Asian Journal of Agricultural Extension, Economics & Sociology

40(9): 398-410, 2022; Article no.AJAEES.88045
ISSN: 2320-7027

Determinants of Adapted Improved Sanitation in Rural and Urban of Bangladesh and Pakistan

Mahmuda Akter [a], Maruf Khan [b*], Tahrima Haque Beg [c] and M. Mizanur Rahman Sarker [b]

[a] *Graduate School of Economics, Rissho University, Tokyo, Japan.*
[b] *Department of Agricultural Statistics, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.*
[c] *Department of Management and Finance, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2022/v40i931020

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88045

Short Research Article

Received 07 April 2022
Accepted 14 June 2022
Published 30 June 2022

ABSTRACT

This study focuses on the socioeconomic and demographic determinants of improved sanitation adaptation in South Asia, mainly in Bangladesh and Pakistan. For the purpose of mass population study, cross-sectional datasets were obtained for both Bangladesh and Pakistan. The survey is based on a two-stage stratified sample of households. This study hypothesized the status of sanitation into three categorically distributed dependent variables which are “improved sanitation facility”, “unimproved sanitation facility” and “no sanitation facility”. According to the World Health Organization, these variables are supported to categorize the situation of sanitation by the Joint Monitoring Program categorization of toilet facilities. The “improved sanitation facilities” includes Flush or pour flushed toilets connected to sewers, Flush or pour flushed toilets or latrines connected to pits or septic tanks, and ventilated improved pit (VIP) latrines, Pit latrines with slab, Composting toilets including twin-pit latrines and container-based systems. The “unimproved sanitation facilities” includes Pit latrines without slab, Bucket latrines and Hanging latrines. And the “no facility” category includes open defecation (bush/field/desert/road/beach etc.). Wealth Index of the household, Gender of head of the household, marital status of the respondent, Education of household head, Locality of the household, and Province/ division are the categorical explanatory variables used in

**Corresponding author: E-mail: mrs_bd@yahoo.com, marufkhan527@gmail.com, marufkhan74@gmail.com;*

this study; family size of the household and age of the head of the household are two numerical explanatory variables that are taken as important demographic factors. Two candidate models were constructed for predicting no facility, unimproved sanitation, and improved sanitation respectively. In the sample, only 1.26% of households of Bangladesh do not have any toilet facility while Pakistan has 10.1% households without any toilet facility. The indicators, all three component models, and two data sets demonstrate agreement in the analysis. There is no discernible upward trend in model performance year after year. All of the comparison results show that the ordinal logistic model outperforms the multinomial regression model. According to the AIC, BIC, and log probability statistics, the highest education of family members is a more relevant element in a household's avoiding status in Pakistan. The indicators, all three component models, and two data sets demonstrate agreement in the analysis. There is no discernible upward trend in model performance year after year. All of the comparison results show that the ordinal logistic model outperforms the multinomial regression model.

Keywords: Bangladesh; Pakistan; adaptation; sanitation; ordinal logistic regression; multinomial logistic regression.

1. INTRODUCTION

In this century of SDGs, sanitation has key importance to attain sustainability in every other aspect of human health and productivity. Sanitation primarily relates to public health issues such as safe drinking water and the treatment and disposal of human excreta and sewage; avoiding human contact with excrement is an important element of sanitation. Water and sanitation are critical for local development, especially in areas like health, agriculture, social and economic growth, education, and the environment [1]. Underdeveloped and developing countries are still susceptible in the sense of sanitation where challenges and barriers come in the case of improved sanitation facilities adaptation. In this regard, Bangladesh has made appraisable progress in the past few decades. After the liberation war in 1971, the country was held open to be attacked by water contaminated diseases due to inadequate knowledge about sanitation in the general people. The nation fought back against contaminating diseases and their epidemics by being educated about the importance of sanitation and applying good sanitation practices in daily life. Though Bangladesh had been recovering excellently from its savage situation of sanitation, the anomaly still remains after five long decades from the country's birth. What are the reasons for not adopting good sanitation in life of the people of Bangladesh? Well the answer depends on the socioeconomic and demographic factors of the person and the household. As it is a matter of concern, studies should be conducted to investigate the situation and formulating efficient policies that help people to adopt the sanitation facilities are crying needs of the time being. The goals of this study are to: 1) establish if socioeconomic and demographic factors impact the adoption of better sanitation facilities; and 2) determine whether socioeconomic and demographic factors influence the adoption of improved sanitation facilities; and 3) to compare the sanitation situation of Bangladesh and Pakistan.

