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Identification of Problems Associated with Open Defecation and Its Related Solutions: A Case Study of South-West Nigeria

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Abstract

Background: Open defecation, a persistent sanitation challenge in South-West Nigeria, drives health, environmental, and economic burdens. Despite interventions, structural, economic, and cultural barriers endure, necessitating evidence-based solutions to achieve Sustainable Development Goal 6 (SDG 6).

Methods: This quantitative study surveyed 500 respondents across Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti using stratified random sampling to balance urban (30.2%), semi-urban (36.4%), and rural (33.4%) representation. Structured questionnaires assessed prevalence, determinants, and impacts of open defecation. Factor analysis (KMO = 0.78) and regression models, adhering to STROBE guidelines, identified key predictors.

Results: Prevalence varies, with Ekiti highest (21.2% frequent) and Lagos lowest (4.3%). Key determinants include lack of toilet access ($\beta = 0.52$, $p < 0.001$), high construction costs ($\beta = 0.41$, $p < 0.001$), weak sanitation law enforcement ($\beta = 0.47$, $p = 0.002$), and cultural practices ($\beta = 0.34$, $p = 0.012$). Health impacts include cholera (19.0%), dysentery (17.2%), and diarrhoea (15.6%); economic losses involve healthcare costs (26.0%) and reduced agricultural productivity (25.8%). Most respondents (53.0%) oppose paying for public toilets, with 41.3% favouring government subsidies.

Conclusion: Open defecation's multifaceted drivers demand integrated solutions: enhanced infrastructure, subsidies, culturally sensitive education, and robust policy enforcement. While these align with SDG 6, their success hinges on overcoming governance challenges, underscoring the need for sustained, community-driven efforts to ensure sanitation access.

Keywords: Open defecation, sanitation infrastructure, public health, economic impact, policy enforcement

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Introduction

The practice of open defecation keeps persisting in Nigeria as a main sanitation challenge, which produces wide-ranging public health consequences and environmental effects and social economic consequences. Throughout various governmental and non-governmental intervention efforts, the practice continues to exist because people dispose of their waste products outside in fields, bushes, water bodies and streets.[1] The United Nations Children's Fund (UNICEF) reports Nigeria among the leading countries in open defecation practice, affecting more than 47 million Nigerians in 2023.[2] The ongoing challenge of open defecation affects rural and peri-urban areas the most since these locations have insufficient sanitation infrastructure and live with strong cultural resistance to toilet use and weak sanctions against sanitation policy violations.[3]

Open defecation within Nigeria's South-West region remains widespread, thereby developing major public health problems alongside water pollution risks. The practices of poor sanitation and open defecation directly lead to the transmission of waterborne diseases, including cholera and diarrhoea, together with typhoid fever and dysentery.[4] Human waste disposed of directly or indirectly into rivers and streams causes water sources contamination, which leads to high rates of health issues and death, especially among children younger than five years.[5] Antimicrobial resistance (AMR) worsens in places practicing open defecation because the bacterial resistance spreads more rapidly throughout the surroundings.[2] Healthcare systems experience more pressure from open defecation practices and face a sustained challenge to effective public health operations. The practice of open defecation results in a combination of major environmental harm together with its effects on human health. Human waste that is thrown without care into open areas leads to soil contamination and groundwater contamination and produces harmful air quality in regions where waste collects through population density.[9] Economic productivity declines when communities suffer from poor sanitation because they obtain diminished agricultural harvests and struggling local markets and reduced tourism activity.[10] It has been estimated by the World Bank (2021) that Nigeria faces annual losses exceeding $3 billion because of its poor sanitary conditions mainly because of open defecation practices. Open defecation results in three main cost implications including medical expenses, earlier mortality rates and lost work hours caused by sanitation-induced sicknesses.

Two main initiatives led by the Nigerian government and named Open Defecation-Free (ODF) Roadmap and community-led total sanitation (CLTS) have shown limited progress according to[6] The current interventions using awareness creation fail to tackle fundamental barriers for toilet access such as construction expenses and government support and poor enforcement of sanitary laws.[7] The practice of open defecation remains influenced by cultural standards and customary beliefs among citizens mostly living in rural areas.[8] The fight against open defecation demands multiple intervention levels which surpass the scope of teaching programs through complete infrastructure support and proper policy enforcement measures.

Despite its different level of urban development South-West Nigeria contains many underserved areas that experience major sanitation issues (Sanusi et al., 2022). The states of Ekiti Osun and Ondo along with their peri-urban and rural regions encounter open defecation problems because their residents lack proper toilet facilities coupled with unstable water supply and inadequate garbage disposal systems.[3] Growing population rates in this region have pushed existing waste disposal and hygiene facilities beyond their capacity thus creating challenges for local governments to fulfil this demand.[9]

This study investigates the prevalence, determinants, and impacts of open defecation in South-West Nigeria, aiming to propose effective solutions. Specifically, it examines the extent of open defecation, identifies socio-economic and cultural factors contributing to its persistence, and assesses its health and environmental consequences. The research addresses the following questions: What are the socio-economic and cultural drivers of open defecation in the region? How does it affect public health and the environment? What interventions can effectively reduce its prevalence? Through a quantitative approach, the study evaluates toilet accessibility, economic constraints, cultural practices, and policy enforcement to develop policy-driven and community-based recommendations, contributing to achieving Sustainable Development Goal 6 for universal sanitation access by 2030.

Literature Review

Various socio-economic aspects together with cultural elements and existing infrastructure determine the complexity of eliminating open defecation in both

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Nigeria and across the African continent. Different intervention tactics create two distinct groups within the research community regarding environmental sanitation improvements between mandatory policy enforcement advocates and social behavioural change advocates. The analysis reviews essential scholarly perspectives regarding open defecation elimination by discussing both unified and disputed aspects of academic discussions.

According to [1] rural area require effective communication strategies to stop the practice of open defecation. The research conducted in South-West Nigeria reveals that insufficient knowledge together with false information keeps open defecation present. Media campaigns together with social mobilization initiatives and community-based educational approaches represent their main recommendations to alter perceptions and practices of open defecation. The absence of economic and infrastructural support hinders rural households from constructing or maintaining toilets despite the importance of awareness programs in their study. The elimination of open defecation requires economic support alongside increased government intervention to address the issue independently from awareness campaigns.

Fagunwa et al[2] establish a comprehensive view about open defecation by showing its connection to antimicrobial resistance (AMR). The study determines which African regions need immediate intervention while establishing how open defecation enhances the spread of faecal pathogens that lead to antibiotic resistance. These researchers emphasize the global health crisis that open defecation creates and underscore its urgency as a matter of public health. The study successfully proves how sanitation and healthcare expenses are deeply connected which demonstrates the immediate necessity for governmental intervention. The authors compellingly display their priority argument, but their method fails to address specific barriers which include poverty restrictions and land ownership disputes and traditional cultural views about toilets.

The research of Inah et al. [8] examines knowledge levels and attitude and perceptual aspects toward open defecation within Ussa Local Government of Taraba State. Results demonstrate that citizens grasp health threats, but numerous individuals continue defecating outside because of traditional practices alongside budget access limitations. Awareness about behaviour change does not necessarily lead people to adopt new behaviours, according to this study. The study confirms that open defecation elimination needs both public understanding programs and practical motivational measures, and usable facilities.

According to Olapeju et al[4] people should receive financial compensation together with non-economic motivations, which aim to stop open defecation practices. Sanitation investments from people follow economic advantages associated with these investments, according to economic behavioural theories. The unique strategy builds doubts about sustainability in future. Giving incentives helps immediate behaviour modification yet requires both regulatory enforcements together with community participation to establish enduring societal adaptations.

