan U, Weiss M, Steinmann P. Psychosocial stress associated with sanitation practices: Experiences of women in a rural community in India. *J Water Sanitation Hyg Dev*. 2015;5(1):115–26. doi:10.2166/washdev.2014.110.
5. Khanna T, Das M. Why gender matters in the solution towards safe sanitation? Reflections from rural India. *Glob Public Health* . 2015;11(10):1185–1201. doi:10.1080/17441692.2015.1062905.
6. O'reilly K, Louis E. The toilet tripod: Understanding successful sanitation in rural India. *Health Place*. 2014;29:43–51. doi:10.1016/j.healthplace.2014.05.007.
7. Coffey D, Gandhi A, Hathi P, Khurana N, Spears D, Srivastav N. Revealed preference for open defecation: Evidence from a new survey in rural north India. *Econ Political Wkly*. 2014;49(38):43–55.
8. Barnard S, Routray P, Majorin F, Peletz R, Boisson S, Sinha A, et al. Impact of Indian total sanitation campaign on latrine coverage and use: A cross-sectional study in Orissa three years following programme implementation. *PLoS ONE*. 2013;8(8):71438. doi:10.1371/journal.pone.0071438.
9. Devine J. Introducing Sani FOAM: A Framework to Analyze Sanitation Behaviours to Design Effective Sanitation Programs. Water and Sanitation Program; 2009. Available from: https://www.wsp.org/sites/wsp/files/publications/GSP_sanifoam.pdf.
10. Kar K. Handbook on Community-led Total Sanitation; 2008. p. 1–99. Available from: https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/872/rc314.pdf?sequence=1&isAllowed=y.
11. Black M, Fawcett B. The last Taboo: Opening the Door on the Global Sanitation Crisis. *Earth Scan*. 2008;.
12. Rheinlander T, Samuelsen H, Dalsgaard A, Konradsen F. Hygiene and sanitation among ethnic minorities in Northern Vietnam: Does government promotion match community priorities? Soc. *Soc Sci Med* . 2010;71(5):994–1001. doi:10.1016/j.socscimed.2010.06.014.
13. Drangert J, Bahadar N. A Cultural-spatial analysis of excreting, recirculation of human excreta and health-the case of North West Frontier Province. *Health Place*. 2011;17(1):57–66. doi:10.1016/j.healthplace.2010.08.012.
14. Robinson A. Community-led total sanitation. . *DrTr Health Assoc J*. 2006;7:18–9.
15. Joshi D, Fawcett B, Mannan F. Health, hygiene and appropriate sanitation: experiences and perceptions of the urban poor. *Environ Urban*. 2011;23(1):91–111. doi:10.1177/0956247811398602.
16. Ghosh A, Cairncross S. The uneven progress of sanitation in India. *J Water Sanitation Hyg Dev*. 2014;4(1):15–22. doi:10.2166/washdev.2013.185.

17. Ganguly SC. India's national sanitation and hygiene programme: from experience to policy West Bengal and Maharashtra models provide keys to success; 2008. Available from: https://www.semanticscholar.org/paper/India-%27-s-national-sanitation-and-hygiene-programme.
18. Gupta J, Bera A, and SJ. India's Sanitation Programme: Mission possible, Down to Earth. *Soc Environ Commun*. 2014;6(31):30–7.
19. Jenkins MW, Curtis V. Achieving the 'good life': Why some people want latrines in rural benin. *Soc Sci Med*. 2005;61(11):2446–59. doi:10.1016/j.socscimed.2005.04.036.
20. Schwab JA. Multinomial logistic regression: Basic relationships and complete problems www; 2002. Available from: www.utexas.edu/courses/schwab/sw388r7/SolvingProblems/.
21. Breslow NE, Day NE. Statistical Methods in Cancer Research; 1980. p. 1–11. Available from: http://www.med.mcgill.ca/epidemiology/hanley/bios602/b-d-II-ch-1-2-3/Breslow-Day-vol-II-ch-0.pdf.
22. Vittinghoff E, Shiboski SC, Glidden DV, Mcculloch CE. Regression Methods in Biostatistics; 2005. p. 488. Available from: https://www.springer.com/gp/book/9781461413523.
23. Garson GD. Logistic Regression. *from Statnotes: Topics in Multivariate Analysis*. 2011;.
24. Mertler C, &vannatta R. Advanced and multivariate statistical methods. vol. 6th; 2002. p. 390. Available from: 10.4324/9781315266978.
25. Pedhazur EJ. Multiple regression in behavioral research : explanation and prediction; 1997. p. 1058.
26. Aldrich JH, Nelson FD. Linear probability, logit, and probit models; 1984. doi:10.4135/9781412984744.
27. Fox J. Linear Statistical Models and Related Methods, with Applications to Social Research. *Br J Soc Psychol*. 1984;38(1):124–5. doi:10.1111/j.2044-8317.1985.tb00823.x.
28. Hosmer DW, Lemeshow S. Introduction to the logistic regression model in applied regression; 2000. p. 479–500. doi:10.1002/9781118548387.
29. Menard S. Applied logistic regression analysis. vol. 106; 1995. p. 128.
30. Washington S, Karlaftis M, Mannering F. Statistical and econometric models for transportation data analysis; 2003. p. 496.
31. Liao TF. Interpreting probability models. Logit, Probit and other generalized linear models. Quantitative Applications in the Social Sciences. vol. 101. Sage Publications; 1994. p. 96.

Author biography

R K Mishra, Senior Professor

Ch Lakshmi Kumari, Associate Professor

P S Janaki Krishna, Professor

Maschendar Goud, Research Associate

Cite this article: Mishra RK, Ch Lakshmi Kumari, Janaki Krishna PS, Goud M. Factors influencing sustainability of open defecation free (ODF) status in rural India: A cross sectional study. *IP J Nutr Metab Health Sci* 2021;4(3):111-120.