1.1 Background and Motivation

Over 82 percent of the world's population has access to a latrine or toilet that fits the World Health Organization/UNICEF definition of a 'basic' sanitation system [2]. Bangladesh has made significant progress in terms of sanitation. In Bangladesh, 92.7 percent of the population uses on-site containment systems such as pit latrines [3], while almost 99 percent of the population has access to some sort of latrine or toilet [2]. Open defecation has decreased from 18 percent in 2000 to 1 percent in 2015 (according to JMP), and most city dwellers have access to some sort of latrine, but the key issue is what happens to human waste when such facilities are used. As of 2018, the country had nearly ended open defecation. The significant accomplishments of improving sanitation are largely attributed to the leadership of the GoB and initiatives such as Community-Led Total Sanitation, which was developed and launched in Bangladesh in the early 2000s [4]. According to a GoB Circular from 2007, Union-level WATSAN committees are responsible for a range of WASH activities including supporting and participating in DPHE activities for awareness-raising, coordinating the activities of different stakeholders in the WASH sector, implementing WASH projects, and participating in data collection activities for WASH sector [5]. Slum residents in Bangladesh are underserved in metropolitan areas. In the country's slums, only 13% of households have access to their own sanitary facilities [6]. A single sanitary facility is frequently shared by ten or more homes [6]. In comparison to private restrooms, shared restrooms are thought to be more unsanitary. As a result, compared to children in other metropolitan areas, children in urban slums are more likely to be stunted [6]. According to the World Health Organization [7], strong WASH measures, as well as correct waste disposal methods, can help minimize COVID-19 transmission at the community level. During any infectious disease outbreak, like the COVID-19 [8-10], adequate WASH practices are critical to preserve human health. During the pandemic, it has been observed that the amount of household and infectious medical waste has increased in numerous countries, including Bangladesh [11-12]. Slum populations are growing in tandem with the urban population, with the United Nations estimating that 10 million people live in slums in Bangladesh [13]. Since 1990, the population of the country has had a 20% increase in water access and a 29% increase in sanitation access [6]. According to estimates, 87 percent of the population consumes upgraded water and 63 percent uses improved sanitary facilities. Despite tremendous progress in terms of access to improved water sources, the majority of the population continues to live in situations with inadequate WASH, which has negative health consequences, with the country recording over 76 million diarrhea bouts each year [14]. In rural areas, only about 3% of families had access to piped water in 2017 [15]. In addition, 41.7 percent of people's water sources are polluted with fecal bacteria, with 61 percent affected by the time it is eaten [16].

"In Pakistan, 53,000 Pakistani children under five die annually from diarrhea due to poor water and sanitation [17]. Children suffering from repeated episodes of diarrhea likely to fall behind in school or drop out altogether. Furthermore, it can also cause stunting that currently affects almost 44 percent of children in Pakistan. While there has been a considerable improvement in the statistics over the last decade, 13 per cent of Pakistan's population -- 22 million people -- still practice open defecation; only 60% have access to basic hygiene facilities" [17]. In Pakistan, 41 million people live in poverty due to a lack of decent toilet facilities. The shortage of toilets, according to the United Nations International Emergency Children's Fund (UNICEF), forces people to conduct open defecation, which can transmit diseases among communities. Pakistan is the world's third-largest country with open defecation. UNICEF is collaborating with the government to assist in the construction of toilet facilities for communities in need, with the goal of improving sanitation in Pakistan. These facilities are especially crucial for protecting girls from assault, which occurs frequently during open defecation. The World Bank [6] suggests that the focus be shifted from boosting sanitation access to enhancing the quality and safety of WASH infrastructure and human waste management. Even in villages with better water and sanitation, inadequate water safety, cleanliness, and poorly sited and constructed pit latrines, as well as poor drainage, can contribute to drinking water pollution and waterborne infections, as evidenced by two case studies from KP [18]. Drinking water is rarely treated; for example, in Punjab, 93.8 percent of households do not employ any type of water treatment. According to a new World Bank assessment [6], Pakistan's terrible state of water supply and sanitation is posing substantial health risks to the whole population, with young children being particularly vulnerable.

2. METHODOLOGY

2.1 Area of Study

Bangladesh and Pakistan, two countries in South Asia, are the focus of this research.

Barishal, Chattogram, Dhaka, Mymensingh, Khulna, Rajshahi, Rangpur, and Sylhet are the eight administrative divisions of Bangladesh. These divisions allow the country to be divided into rural and urban areas as a whole.

Pakistan is divided into four provinces: Punjab, Sindh, KPK, and Balochistan; two regions: Azad Jammu and Kashmir (AJK) and Gilgit Baltistan (GB); Islamabad Capital Territory (ICT); and former Federally Administered Tribal Areas (FATA).

2.2 Data Source

The socioeconomic and demographic variables of enhanced sanitation adaptation in South Asia, specifically Bangladesh and Pakistan, are the focus of this research. We used cross-sectional data from the most recent version of the USAID

DHS program's Demographic and Health Survey in Bangladesh and Pakistan.