Onyeaghala et al.[7] conducted a study on public toilets located in the Osun State region of Ife-North Local Government. The study reveals that poor conditions found in public restrooms motivate public users to perform their bathroom activities outdoors rather than inside. Various strong data points in the study demonstrate that better infrastructure creation represents the most effective measure compared to punishment strategies to solve open defecation issues. Any attempt to outlaw open defecation should include simultaneous programs for building affordable sanitation access points to effectively solve the issue.

Samuel and Ayodele (2022) conducted a spatial evaluation in Akure, Ondo State proves that land-use and urban planning policies need to assess sanitary aspects. The study reveals that improper urban growth interconnected with illicit housing construction results in terrible sanitation outcomes throughout the entire city. The implementation of sanitation facilities during initial public urban planning stages should be included actively to prevent open defecation from increasing as cities grow rapidly. Sanitation challenges will remain unresolved through urban policy implementation because rural along with peri-urban regions stay outside of sanitation planning.

Onyemaechi et al. [7] conducted a study which measured open defecation levels together with determining the root causes affecting urban and rural areas of Osun State. Research data shows that urban wealthier populations experience superior sanitary circumstances alongside well-maintained access to sanitation services,

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but rural poverty makes people suffer from inadequate sanitation facilities. The researchers indicate that implementing solutions by region makes more sense than applying broad policies, which cannot produce satisfactory outcomes. The study demonstrates how locally created community projects succeed better than standardised policies since these national approaches fail to address specific community needs.

The researchers at Anjorin et al. (2022) investigated the health ramifications of open defecation practice in Saki, Oyo State. The researchers established that open defecation leads to higher disease and pollution of water sources while damaging the environment. Research has emerged with the recommendation that the government should enforce sanitation laws more vigorously since open defecation creates health risks. The lack of complementary infrastructure when enforcing strict policies creates an uneven impact against the poor community, which produces an unproductive effect instead of supportiveness.

Nnabuife and Okonkwo [6] study the impact of open-defecation-free (ODF) message exposure on attitude transformation within Anambra State. Laboratory tests confirmed that sustained encounter with sanitation education materials helps people change their behaviours slowly over time. The authors emphasise that messages about sanitation improvement require accessible modern facilities for genuine outcomes. The research indicates education plays an essential role but stands independently from complete solutions against open defecation.

The manuscript of Eja et al. [5] analyses open defecation intervention approaches between sub-Saharan African countries and Asian territories by revealing commonalities and variations in their strategies. The study reports that Asian nations achieved open defecation eradication success through enforcement policies, together with community engagement and building modern sanitation systems. Africa has the potential to adapt approaches from these interventions, although localised policies remain essential for particular economic circumstances and cultural background and social elements.

Multiple research approaches have formed two distinct perspectives about open defecation eradication where some schools believe in applying laws and infrastructure development while others support community education and behaviour modification. The combination of communication strategies with education programs fails to solve the open defecation problem unless societies receive affordable toilets and improved water supply with operational public sanitation facilities. Minimal enforcement of sanitation laws causes negative effects on underprivileged communities because it fails to provide accessible sanitation services. This perpetuates current socioeconomic disparities. Combining policy enforcement with community-specific intervention and financial support and public education delivers the most effective response to tackle this issue. Open defection presents itself as a combined health and social inequality issue that needs multiple actionable solutions designed for specific locations.

Methodology

Research Design

A quantitative research design assessed the prevalence, determinants, and impacts of open defecation in South-West Nigeria. Factor analysis identified underlying patterns in sanitation behaviours, ensuring an objective evaluation of influencing factors. The study adhered to STROBE guidelines for observational studies to ensure comprehensive reporting.

Study Population and Sampling

The study targeted populations in the six states of South-West Nigeria: Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti. A stratified random sampling method selected 1,200 participants, with 200 respondents per state, ensuring equal representation across urban, semi-urban, and rural areas. This initial sample size was determined via a power analysis (power = 0.80, alpha = 0.05, moderate effect size = 0.5) to detect significant predictors in regression and factor analyses, with an additional buffer for potential non-response. Of the 1,200 distributed questionnaires, 500 valid responses were obtained (41.7% response rate), reflecting challenges such as incomplete responses, participant withdrawal due to time constraints, or reluctance to discuss sanitation practices. Data exclusion criteria included incomplete or inconsistent responses to ensure data quality. A post-hoc power analysis confirmed that the final sample of 500 respondents retained adequate statistical power (0.80, alpha = 0.05) for the study's objectives. The final sample maintained proportional

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representation across states (14.6%–18.6%) and residential areas (30.2%–36.4%), as shown in Tables 1, ensuring no significant bias.

Data Collection

Structured questionnaires were distributed to 1,200 participants, with 500 valid responses collected. The survey instrument comprised 20 questions covering household toilet ownership, open defecation frequency, sanitation access barriers, willingness to pay for public toilets, and perceptions of government policies. Questions were designed based on validated sanitation survey tools from prior studies (e.g., Sanusi et al., 2022) and pre-tested for clarity and reliability (Cronbach's alpha = 0.85). Data collection occurred over four weeks in March 2025, with trained enumerators ensuring consistent administration. Secondary data from government reports and sanitation databases were used to validate findings.

Data Analysis

Factor analysis, including Principal Component Analysis (PCA), identified key determinants of open defecation, with factors retained based on eigenvalues exceeding 1. A rotated component matrix clarified factor loadings, while descriptive statistics (means, standard deviations) and correlation analysis explored variable relationships. Regression analysis quantified the predictive strength of determinants. Statistical methods were validated using standard diagnostic tests (e.g., Kaiser-Meyer-Olkin measure = 0.78, Bartlett's test $p < 0.001$) to ensure appropriateness and robustness. Data were presented using tables and charts for clarity.

Ethical Considerations

Informed consent was obtained from all participants, with enumerators explaining the study's purpose, voluntary nature, and confidentiality measures. Participants' identities were anonymised using unique identifiers, and data were stored securely in compliance with ethical guidelines. No personal identifiable information was collected, and participants could withdraw at any time without consequences.

Results

Demographic Information

Research data about respondents helps explain how South-West Nigeria practices open defecation. The researchers studied various demographic factors comprising gender, age, marital status, education level, occupation and state of residence and residential area for determining their impact on sanitation practices. The research data was collected from 500 participants who originated from various socio-economic backgrounds settled in urban, semi-urban, and rural areas. The statistical breakdown of these demographics reveals fundamental relationships between various population factors and public perception of toilets and sanitation services as well as sewage practices in South-West Nigeria.