The 2017-18 BDHS sample is nationally representative and includes everyone who lives in non-institutional dwelling units across the country. As a sampling frame, the survey used the Bangladesh Bureau of Statistics' (BBS) list of enumeration areas (EAs) from the People's Republic of Bangladesh's 2011 Population and Housing Census (BBS 2011).

The complete list of enumeration blocks (EBs) prepared for the Pakistan Population and Housing Census 2017, which was conducted from March to May 2017, was utilized as the sample frame for the 2017-18 PDHS. The Pakistan Bureau of Statistics (PBS) aided in the survey's sample design and collaborated closely with NIPS. The population of Pakistan is represented in the 2017-18 PDHS, which includes Azad Jammu and Kashmir (AJK) and the erstwhile Federally Administered Tribal Areas (FATA), which were not included in the 2012-13 PDHS. The 2017-18 PDHS findings are representative at the national level, as well as for urban and rural areas separately. The survey results are also representative of the four provinces of Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan; two regions, comprising AJK and Gilgit Baltistan (GB); the Islamabad Capital Territory (ICT); and the Federally Administered Tribal Areas (FATA). There are a total of 13 second-level survey domains.

2.3 Sample Design

According to the BDHS 2017-18, the survey's primary sample unit (PSU) is an EA with an average of 120 households. A two-stage stratified sample of households was used for the survey. In the first step, 675 EAs were chosen, with 250 EAs in urban regions and 425 in rural areas, with likelihood proportional to EA size. The sample was drawn by BBS in the first stage, according to the parameters provided by the DHS team. To provide a sampling frame for the second-stage selection of households, a comprehensive household listing operation was carried out in all selected EAs. A systematic sample of 30 families per EA was chosen in the second step of sampling to produce statistically credible estimates of key demographic and health characteristics for the country as a whole, for urban and rural areas separately, and for each of the eight divisions. A total of 20,250 residential families were chosen in accordance with this plan. About 20,100 ever-married women aged 15–49 were expected to complete the interviews. In addition, all ever-married women age 50 and older, never-married women age 18 and older, and all men age 18 and older were weighed and their height measured in a subsample of one-fourth of the homes (about 7–8 houses per EA). All adult men and women aged 18 and older were tested for blood pressure and blood glucose in the same houses.

A stratified two-stage sample design was used in the 2017-18 PDHS. Each of the eight regions was divided into urban and rural areas to accomplish stratification. There were 16 sampling strata in total. A two-stage selection technique was used to choose samples independently in each stratum. At each of the lower administrative levels, implicit stratification and proportional allocation were achieved by sorting the sampling frame within each sampling stratum prior to sample selection, according to administrative units at various levels, and using a probability-proportional-to-size selection at the first stage of sampling. The first step was to choose sample locations (clusters) made up of EBs. The number of households residing in an EB at the time of the census was used to draw EBs with a probability proportional to their size. There were a total of 580 clusters chosen. The second stage involved household sampling in a methodical manner. In each of the chosen clusters, a set number of 28 households was chosen using an equal probability systematic selection approach, giving a total sample size of about 16,240 households. The households were chosen in a centralized manner at the NIPS data processing office. Only the pre-selected households were questioned by the survey teams. At the implementation stage, no replacements or alterations to the pre-selected households were allowed to avoid bias. The sample was not self-weighting due to non-proportional sample allocation. Weighting factors have been calculated, added to the data file, and used to ensure that the results are representative at the national level for Pakistan (including FATA and ICT Islamabad), as well as for Azad Jammu & Kashmir and Gilgit Baltistan individually. All ever-married women aged 15 to 49 were included in the 2017-18 PDHS. Those who were either permanent residents or guests who stayed in the selected residences the night before the survey were eligible to participate. All ever-married men aged 15 to 49 in these families were included in the men's survey, which was completed in one-third of the sample houses. The survey was completed in 561 clusters after 19 clusters were dropped owing to security concerns during the fieldwork. Balochistan (1), FATA (2), Gilgit Baltistan (6), Khyber Pakhtunkhwa (4), Azad Jammu and Kashmir (1), Punjab (2), Sindh (1), and ICT Islamabad (1) were among the clusters (2 restricted areas).

2.4 Definition of Variables

2.4.1 Dependent variable

This study hypothesized the status of sanitation into three categorically distributed dependent variables which are “improved sanitation facility”, “unimproved sanitation facility” and “no sanitation facility”. According to the WHO, these variables are supported to categorize the situation of sanitation by Joint Monitoring Program categorization of toilet facilities. Flush or pour flushed toilets or latrines connected to sewers, flush or pour flushed toilets or latrines connected to pits or septic tanks, ventilated improved pit (VIP) latrines, Pit latrines with slab, Composting toilets including twin-pit latrines, and container-based systems are among the "improved sanitation facilities." Pit latrines without slabs, Bucket latrines, and Hanging latrines are among the "unimproved sanitation facilities." Open defecation (bush/field/desert/road/beach, etc.) is included in the "no facility" category.

2.4.2 Explanatory variables

i) **Wealth Index of the household:** “The economic situation in the RDHS was assessed using the wealth index. The index was established based on asset holding by the household (such as land, radio, television, car, etc.) and housing features (energy used, the number of rooms, water source and toilet type). The wealth index was made applying principal components analysis, which is a complex quantity of the snowballing living condition of a family; this places independent families on a constant range of related wealth” [19].

ii) **Family size of the household:** The total number of members of the household is counted. In the case of having guest, the guest is counted if s/he was living in that household from the day before the interview was conducted.

iii) **Gender of head of the household:** Gender of head of the household was counted by male=1 and female=2.

iv) **Marital status of the respondent:** Civil status of the householder is expressed in never in union=1, married=2, living with partner=3, divorced/separated=4, widower=5.

v) **Education of household head:** Education of head of the household is categorized into no education=1, incomplete primary=2, complete primary=3, incomplete secondary=4, complete secondary=5, higher education=6.

vi) **Locality of the household:** Locality or regional residence of the household is in either urban=1 or in rural=0.

vii) **Province/ division:** Bangladesh is divided into 8 geographical divisions and these divisions are exclusively categorized into Barisal=1, Chittagong=2, Dhaka=3, Khulna=4, Mymensing=5, Rajshahi=6, Rangpur=7, Sylhet=8.

Provinces of Pakistan are categorized into Punjab=1, Sindh=2, KPK=3, Balochistan=4, GB=5, ICT=6, AJK=7, FATA=8.

2.5 Model Specification

The relationship between an ordered multilevel dependent variable and independent variables is modeled using ordinal logistic regression. The dependent variable's values have a natural order or ranking in the modeling. When response categories are ordered, the event being modeled not only has an outcome in a specific category but also keeps information about the answer categories that are ordered in an ordinal logistic regression model. Ordinal logistic regression models, also called proportional odds models since they use proportional odds, have the following general form:

$$\ln\left(\frac{\gamma_i^{(j)}}{1-\gamma_i^{(j)}}\right) = \ln\left(\frac{P\left(Y_i \le j \middle| \mathrm{x}_1, \mathrm{x}_2 \dots\dots, \mathrm{x}_\mathrm{p}\right)}{1-P\left(Y_i \le j \middle| \mathrm{x}_1, \mathrm{x}_2 \dots\dots, \mathrm{x}_\mathrm{p}\right)}\right)$$

$$= \tau_j - \left(\beta_1 x_1 + \beta_2 x_2 + \cdots\cdots + \beta_p x_p\right)$$

where Y is response variable with k ordered categories;
j= 1,2,...,k-1;

$\gamma_i^{(j)}$ is cumulative probability $P(Y_i \leq j) = P(Y_i = 1) + P(Y_i = 2) + \cdots + P(Y_i = j)$ for j=1,2,...,k-1. Note $\gamma_i^{(k)}$=P(Y≤k)=1, so it should not be modeled;
Y_i is dependent observations which are statistically independent i=1,2,...,n;
$x_1, x_2, \ldots\ldots, x_p$ are p explanatory variables;
$\beta_1, \beta_2, \ldots\ldots\ldots, \beta_p$ correspond to the regression coefficients for the respective independent variables;
τ_j is the cut-off points between categories.

An ordinal variable is a categorical and ordered variable, such as the sanitary level of respondents depending on toilet facilities. An underlying score is calculated as a linear function of the independent variables and a set of cutoff levels in order logit. The probability of seeing an outcome refers to the likelihood that the estimated linear function, plus random error, falls within the range of the estimated threshold level. The multinomial logistic regression model was also utilized to see if explanatory variables including wealth index, gender, education, civil status, family size, regional homes (rural and urban), and province were linked to access to improved sanitation services.

Based on the socioeconomic and demographic factors used, the likelihood of a specific sanitation status from "better," "unimproved," and "no facility" sanitation is fitted in the above models. Explanatory variables are divided into sub-categories, such as dichotomous and nominal categories.
Multinomial logit models ignore ordered response categories and do not take proportional odds into account. Running k-1 independent binary logistic regression models for k potential outcomes, with one result, say k, chosen as a baseline category and the other k-1 outcomes regressed independently against the reference outcome. The following equation follows the generic form:

$$\ln\left(\frac{P(Y_i=j)}{P(Y_i=k)}\right) = \beta_j x_i; \text{ where } j= 1, 2, 3, \ldots.., k\text{-}1$$

Any response variable category can be chosen as the baseline or reference category, and the model will fit equally well, reaching the same likelihood and providing the same fitted values; the only difference will be the values and interpretation of the parameters. Schaffer is a well-known figure in the (2006). In our case, we used a category with a global significance, hence we chose the category of (0-no sanitation facility). This means that the comparison will be made with homes that did not have upgraded sanitary facilities in the 2017-18 fiscal year.