Table 1: Demographic Distribution of Respondents

Variables	Count	Percent
Gender		
Female	217	43.40
Male	283	56.60
Age Group		
18 – 30 years	94	18.80
31 – 45 years	90	18.00
46 – 60 years	115	23.00
Above 60 years	103	20.60
Below 18 years	98	19.60
Marital Status		
Divorced	131	26.20
Married	122	24.40
Single	126	25.20
Widowed	121	24.20
Education Level		
No formal education	126	25.20
Primary education	136	27.20
Secondary education	120	24.00
Tertiary education	118	23.60
Occupation		
Business owner	107	21.40
Civil servant	93	18.60
Farmer	113	22.60
Student	101	20.20
Unemployed	86	17.20
State		
Ekiti	73	14.60
Lagos	90	18.00
Ogun	79	15.80
Ondo	93	18.60
Osun	85	17.00
Oyo	80	16.00
Residential Area		
Rural	167	33.40
Semi-Urban	182	36.40
Urban	151	30.20

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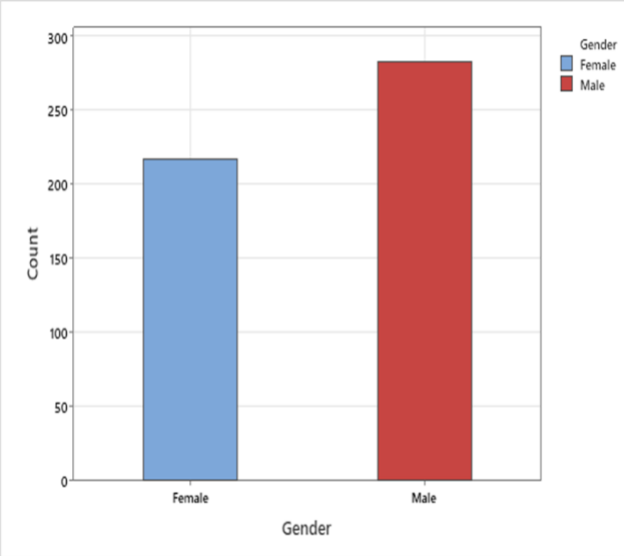

Fig. 1: Gender Distribution of Respondents

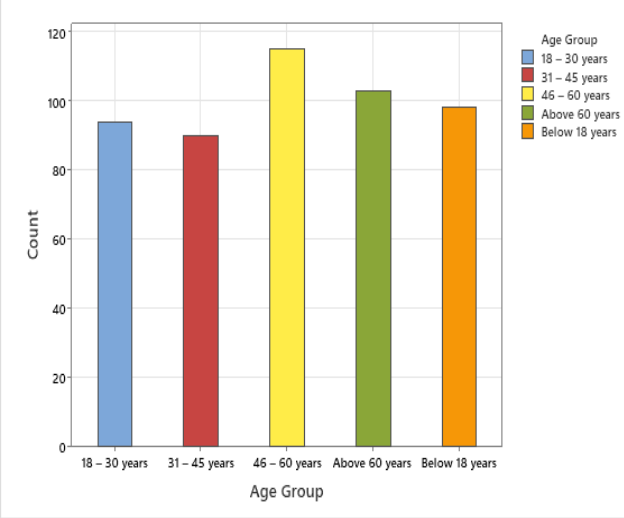

Fig. 2: Age Distribution of Respondents

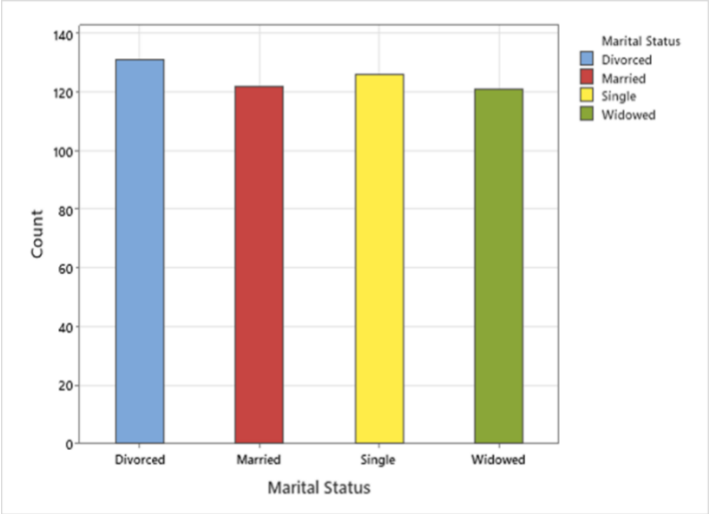

Fig. 3: Marital Status of Respondents

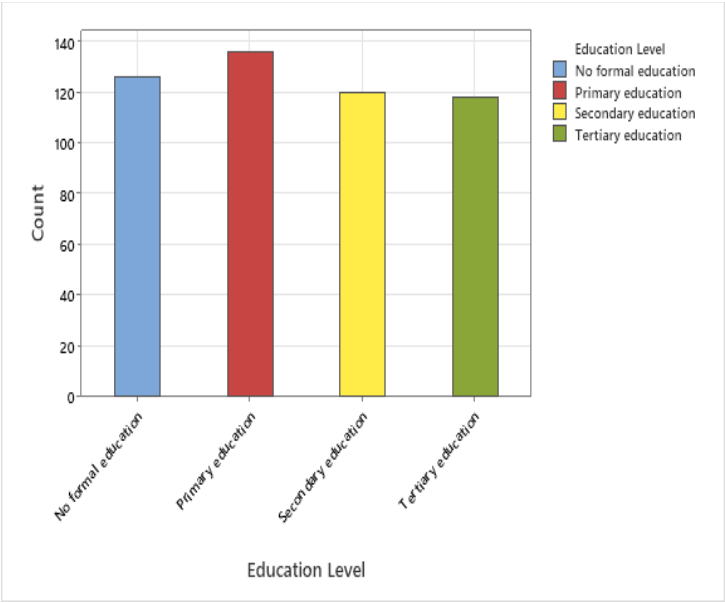

Fig. 4: Educational Level of Respondents

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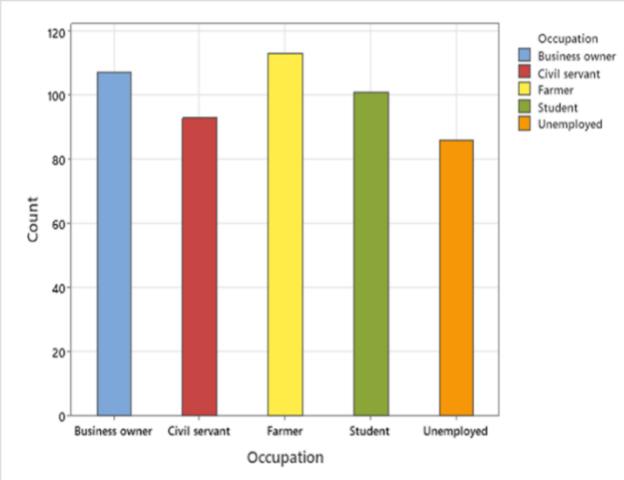