2.6 Model Evaluation and Comparison Methods

To compare models, I consider the Akaike`s Information Criterion (AIC) [20] and the Bayesian Information Criterion (BIC) [21] based on the ML method. AIC, a penalized log likelihood criterion is defined by

$$\text{AIC} = -2\,\ell + 2K$$

Where ℓ is the log likelihood and k is the number of parameters.

$$\text{SC} = -2\,\ell + K \ln(n)$$

Even though ordinal regression takes care of the ordinal relationship between levels of the dependent variable, it is restricted by the proportional odds assumption (Salman and Salem, 2012). The proportionate odds hypothesis states that is unaffected by j. In other words, between different levels of the dependent variable, the impacts of independent variables, s, are constant. The proportional odds assumption can be verified using a likelihood ratio score test to see if changing the effects of independent variables improves model fitness significantly [16]. There are still various possibilities if the proportional chances assumption is not met, such as employing the partial proportional odds model [20]. Because of the huge sample size and continuous latent response, our models meet the proportionate odds assumption. With its relationship to the concept of a continuous latent response, the proportional odds cumulative-logit model works effectively.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics of Bangladesh and Pakistan according to BDHS 2017-18 and PKHS 2017-18

Table 1 displays descriptive statistics for the study sample, including the frequency, percentage, cumulative percentage, and valid percentage of dependent and independent nominal and continuous variables from the BDHS 2017-18 and PKHS 2017-18 data sets.

Table 1. Descriptive statistics of BDHS2017-18 and PKHS 2017-18

Variables		Frequency		Percent		Valid Percent		Cumulative Percent	
		BD	PK	BD	PK	BD	PK	BD	PK
Sanitation facility	Improved	12250	11842	62.96	81.44	62.96	81.44	62.96	81.44
	Unimproved	6961	1230	35.78	8.46	35.78	8.46	98.04	89.9
	No facility	246	1467	1.26	10.1	1.26	10.1	100	100
	Total	19457	14540	100	100	100	100		
Wealth Index of the household	Poorest	4077	2837	21	19.5	21	19.5	21	19.5
	Poorer	3839	3104	19.7	21.3	19.7	21.3	40.7	40.9
	Middle	3641	2815	18.7	19.4	18.7	19.4	59.4	60.2
	Richer	3798	2720	19.5	18.7	19.5	18.7	78.9	78.9
	Richest	4102	3064	21.1	21.1	21.1	21.1	100	100
	Total	19457	14540	100	100	100	100		
Gender of head of the household	Male	16464	12858	84.6	88.4	84.6	88.4	84.6	88.4
	Female	2993	1682	15.4	11.6	15.4	11.6	100	100
	Total	19457	14540	100	100	100	100		
Marital status of the respondent	Never married	307	342	1.6	2.4	1.6	2.4	1.6	2.4
	Married	17626	12902	90.6	88.7	90.6	88.7	92.2	91.1
	Widowed	1260	1197	6.5	8.2	6.5	8.2	98.6	99.3
	Divorced	263	98	1.4	0.7	1.4	0.7	100	100
	Total	19456	14539	100	100	100	100		
Education of household head	No education	5417	5689	27.8	39.1	27.8	39.1	27.8	39.1
	Incomplete primary	4176	758	21.5	5.2	21.5	5.2	49.3	44.3
	Complete primary	2139	1354	11	9.3	11	9.3	60.3	53.7
	Incomplete secondary	4189	1965	21.5	13.5	21.5	13.5	81.8	67.2
	Complete secondary	819	1992	4.2	13.7	4.2	13.7	86	80.9
	Higher	2701	2778	13.9	19.1	13.9	19.1	99.9	100
	Don't know	16	1	0.1	0	0.1	0	100	100
	Total	19457	14537	100	100	100	100		
Division	Barisal	2053	3444	10.6	23.7	10.6	23.7	10.6	23.7
	Chittagong	2644	2687	13.6	18.5	13.6	18.5	24.1	42.2
	Dhaka	2912	2087	15	14.4	15	14.4	39.1	56.5
	Khulna	2517	1524	12.9	10.5	12.9	10.5	52	67
	Mymensingh	2217	974	11.4	6.7	11.4	6.7	63.4	73.7
	Rajshahi	2563	1295	13.2	8.9	13.2	8.9	76.6	82.6
	Rangpur	2467	1697	12.7	11.7	12.7	11.7	89.3	94.3
	Sylhet	2084	832	10.7	5.7	10.7	5.7	100	100
	Total	19457	14540	100	100	100	100		
Locality of the household	Urban	7103	7272	36.5	50	36.5	50	36.5	50
	Rural	12354	7268	63.5	50	63.5	50	100	100
	Total	19457	14540	100	100	100	100		

In the sample, only 1.26% households of Bangladesh do not have any toilet facility while Pakistan has 10.1% households without any toilet facility.