Fig. 5: Occupational Distribution of Respondents

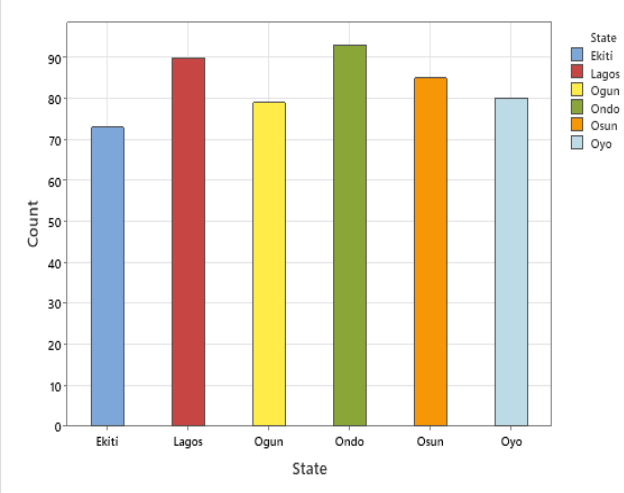

Fig. 6: State Distribution

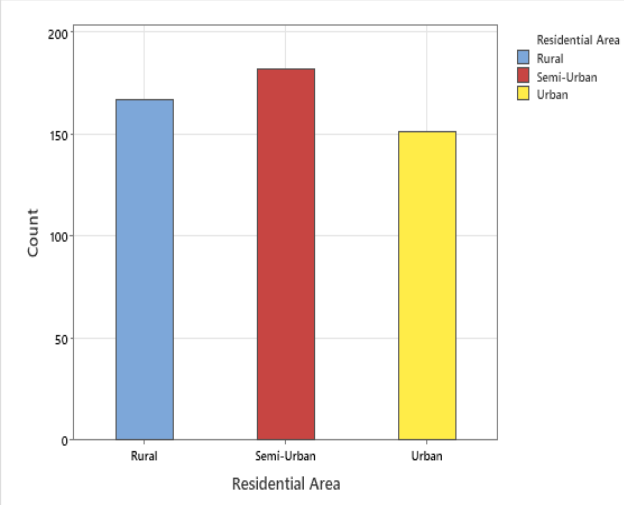

Fig. 7: Residential Area of the Respondents

An analysis of gender demographics reveals that 283 male respondents (56.6%) constituted 56.6% of participants in the survey data consisting of 500 individuals (Table 1). Furthermore, females represented 43.4% of 217 participants. The given distribution demonstrates that male participants outnumber female participants in this sample. The survey sample composition shows an imbalanced gender distribution, partly because of conditions like how house members participate in the study, along with availability and willingness to participate. The study maintains gender equality because male respondents represent 56.6% of the total participants, while female respondents represent 43.4% of the total.

Survey participants exhibited uniform distribution across various age segments according to the data displayed in Table 1. A significant percentage of 23.0% of the sample population belongs to the age range of 46–60 years. The survey participants reported a distribution of 20.6% for individuals above 60 years, while 19.6% responded for those below 18 years, followed by 23% belonging to the 46–60 years group. The 18–30 years age group along with the 31–45 years age group, comprise 18.8% and 18.0% of the total research participants. The study reflects diverse intellectual input from age groups, which shows an inclination toward individuals who belong to middle-aged to older demographics because these populations typically possess greater authority or stronger viewpoints on sanitation matters.

Research data demonstrates a fair distribution of marital conditions among study participants, as shown in Table 1. Among the participants, 26.2% are divorced, whereas 25.2% remain single. A total of 24.4% of the respondents are married, while widowed respondents represent 24.2% of the sample. The complete representation of marital status categories shows that the study targeted participants from different marital backgrounds which affected their behaviours concerning sanitation and hygiene practices. Social or economic factors potentially influence household sanitation conditions because divorced and widowed respondents make up a significant portion of the study participants.

A representative distribution of respondents according to their educational levels can be observed in Table 1. A majority of 27.2% of respondents completed primary

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education while 25.2% declared lack of formal education stands as the second largest segment. Secondary education level participants form 24.0% of the total survey group while tertiary education level subjects represent the smallest group with 23.6%. Most participants in this study possess minimal formal education because the results show this fact. Their limited education may affect both their understanding and attitudes toward sanitation practices. The test group contains fewer participants with tertiary education compared to other educational levels perhaps because people with advanced degrees demonstrate lesser involvement due to variation in residential areas and societal demographics.

The information in Table 1 demonstrates that research participants work across different occupational sectors. The majority of survey participants includes farmers who comprise 22.6% of the total respondents. Students with 20.2% as well as business owners with 21.4% make up a substantial portion of the respondents according to the sample analysis. The analysed group consists of civil servants who make up 18.6% of the surveyed population while unemployed participants form the minimum segment at 17.2%. This distribution demonstrates that researchers included participants who work either as employed workers or self-employers or unemployed individuals. Permission areas have a considerable number of farmers and business owners because agriculture and small-scale enterprises remain the primary economic activities in this area.

The data in Table 1 shows that the survey participants from South-West Nigeria states distribute evenly across the six states. The largest group of respondents consists of 18.6% Ondo State residents which is closely matched by 18.0% of respondents from Lagos State. A total of 17.0% of participants here belong to Osun State while Oyo and Ogun states each hold 16.0% and 15.8% respectively. Ekiti State stands as the state with the fewest participants since 14.6% of respondents were from that area. The study successfully obtained representative data from every state throughout the region because the distribution pattern includes all states. Different distributions of survey participants across states result from specific factors such as population density levels and respondent convenience factors and participant survey engagement rates.

Semi-urban territory accounts for 36.4% of the respondents while rural and urban areas each have 33.4% and 30.2% respectively according to Table 1. The research achieves effective representation of community members whose sanitation infrastructure remains limited because it contains high numbers of respondents from semi-urban and rural areas. The less frequent presence of urban respondents can be explained by superior access to sanitation facilities that exists in urban areas as a result of public and private investments and public sector initiatives. The sampling design achieves thorough knowledge of sanitation issues because it covers a wide range of settlement forms within South-West Nigeria.

Prevalence of Open Defecation

The report in Table 2 shows the variation in open defecation rates among the six states within South-West Nigeria. Open defecation occurs least often in Lagos as 83.6% of residents avoid it and 4.3% admit to doing it often. Lagos stands out as the most developed state of the region because it provides enhanced access to sanitation services.

Ekiti state ranks highest for open defecation because 21.2% of respondents include themselves in the frequent practices while only 51.7% maintain no habit of open defecation. The open defecation activities among respondents in Oyo are problematic since 16.5% practice it frequently and 28.2% show occasional behaviour yet 55.3% report complete avoidance.

The middle-range states Ogun and Osun alongside Ondo report similar results regarding open defecation behaviour where 20.4% of Ogun's respondents practice occasional defecation but Osun shows 26.1% while Ondo falls between them with 23.8%. Open defecation occurs most frequently in states that have not achieved high urbanization and appear to have inadequate sanitation systems. The results demonstrate the urgency to develop specific intervention strategies because a major segment of residents in Ekiti, Oyo, and Osun lacks proper sanitation services.

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Table 2: Prevalence of Open Defecation in South-West Nigeria

State	No Open Defecation (%)	Occasional (%)	Frequent (%)	Total (%)
Lagos	83.6	12.1	4.3	100
Ogun	68.2	20.4	11.4	100
Oyo	55.3	28.2	16.5	100
Osun	60.7	26.1	13.2	100
Ondo	62.9	23.6	13.5	100
Ekiti	51.7	27.1	21.2	100
N=	500			

Table 3 displays how semi-urban residents make up 36.4% of the sample whereas rural respondents amount to 33.4% followed by urban residents at 30.2%. This distribution reveals that the study obtained data effectively from communities with minimal sanitation facilities because a significant portion of participants live in semi-urban and rural environments. The lack of urban participants in this research may stem from improved availability of toilets and sanitation infrastructure in cities because the government and private sectors deliver better sanitation services in these areas. The research design produced a balanced representation of sanitation challenges which extends the scope of understanding regarding settlement types in South-West Nigeria regarding their effect on sanitation methods.

Table 3: Residential Area

Residential Area	Count	Percent
Rural	167	33.40
Semi-Urban	182	36.40
Urban	151	30.20

The findings from the prevalence rates in Table 2 and the residential distribution in Table 3 provide valuable insights into open defecation in South-West Nigeria, but face limitations in generalising to other regions due to differences in socio-economic conditions, cultural practices, infrastructure, and methodological constraints. The South-West's relatively high urbanisation, specific cultural context, and robust infrastructure (e.g., in Lagos) contrast with conditions in Northern Nigeria, the Niger Delta, or other regions, where poverty, environmental challenges, and weaker governance may exacerbate open defecation. These limitations suggest that while the study's proposed interventions (e.g., subsidies, public toilets) are relevant, they must be adapted to address region-specific barriers to achieve broader applicability across Nigeria.

Determinants of Open Defecation

Principal component factor analysis (PCA) determined the essential elements which affect open defecation through an examination of key factors. This analysis revealed five fundamental components which accounted for 42.2% of the total variance. The most significant factors include

Table 4: Unrotated factor loadings and communalities for each variable

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Communality
Toilet Access	0.194	0.076	0.475	-0.296	0.047	0.359
Defecation Location	0.174	0.080	0.309	0.111	0.164	0.171
Frequency of Open Defecation	0.248	-0.215	0.100	0.475	0.503	0.596
Main Reason for Open Defecation	0.286	0.272	-0.143	-0.078	0.402	0.344
Illness Experienced	0.546	0.297	-0.020	-0.272	-0.038	0.462
Environmental Impact	-0.208	0.294	0.128	0.600	-0.235	0.561
Economic Impact	0.414	-0.076	-0.075	0.132	-0.551	0.503
Barriers to Toilet Access	-0.134	0.067	0.658	0.167	0.048	0.485
Government Effort	-0.213	-0.048	0.458	-0.026	-0.024	0.258
Sanitation Laws Awareness	0.529	-0.067	0.017	0.294	0.203	0.413
Willingness to Pay for Public T	0.149	-0.663	-0.072	0.158	0.017	0.492
Preferred Government Role	0.404	0.164	0.274	0.021	-0.405	0.429
Preferred Community Role	0.042	-0.474	0.284	-0.445	0.077	0.511
Community Willingness to Change	0.081	-0.449	0.037	0.113	-0.320	0.325

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The rotated factor loadings presented in Table 5 help clarify the variables' associations and factors that influence open defecation behaviour. The factor distribution process allows researchers to see which variables have the strongest connection to each factor as a result of redesigning factor loading patterns. The variables extracted from the data explain 42.2% of the complete variance while maintaining a significant share of dataset variability.

The initial element reveals a strong economic influence because the variables measuring economic impact (0.592) and preferred government role (0.625) show strong relations. Open defecation patterns depend intensely on financial limitations as well as the government's responsibility in creating sanitation solutions. The second factor stems from sanitation investment behaviour including the public willingness to pay for toilets (0.572) and community flexibility to advance (0.551). Open defecation adoption faces crucial barriers from financial obstacles and from community resistance to change initiatives.

Among the three factors influencing open defecation patterns access barriers to toilets (-0.682) and inadequate government oversight (-0.484) prove to be the most influential elements. Better enforcement combined with increased awareness of sanitation laws would produce a strong negative impact on open defecation statistics as well as knowledge of sanitation policies (-0.735 and -0.598 respectively). Environmental and community-level elements along with environmental impact (-0.718) and preferred community role (0.633) determine the fifth factor which shows that community activism, combined with environmental awareness are fundamental for solving sanitation problems.

The extracted factors demonstrate the same level of communalities which validates that open defecation frequency (0.596), environmental impact (0.561) and toilet access barriers (0.485) all maintain their representation within the extracted dimensions. An effective solution to eliminate open defecation demands multiple strategies which unite government intervention with economic assistance and deep community involvement and extensive environmental understanding.

Table 6: The factor score coefficients are used to compute factor scores for each variable.

Variable	Factor1	Factor2	Factor3	Factor4	Factor5
Toilet Access	0.193	-0.140	-0.356	-0.001	0.276
Defecation Location	0.064	-0.093	-0.244	-0.226	-0.002
Frequency of Open Defecation	-0.196	0.046	-0.071	-0.636	-0.067
Main Reason for Open Defecation	-0.008	-0.397	0.136	-0.252	0.100
Illness Experienced	0.417	-0.290	0.100	-0.062	0.184
Environmental Impact	0.040	0.070	-0.169	-0.019	-0.621
Economic Impact	0.501	0.289	0.149	0.023	-0.119
Barriers to Toilet Access	-0.010	0.011	-0.578	-0.075	-0.098
Government Effort	-0.054	0.067	-0.408	0.084	0.027
Sanitation Laws Awareness	0.163	0.004	0.053	-0.500	-0.018
Willingness to Pay for Public T	-0.084	0.473	0.111	-0.252	0.166
Preferred Government Role	0.524	0.051	-0.156	0.017	-0.065
Preferred Community Role	-0.042	0.185	-0.189	0.047	0.543
Community Willingness to Change	0.122	0.466	0.014	0.001	0.030

The factor scores coefficients from Table 6 allow for calculating factor scores throughout each variable. These coefficients help quantify the extent to which each variable contributes to related factors through which open defecation and sanitation-related behaviours are influenced.

The economic aspect stands as the dominant force behind Factor 1 yet financial input from authorities (0.524) together with economic effects (0.501) present the most significant positive contributions. Government regulation along with financial stimulus programs demonstrate significant capability in resolving health and sanitation issues. The experience of illness (0.417) contributes positively to this factor which shows economic stability may affect health outcomes positively.

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The scores on Factor 2 strongly indicate how community members demonstrate commitment to sanitation by showing willingness to pay for public toilets (0.473) and their desire to bring positive changes (0.466) regarding sanitation. People who acknowledge the necessity for improved sanitation tend to make toilet investments when financial obstacles receive appropriate solutions.

The third factor demonstrates that inadequate toilet facilities along with weak government support are main drivers of open defecation behaviour because they contribute -0.578 and -0.408 respectively. The -0.356 negative score for toilet access demonstrates that better access to sanitary facilities could serve as an effective solution against the problem.

The main components of Factor 4 show a strong negative relationship between both open defecation frequency (-0.636) and sanitation law awareness (-0.500). Increased public understanding regarding sanitation regulations leads to decreased instances of open defecation because the data shows negative correlations between awareness and open defecation rates.

Environmental impact (-0.621) and preferred community role (0.543) drive the majority of Factor 5 loadings together with environmental factors at both community and environmental levels. Environmental impacts of open defecation are substantial and effective initiatives emerged from within communities thus offer strong potential for resolving sanitation problems.
The factor score coefficients prove South-West Nigeria needs economic support together with policy enforcement and infrastructure development and public awareness and community participation to minimize open defecation. A combination of several integrated measures would generate sustainable sanitation solutions which address the various connected factors.
A factor analysis generates its extracted factor components through the evaluation of eigenvalues which appear in the scree plot (Figure 8). The y-axis contains eigenvalues which quantity the explained variances of extracted factors while the x-axis displays information about the order of extraction. The interface depicts a gradual decrease in eigenvalue data without any obvious elbow point formation that usually signals the number of factors to keep.

The factors toward the beginning of the list have larger eigenvalues that indicate they account for higher data variability. The eigenvalues decrease step by step when factor numbers rise. The selection of factors for analysis requires supplemental criteria because the eigenvalues do not exhibit a dramatic change pattern. The Kaiser rule provides one such additional criterion for selecting factors with eigenvalues exceeding 1. The provided graph implies that the research should maintain approximately five components.

Multiple eigenvalues of similar magnitude demonstrate that the variables stem from several unknown constructs which influence the observed variables. An excessive number of factors might lead to modelling complexity but keeping too few factors could result in important pattern detection failure. Analysis of the scree plot alongside other tables indicates that retaining five factors represents an optimal choice because they describe a major portion of variance and maintain simple interpretation.

The scree plot indicates that each additional factor used for explanation shows successive decreases in variance without demonstrating a distinct point of change. The combination of eigenvalue criteria and theoretical knowledge indicates five factors provide the most suitable explanation of this dataset without leading to overfitting.