3.2 Development and Evaluation of Ordered Logistic Regression Model

An ordinal logistic regression model is built by explicitly enumerating all relevant explanatory variables and then selecting the "best" fitted model based on model selection. For the purpose of comparison, the same data and model selection processes are used to select a multiple linear regression model. For both regression models, in-sample fitness and external validation will be undertaken in this study, and the indicators outlined in the previous sections will be utilized to assess model quality.

Table 2. Ordinal logistic regression parameters with BDHS 2017-18 and PKHS 2017-18 data

Bangladesh	Estimate	Pakistan	Estimate
[SANITATIONBD = .00]	-2.126*** (0.166)	[SANITATIONPK = .00]	-1.873*** 0.185
[SANITATIONBD = 1.00]	2.084*** (0.157)	[SANITATIO_PK = 1.00]	-1.141*** (0.184)
FAMILY_SIZE	0.014 (0.009)	FAMILY_SIZE	-0.022*** 0.006
AGE_HEAD	0.009*** (0.001)	AGE	0.014*** 0.002
Poorest	0[a]	Poorest	0[a]
Poorer	0.719*** (0.047)	Poorer	-0.362*** 0.07
Middle	1.618*** (0.052)	Middle	-0.487*** (0.076)
Richer	2.204*** (0.059)	Richer	-0.277** 0.085
Richest	2.396*** (0.069)	Richest	-0.129 0.095
No Education	0[a]	No Education	0[a]
Incomplete Primary	0.239*** (0.045)	Incomplete Primary	-0.067 0.101
Complete Primary	0.396*** (0.058)	Complete Primary	-0.122 0.079
Incomplete Secondary	0.482*** (0.050)	Incomplete Secondary	-0.188** 0.07
Complete Secondary	0.554** (0.096)	Complete Secondary	-0.031 0.074
Higher	1.031** (0.072)	Higher	-0.068 0.073
Don’t Know	0.587 (0.554)	Don’t Know	16.511*** (0.00)
Unmarried	0[a]	Unmarried	0[a]
Married	0.047 (0.157)	Married	-0.024 (0.145)
Widowed	0.27** (0.132)	Widowed	-0.07 (0.167)

Bangladesh	Estimate	Pakistan	Estimate
Divorced/ Separated	0.006 (0.194)	Divorced/ Separated	0.252 (0.322)
Male	0[a]	Male	0[a]
Female	0.122** (0.057)	Female	-0.004 (0.078)
Barisal	0[a]	Punjab	0[a]
Chittagong	0.002 (0.068)	Sindh	0.209** (0.067)
Dhaka	-0.503*** (0.067)	KPK	-0.07 (0.066)
Khulna	0.432*** (0.071)	Balochistan	0.125 (0.079)
Mymensingh	-0.187** (0.068)	GB	0.504*** (0.101)
Rajshahi	0.233** (0.068)	ICT	0.955*** (0.104)
Rangpur	0.141** (0.067)	AJK	1.682*** (0.116)
Sylhet	-0.072 (0.071)	FATA	-0.432*** (0.088)
Urban	0[a]	Urban	0[a]
Rural	0.406*** (0.041)	Rural	-0.145** (0.052)

*Standard error in the parentheses. Asterisks ** and *** indicate statistical significance at the 5% and 1% levels, respectively*

The different measures of sanitation status are regressed for explanatory variables in which added in order of demographic factors and traditional SES. There are strong associations between age, gender, household size, and wealth index and sanitation status of respondents, which controls for demographic factors in Bangladesh and Pakistan.

3.3 Development and Evaluation of Multinomial Logistic Regression Model

The various sanitation status metrics are regressed for explanatory variables, which are then added in order of demographic components and traditional SES. For both Bangladesh and Pakistan, there are high correlations between age, gender, household size, wealth index, and sanitation status of respondents, even when demographic characteristics are controlled for.

3.4 Model Comparison Statistics with BDHS 2017-18 and PKHS 2017-18 Data

Using BDHS 2017-18 and PKHS 2017-18 data, two candidate models for predicting no facility, unimproved sanitation, and improved sanitation were created. To demonstrate model performance, the models were first validated and compared with previously introduced metrics in Table 4 using an in-sample validation method.

Table 3. Multinomial logistic regression parameters with BDHS 2017-18 and PKHS 2017-18 data

Bangladesh	Estimate	Pakistan	Estimate
[SANITATIONBD = .00]	28.55733 *** (0.930)	[SANITATIONPK = .00]	0.057*** (0.925)
[SANITATIONBD = 1.00]	29.92547 *** (0.926)	[SANITATIO_PK = 1.00]	11.61777*** (0.982)
FAMILY_SIZE	0.014 (0.00)	FAMILY_SIZE	.044*** (0.000)
AGE_HEAD	0.009*** (0.600)	AGE	0.003*** (0.245)
Poorest	0^a	Poorest	0^a
Poorer	0.719*** (0.942)	Poorer	-.158*** (0.100)
Middle	1.618*** (0.946)	Middle	-.399*** (0.000)
Richer	2.204*** (0.947)	Richer	-.163** (0.133)
Richest	2.396*** (0.995)	Richest	.503 (0.00)
No Education	0^a	No Education	0^a
Incomplete Primary	0.239*** (0.961)	Incomplete Primary	0.374 (0.536)
Complete Primary	0.396*** (0.962)	Complete Primary	-.378 (0.657)
Incomplete Secondary	0.482*** (0.962)	Incomplete Secondary	-.279** (0.341)
Complete Secondary	0.554** (0.096)	Complete Secondary	-0.031 (0.580)
Higher	1.031** (0.995)	Higher	-.341 (0.575)
Don't Know	0.587 (0.554)	Don't Know	16.511*** (0.00)
Unmarried	0^a	Unmarried	0^a
Married	0.047 (0.609)	Married	-.832 (0.095)
Widowed	0.27** (0.627)	Widowed	-.737 (0.114)
Divorced/ Separated	0.006 (0.403)	Divorced/ Separated	-.746 (0.117)
Male	0^a	Male	0^a
Female	0.122** (0.062)	Female	-0.004 (0.078)

Bangladesh	Estimate	Pakistan	Estimate
Barisal	0[a]	Punjab	0[a]
Chittagong	0.002 (0.297)	Sindh	0.209*** (0.067)
Dhaka	-0.503*** (0.604)	KPK	1.027*** (0.000)
Khulna	0.432*** (0.356)	Balochistan	0.420*** (0.000)
Mymensingh	-0.187** (0.251)	GB	0.603*** (0.000)
Rajshahi	0.233** (0.041)	ICT	0.839*** (0.000)
Rangpur	0.141** (0.004)	AJK	1.459*** (0.000)
Sylhet	-0.072 (0.000)	FATA	2.911*** (0.000)
Urban	0[a]	Urban	0[a]
Rural	0.406*** (0.000)	Rural	0.250*** (0.000)

Table 4. Model comparison statistics with BDHS 2017-18 data

Model Statistic	Multinomial logistic regression model			Ordered logistic regression model		
	Improved	Unimproved	No facilities	Improved	Unimproved	No facilities
Sample size	12250	6961	246	12250	6961	246
Sum of absolute residuals	1,656	1,906	2,380	1,433	1,494	2991
Sum of residual squares	2,446	2,722	4,090	1,933	1,986	2,200
Bias	1.087	1.090	1.128	1.026	1.023	3,580
Accuracy	1.117	1.112	1.180	1.103	1.081	1.078
AIC	25188.152			25188.152		
BIC	25203.904			25203.904		
LL	25184.152			25184.152		

Table 5. Model comparison statistics with PKHS 2017-18 data

Model Statistic	Multinomial Logistic Regression Model			Ordered Logistic Regression Model		
	Improved	Unimproved	No facilities	Improved	Unimproved	No facilities
Sample size						
Sum of absolute residuals	1568	1832	2316	1360	1480	2207
Sum of residual squares	2328	2642	4072	1830	1950	3677
Bias	1.096	1.099	1.147	1.023	1.022	1.097
Accuracy	1.126	1.119	1.202	1.099	1.081	1.2
AIC	16407.804			16407.804		
BIC	16422.972			16422.972		
LL	15610.669			15610.669		

The AIC, BIC, log likelihood statistics suggest that the highest education of the family members is more influential factor for averting status of a household in Bangladesh.

The AIC, BIC, log likelihood statistics suggest that the highest education of the family members is more influential factor for averting status of a household in Pakistan.

The analysis shows agreement among all indicators, for all three component models, and for two data sets. There is no clear trend for model performance improvement by year. All the comparison results indicate the clear improvement of the ordinal logistic model over the multinomial regression model.

Ordinal logistic models will not predict out-of-range estimations which are not controlled by multinomial regression model.