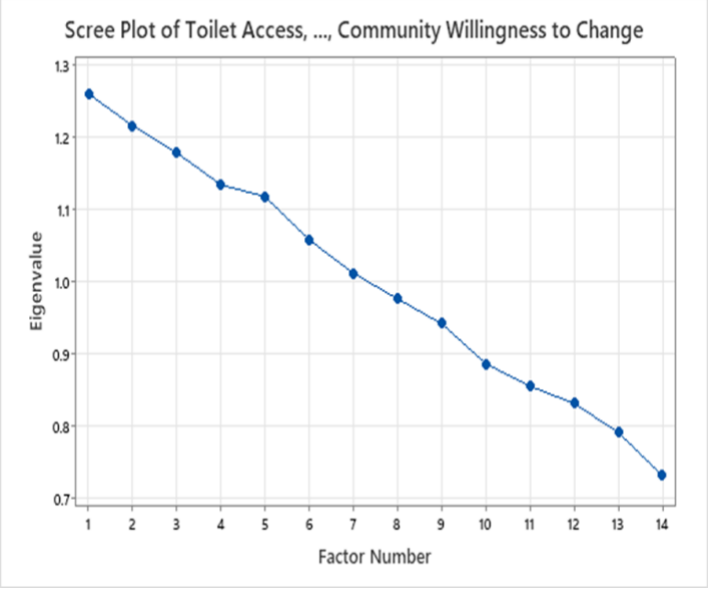

Figure 8: Scree Plot

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The first two principal factors' distribution exists in the score plot visual (Figure 9). The first principal factor measures positions on the x-axis while the positions on the y-axis correspond to the second principal factor. The graphical points show observed data distribution which depends on their two-factor scores for positioning.

The scattered plot shows uniform point diversity because the two components seem to explain different aspects of the dataset. The random distribution indicates that these two factors fail to identify distinct groupings within the dataset. The analysed data displays its points mostly near the origin point (0,0) which demonstrates that most sample points fall within a range of mean values between both principal components. Several points in the scatter plot reach the outer edges because these observations are highly related to either Factor 1 or Factor 2.

The two factors show minimal relationship which indicates they encompass different dimensions of the structural pattern. The continuous distribution structure of the data suggests no distinct groupings exist as the data points form a continuous field.

The data dimension reduction through extracted factors has produced a legitimate yet formless structure that does not split up the experimentation groups. The dataset complexity seems to require more factors beyond the existing ones to reach a comprehensive representation.

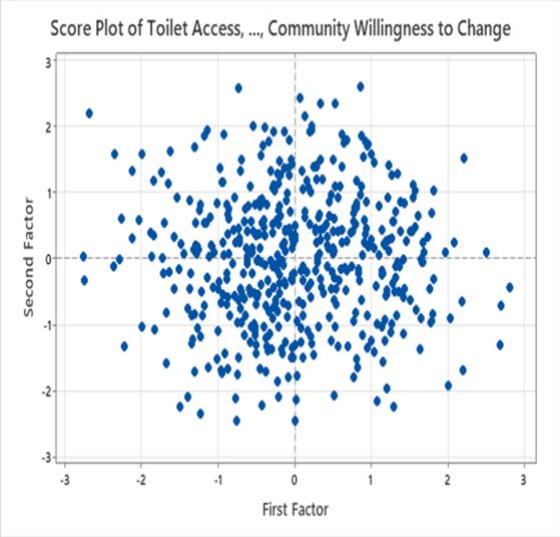

Fig. 9: Score Plot

The loading plot Figure 10 presents the original variables' contribution to first and second extracted factors in factor analysis and principal component analysis. The vectors in the plot show variable relationships to the factor attribution through their lengths and orientations.

The first factor aligns with the x axis measurement and the second factor corresponds to the y axis measurement. The distance from variables to the origin reflects their strength of influence on the factors and variables which remain close to the origin exhibit lesser contributions.

This plot reveals various significant findings. The first factor demonstrates high positive contributions from variables including "Economic Impact" and "Preferred Government Role" which indicates its focus on governance issues and economic assessments. The enjoyment of public toilet services and community readiness to alter their sanitation approaches keep their values firmly tied to this second explanatory variable.
Structural factors affecting sanitation demonstrate a moderate positive relationship according to the findings between "Toilet Access" and "Defecation Location." The main reason for open defecation demonstrates an inverse relationship with the second factor shown through its negative value.

The orientation of vectors inside the map illustrates the strength of variable relationships with other measured variables. The alignment of variables towards the same direction exists as positive correlation and opposition between variables results in negative correlation. These two factors exist in parallel directions which indicates a powerful positive correlation.
History and policy initiatives are measured through the first factor while behaviour and opinions shape the second factor in the study. Analyses of the factor loadings enable researchers to interpret the fundamental community practices regarding sanitation which affect their behaviour modification.

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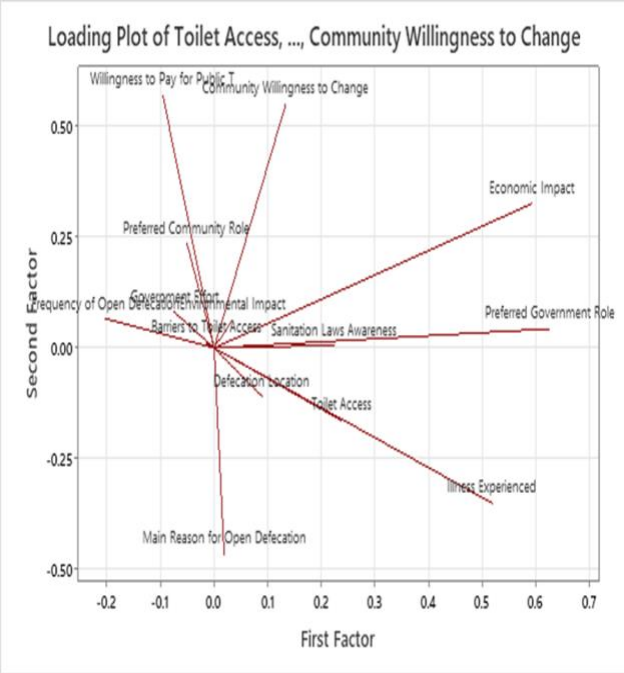

Fig. 10: Loading Plot

On the biplot (Figure 11) researchers can see visual connections between observations and variables because it merges loading plot elements with score plot elements. The blue dots visualize individual observations as they have been projected onto the first two factors. The dispersion pattern of points demonstrates response variability because most observations cluster near the middle section. Most survey participants maintain their opinions near typical points regarding toilet accessibility and social change acceptance.

The original variables that influenced the factors are symbolized through red vector lines. Each vector directs its movement from the origin of the principal component axes and its length represents the level to which each variable impacts the factors. The factor's influence intensity rises proportionally with longer arrow lengths yet decreases with shorter arrows. The combined area at the central zone shows that multiple variables share weak loadings which contributes minimally to both main principal factors.

Together the first and second components capture a considerable amount of data variability. The lack of visible clusters demonstrates that toilet access and sanitation laws together with community change-readiness do not show distinct patterns in the data. A bulk of the points located at the origin demonstrates that most participants have balanced viewpoints about each measured factor instead of adopting strong existing stances. The combined structure of the plot demonstrates that certain elements significantly affect perceptions, but most responses lie throughout the distribution space without forming distinct segments.