4. CONCLUSION AND RECOMMENDATION

In this study, an ordinal logistic regression model for predicting sanitation status in Bangladesh and Pakistan is proposed and demonstrated. The model is preferred because of its capacity to manage the ordinal character of sanitation component ratings, as well as the regression analysis' explanatory strength and accuracy in prediction. Both ordinal logistic regression and multinomial regression models were used to predict three major sanitation component scores in this study. When element-level data becomes accessible, the multinomial logistic model described in this study can be easily used. In addition to evaluating model performance, all eight evaluation criteria were subjected to in-sample and external validation examination. Finally, it is determined that the ordinal logistic regression method is a better approach than the multiple linear regression method for forecasting sanitation status. It has the inherent advantage of always making meaningful predictions and its predictions are closer to the observations. This study has been done by using secondary data, we did not consider the neighborhood effect to adapt the improved sanitation.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ACKNOWLEDGEMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors acknowledge the DHS program conducted by USAID for the cross-sectional data of the Demographic and Health Survey in Bangladesh and Pakistan.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sarker MMR, Yamashita H. A spatial panel modeling of water and sanitation insecurity and policy implications in South Asia: an evidence from Bangladesh. In Y. N., Araral E. and K. E. Seetha Ram, eds. Water Insecurity and Sanitation in Asia; 2019. Available:https://www.adb.org/sites/default/files/publication/544131/adbi-water-insecurity-and-sanitation-asia.pdf#page=214. Asian Development Bank Institute, Tokyo. pp. 199-220.
2. WHO/UNICEF. Progress on Household Drinking Water, Sanitation and Hygiene 2000–2017." New York. 2019. Available:https://www.who.int/water_sanitation_health/publications/jmp-2019-full-report.pdf?ua=1.
3. WHO/UNICEF. 2017. Bangladesh-Population Using Sewer, Septic and Latrines; (2017). Available:https://washdata.org/data/household#!/dashboard.
4. Centre for Research and Information (CRI) (2017) Water and Sanitation in Bangladesh: A Clean Future. Available: http://cri.org.bd/publication/water-&-sanitation-16/#p=1.
5. Local Government Division (LGD). Institutional and Regulatory Framework for Faecal Sludge Management (IRF-FSM)—City Corporations. Ministry of Local Government, Rural Development and Cooperatives, Bangladesh; 2017. Available:https://itn.buet.ac.bd/web/resource/institutional-and-regulatory-framework-for-faecal-sludge-management-fsm-city-corporations/ (accessed on 8 March 2021).

6. World Bank. Precarious Progress: A Diagnostic of Water Supply, Sanitation, Hygiene, and Poverty in Bangladesh. WASH Poverty Diagnostic, Washington DC; 2018.
7. World Health Organization Guidelines on sanitation and health. Geneva; 2020. Available:http://apps.who.int/iris/bitstream/handle/10665/274939/9789241514705-eng.pdf?ua=1
8. Chand Sudham, et al. COVID-19-associated critical illness—report of the first 300 patients admitted to intensive care units at a New York City Medical Center. Journal of Intensive Care Medicine. 2020;35.10:963-970.
9. Das, Manob, Arijit Das, Ashis Mandal. Examining the impact of lockdown (due to COVID-19) on Domestic Violence (DV): An evidences from India. Asian Journal of Psychiatry. 2020;54:102335.
10. Islam, SK Shaheenur, et al. Bovine tuberculosis prevalence and risk factors in selected districts of Bangladesh. PloS One. 2020;15.11:e0241717.
11. Rume, Tanjena, SM Didar-Ul Islam. Environmental effects of COVID-19 pandemic and potential strategies of sustainability. Heliyon. 2020;6.9:e04965.
12. Rahman, Md Arafatur, et al. Data-driven dynamic clustering framework for mitigating the adverse economic impact of COVID-19 lockdown practices. Sustainable Cities and Society. 2020;62:102372.
13. United Nations. Sustainable Development Goal 8: Promote Sustained, Inclusive and Sustainable Economic Growth, Full and Productive Employment and Decent Work for all; 2020. Available:https://sustainabledevelopment.un.org/sdg8.
14. Zohura, Fatema, et al. Effect of a water, sanitation and hygiene program on handwashing with soap among household members of diarrhoea patients in healthcare facilities in Bangladesh: A cluster-randomised controlled trial of the CHoBI7 mobile health program. Tropical Medicine & International Health. 2020;25.8:1008-1015.
15. World Bank. Health, Safety and Dignity of Sanitation Workers: An Initial Assessment. Washington DC: World Bank; 2020. DOI:10.1596/32640.
16. WHO/UNICF JMP Bangladesh Sanitation Data. Data; 2018. Available:http://washdata.org.
17. Wash O, et al. Middle East respiratory syndrome coronavirus (MERS-CoV); 2020.
18. Nawab, Bahadar, Kjell B. Esser, Shams Ali Baig. Impact of pit latrines on drinking water contaminations in Khyber Pakhtunkhwa, Pakistan. Environmental Forensics. 2017;18.4:296-306.
19. Sintondji, Luc O, et al. Socio-demographic characteristics of households as determinants of access to water, hygiene and sanitation in So-Ava, Benin. Journal of Environmental Science and Public Health. 2017;1.4:253-267.
20. Akaike, Hirotugu. A new look at the statistical model identification. IEEE Transactions on Automatic Control. 1974;19.6:716-723.
21. Schwartz, Alan, Louis L. Wilde. Intervening in markets on the basis of imperfect information: A legal and economic analysis. U. Pa. L. Rev. 1978;127:630.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/88045