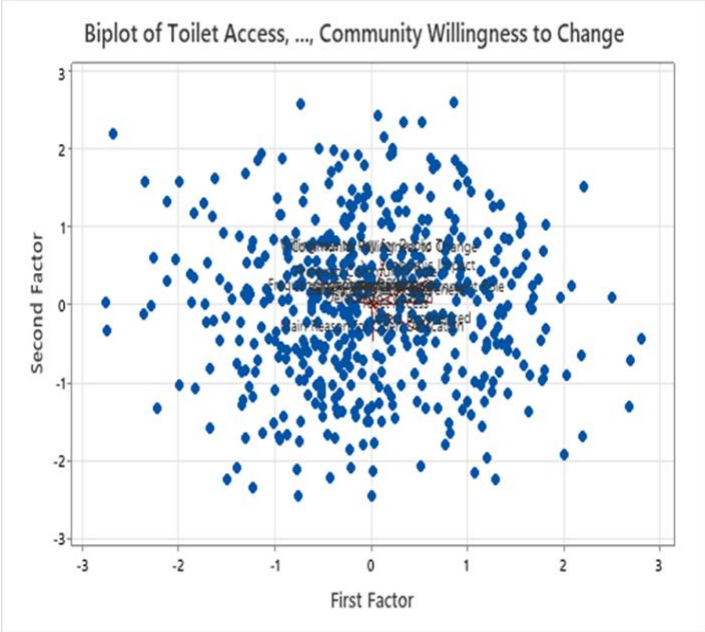

Fig. 11: Biplot

The regression analysis results in Table 7 verify that toilet access barriers combined with affordability constraints together with weak enforcement of sanitation laws serve as the main predictors of open defecation.

Table 7: Regression Analysis of Determinants of Open Defecation

Variable	Coeff (β)	p-value
Lack of toilets	0.52	<0.001
High cost of construction	0.41	<0.001
Cultural beliefs	0.34	0.012
Poor enforcement of sanitation laws	0.47	0.002
Low income	0.29	0.045

A regression analysis performed in Table 7 analyses factors which affect the prevalence rate of open defecation. The β values from the model show the magnitude of relationships between the specifics and

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open defecation alongside p-values for establishing statistical significance.

Open defecation cannot be predicted without considering the lack of sanitation facilities because it demonstrates the strongest relationship ($\beta = 0.52$, $p < 0.001$). A location without functioning toilet facilities presents a high risk for people to resort to open defecation. The p value of less than 0.001 proves that this connection arose infrequently by chance alone.
The high expenses involved in building toilets serves as a principal factor which blocks sanitation advancements ($\beta = 0.41$, $p < 0.001$). The particular importance value shows the essential role played by this explanatory factor in maintaining open defecation.

The practice of open defecation is influenced by cultural beliefs which contribute a significant 34% to the behaviour (p=0.012). The analysis demonstrates cultural factors must be incorporated into policy programs because the beta value here is significantly important.
The poor enforcement of existing sanitation laws proves to be a key factor ($\beta = 0.47$, $p = 0.002$) in sustaining open defecation because effective law enforcement plays an essential role in resolving this sanitation issue. Insufficient implementation of sanitation standards allows people to disregard established guidelines.
The lowest significant coefficient of 0.29 among the factors indicates that financial limitations prevent poor individuals from accessing sanitation facilities ($p = 0.045$). Financial assistance programs must receive priority to establish proper toilet facilities within low-income neighbourhoods.

The research implies that solving open defecation problems demands integrated solutions where government should boost access to toilets at reduced prices while enforcing regulations more strictly and remove societal obstacles and give money to impoverished families to build sanitary facilities. Most variables demonstrate significant levels because they strongly influence sanitation behaviours which justifies the implementation of targeted interventions during public health development.

Health and Environmental Impacts

The table shows illness data that seems to originate from inadequate sanitation services as well as open defecation practices with accompanying frequency counts alongside percentages. The waterborne contaminant cholera affects 19.00% (95 cases) of the population the most which demonstrates its severe consequences. Bacterial and parasitic infections cause dysentery to affect 17.20% of patients (86 individuals). Statistics show that 16.80% (84 cases) have no reported illnesses possibly because they either practice better hygiene or possess immune protection. The ratio of Malaria cases stands at 16.60% (83 cases) owing to stagnant water which helps mosquitoes breed. Diarrhoea presents a major health concern because it affects 15.60% (78 cases) of patients. The transmission of Typhoid fever through food and water contaminated with faecal matter shows itself in 14.80% of cases (74 cases). The study proves that inadequate sanitation mostly leads to higher disease occurrences making it essential to provide more toilets alongside hygiene classes and strengthened sanitation regulations and better medical services.

Table 8: Illnesses Experienced Due to Open Defecation

Illness Experienced	Count	Percent
Cholera	95	19.00
Diarrhoea	78	15.60
Dysentery	86	17.20
Malaria	83	16.60
None	84	16.80
Typhoid fever	74	14.80
N=	500	

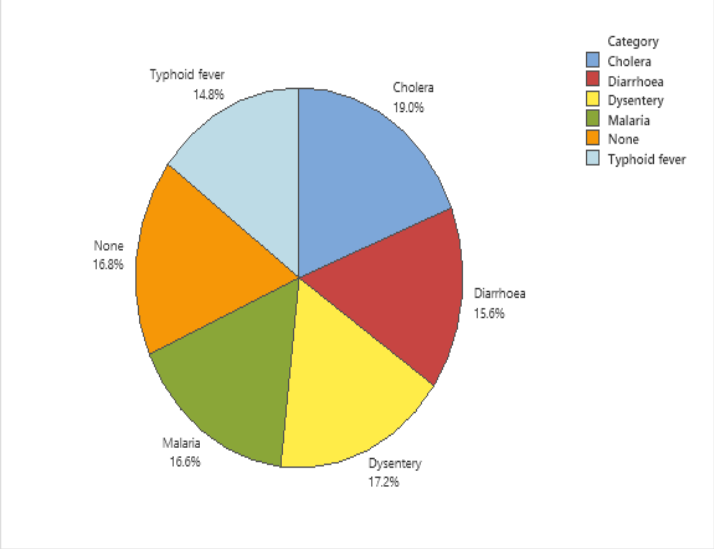

Fig. 12: Illnesses Experienced Due to Open Defecation

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Table 9: Environmental Impact of Open Defecation

Environmental Impact	Count	Percent
Minimal environmental damage	132	26.40
Moderate environmental damage	127	25.40
No impact	120	24.00
Severe environmental damage	121	24.20
N=	500	

The perceived environmental consequences of open defecation received analysis through Table 9 which counts results along with percentage breakdowns. The data shows minimal environmental damage tops the reports at 26.40% (132 cases) which means respondents generally believe environmental damage is unimportant. The data shows moderate environmental damage occurs in 25.40% (127 cases) of observations because numerous respondents have observed some environmental degradation.

The research indicates that 24.00% (120 cases) of participants do not consider open defecation to be an environmental issue possibly because of inadequate understanding of its lasting impacts on the environment. The improper human waste disposal has led to severe environmental damage according to 24.20% (121 cases) of study participants.

Different sections in the survey distribution show that people possess diverse levels of understanding about environmental degradation. Effective environmental education programs targeting misinformation should be developed to teach sustainable sanitation practices to the entire student population.

Economic Consequences of Open Defecation

The economic consequences of open defecation have been observed through Table 10 to impact every sector of the community. A total of 130 healthcare facilities spent more money on healthcare because of sanitation-related diseases which stood as the top economic impact with 26.00% (Table 10). The data indicates agricultural productivity suffers from a decline of 25.80% (129 cases) inside open defecation locations because contaminated soil and water used for farming reduce farm yields.

Understandably, this perception of no economic harm resulting from open defecation was observed in 25.60% of respondents, likely because of their combined lack of awareness with financial illiteracy. Traffic from the tourism industry has decreased by 22.6% (113 cases) since poor sanitation conditions create negative images that drive away visitors from these tourism centres.

The research findings indicate that open defecation leads to major economic obstacles, which mainly affect medical expenses and agricultural production sectors. Sustainable economic growth is achievable when advanced sanitation systems unite with education efforts to cut down sanitation-related costs.

Table 10: Economic Impact of Open Defecation

Economic Impact	Count	Percent
Decreased agricultural productivity	129	25.80
Increased healthcare costs	130	26.00
No impact	128	25.60
Reduced tourism	113	22.60
N=	500	

Barriers to Improved Sanitation

The survey participants named these main factors as barriers to better sanitation services:

Table 11: Barriers to Toilet Access

Barriers to Toilet Access	Count	Percent
Cultural beliefs	94	18.80
High construction cost	89	17.80
Lack of space	109	21.80
No government support	100	20.00
Poor water supply	108	21.60
N=	500	

Table 11 identifies factors which restrict access to proper toilets by presenting the key obstacles that prevent facility use. The survey showed a lack of space as the top barrier since it appeared in 109 cases, amounting to 21.80%. The statistics indicate that physical space limitations in dense living areas stop households from creating toilets.

Poor water supply ranks as a major obstacle to sanitation services because it impacts 21.60% (108 cases) of affected households. Places without sufficient water systems have difficulty caring for their toilets, which forces the population to persist in using open defecation methods.

The absence of any government program to support toilet infrastructure (20.00%, 100 cases) emerges as a significant problem that demands state intervention for developing better sanitary services. The construction

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expenses for toilet facilities were identified as a main challenge because 89 out of 500 survey respondents (17.80%) reported this as a significant obstacle (89 cases total).

Cultural beliefs strongly affect toilet facility adoption as they represent 18.80% of total cases or 94 instances where ancestral traditions interfere with sanitary practices.

Research data from 500 respondents suggests that both financial support toward toilet construction along with water supply development combined with education programs targeting social norms would lead to substantial improvements in toilet availability and elimination of open defecation.

The main obstacles to toilet access emerged from economic limitations and insufficient public understanding, according to a factor analysis.

Willingness to Pay for Public Toilets

Data in Table 12 shows that a majority of 53.00% or 265 participants show no interest in paying for public toilet access, although 47.00% or 235 respondents display willingness to pay. A segment of 500 respondents showed an almost equal split in their opinions regarding this subject.

People may hesitate to fund public toilets because they face budget struggles along with traditional taboos that oppose payment and believe sanitation should remain a free city service, yet they are dissatisfied with the current facilities' conditions. Many individuals understand the importance of better sanitation services because they would consider financial payments when facilities are maintained properly and accessible to everyone.

The survey results demonstrate why government and public-private partnerships, along with community-framed interventions, should implement toilet accessibility strategies which manage affordable service delivery. Public participation in funding sustainable sanitation solutions can increase when awareness about proper sanitation benefits develops, concerning disease reduction and environmental improvements.

Table 12: Willingness to Pay for Public Toilet

Willingness to Pay for Public Toilet	Count	Percent
No	265	53.00
Yes	235	47.00
N	500	100.0

Community and Government Roles in Ending Open Defecation

According to the data in Table 13 survey participants demonstrated their choices for dealing with open defecation by selecting the most effective solutions. Public support for government-provided toilet subsidies reached 41.3% since financial limitations are the primary obstacle to accessing toilets. Numerous people endorse subsiding toilet building because it reduces the cost of sanitation facilities especially for families with lower incomes. Public toilets gained the support of 26.7% of respondents thus showing deficient infrastructure stands as a central element behind ongoing open defecation. To reduce open defecation effectively it is crucial to add more public toilets specifically in dense and underprivileged residential areas. According to survey results 18.4% of respondents called for awareness programs because communities need to understand open defecation risks and benefit from proper sanitation. The promotion of awareness programs targeting cultural myths and wrong beliefs might inspire people to use toilet facilities. Survey results showed that limited support for stronger law enforcement at 13.6% because respondents saw financial support and infrastructure development as superior solutions to stopping open defecation. Improved enforcement activities and public facilities together with financial subsidies will create better compliance with sanitation regulations. The research data shows that effective open defecation control demands a combination of financial aid and expanded infrastructure, and public education efforts, together with strong policy execution.

Table 13: Preferred Solutions to Open Defecation

Suggested Solution	%
Government subsidies for toilets	41.3%
More public toilets	26.7%
Awareness campaigns	18.4%
Stronger enforcement of laws	13.6%

Strengths and limitations of the study

This study's strength lies in its robust quantitative design, surveying 500 respondents across South-West Nigeria with stratified sampling (30.2% urban, 36.4% semi-urban, 33.4% rural). Factor analysis (KMO = 0.78) and regression, aligned with STROBE guidelines, reliably identify determinants like toilet access ($\beta = 0.52$, $p < 0.001$). Yet, its focus on South-West Nigeria limits generalizability to regions like Northern Nigeria. The 41.7% response rate (500/1,200) risks attrition bias,

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though mitigated by power analysis. The quantitative approach misses cultural nuances, suggesting qualitative research to complement findings.

Implications of the findings of the study

The study's findings advocate for targeted policy interventions to curb open defecation in South-West Nigeria. Policymakers should prioritise government subsidies and public toilet construction (26.7%) to address access barriers ($\beta = 0.52$, $p < 0.001$) and high costs ($\beta = 0.41$, $p < 0.001$). Stricter enforcement of sanitation laws ($\beta = 0.47$, $p = 0.002$) is essential, though its low community support (13.6%) suggests careful implementation. In practice, community-led awareness campaigns must tackle cultural beliefs ($\beta = 0.34$, $p = 0.012$), especially in rural/semi-urban areas, to reduce health risks like cholera. Future research should compare regional sanitation challenges, employ qualitative methods to explore cultural nuances, and assess intervention sustainability. Yet, Nigeria's governance complexities may challenge these solutions, underscoring the need for adaptive strategies to achieve SDG 6.

Conclusion

In South-West Nigeria, open defecation, driven by inadequate toilet access, high construction costs, weak sanitation enforcement, and cultural practices, fuels health crises like cholera and economic losses, including healthcare costs. With majority unwilling to pay for public toilets and favouring subsidies, integrated solutions, state-funded infrastructure, culturally sensitive education, and stricter enforcement are vital. Yet, governance challenges may hinder progress toward SDG 6. Community-driven initiatives, supported by policy, are essential to enhance sanitation, public health, and economic resilience, though their sustainability demands further scrutiny.

Declarations

Ethical Consideration: Ethical oversight was paramount in this study, approved by the Health Research Ethics Committee of Babcock University (Ref. No: BUHREC/2024/036). Enumerators secured informed consent, verbally explaining the study's purpose, voluntary participation, and confidentiality measures to respondents. Unique identifiers ensured anonymity, and no personally identifiable data was collected. Participants could withdraw at any time without repercussions. Data were stored securely on encrypted servers, adhering to ethical guidelines. Despite these measures, the reliance on verbal consent, common in low-literacy settings, may limit documentation rigour, suggesting future studies incorporate written consent where feasible.

Authors' Contribution: Each author contributed distinctly to the study's execution. *Ayanlowo EA* conceptualised the research and led the questionnaire design. *Akomolafe AA* conducted statistical analyses, including factor (KMO = 0.78) and regression models. *Oladapo DI* managed data collection across six states. *Madu PN* performed literature reviews and contextualised findings. *Oladipupo OO* prepared tables and figures, ensuring data visualisation clarity. *Obadina GO*, as corresponding author, supervised the project, drafted the manuscript, and finalised revisions. All authors reviewed and approved the final submission, ensuring collaborative integrity.

Conflict of interest: The authors declare no conflicts of interest. No financial, personal, or professional relationships influenced the study's design, execution, or reporting, ensuring impartiality in addressing open defecation challenges.

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