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FACTORS ASSOCIATED WITH INCOMPLETE CONSTRUCTION OF PIT LATRINES AND THEIR PUBLIC HEALTH RISK IN KARONGI DISTRICT RURAL HOUSEHOLDS, RWANDA.

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ABSTRACT

Background

Globally, 2 billion people lack access to improved latrines, with 60% of these individuals residing in rural areas of Asia and Africa. In Sub-Saharan Africa, 41% of the population continues to use unimproved latrines, and in Rwanda, 25% of the population still relied on unimproved latrines in 2020, with most using pit latrines presenting significant structural deficiencies. Despite being a primary sanitation facility in developing countries, many pit latrines lack essential structural and design qualities. There is limited understanding of the factors influencing poor pit latrine constructions and the associated health risks. This study aims to assess the factors related to incomplete construction of pit latrines and their public health risks in Karongi district rural households in Rwanda, contributing to efforts to improve sanitation facilities in similar settings.

Methods

A cross-sectional study design was carried out on 288 households, were sampled from 30,900 rural households using fisher formula. A cluster sampling technique was used to select participants for the study. Data were collected using pre-tested interview-administered questionnaire and observation technique. Data were analyzed and presented using SPSS version 22. Multivariable logistic regression analysis was performed to identify variables associated with incomplete construction levels of pit latrine and their public health risk in rural Karongi district, Rwanda

Results

The study revealed that among 288 households, 73.6% had pit latrines at the superstructure level, while 26.4% had them at the sub-superstructure level. Several significant factors were associated with incomplete construction levels of pit latrines. Households expressing concern about latrine security (in terms of collapse) had higher odds of incomplete construction levels (OR: 3.7, 95% CI: 1.56-8.95). Similarly, households expressing neutrality about latrine security also had higher odds of incomplete construction levels (OR: 2.9, 95% CI: 1.07-7.90). Additionally, households

perceiving their latrine privacy status as poor were significantly more likely to have incomplete construction levels (OR: 4.9, 95% CI: 1.44-6.99). Furthermore, the practice of digging new pits to manage filled ones was identified as a significant health risk associated with incomplete construction levels (OR: 4.0, 95% CI: 1.77-9.20) in Karongi district rural households.

Conclusion

This study emphasizes the critical need to address incomplete construction levels of pit latrines despite population is found risk-aware, and guide mitigation strategies to reduce environmental health risks in Karongi rural households and similar communities. It underscores the importance of increasing community knowledge about the various incomplete construction levels of pit latrines and their associated public health risks. The study recommends that Karongi district authorities leverage sanitation awareness initiatives, particularly by educating the community about risk awareness, integrating related subjects into community norms, economic strengthening and promoting attitudes that encourage individual families to adopt fully constructed pit latrines.

Keywords: **incomplete construction of pit latrines, Karongi district, rural households, Rwanda**

INTRODUCTION

Access to improved sanitation facilities remains a critical aspect of promoting public health and ensuring a hygienic living environment. Millennium Development Goals (MDGs) era is praised for over two billion people now have access to basic sanitation, and the number of people who defecated outside has almost halved from 2000 to 2015.[1] Globally, the Sustainable Development Goal (SDG) 6.2, which aims to achieve universal access to basic sanitation facilities, still falls short, with 2 billion people worldwide using unimproved sanitation facilities.[2]

Despite hosting 90% of the world's rural population, rural parts of Asia and Africa account for 60% of worldwide who lack of access to improved sanitation facilities.[3] Sanitation-related issues have profound implications, as evidenced by statistics showing that sanitation alone contributes to 13% of deaths among children under 5 years old, with poor human excreta disposal linked to approximately 289,000 annual deaths from diarrheal diseases.[4] Moreover, the economic impact of sanitation-related issues is staggering, with estimated losses of around $222.9 billion per year attributed to premature deaths, healthcare expenditures, and productivity losses in the ill workforce in developing countries.[5]

In Sub-Saharan Africa, particularly in regions like Uganda and Burundi, pit latrines are the predominant sanitation solution in absence of sewer systems known for developed countries.[6,7] These latrines are valued for their simplicity in construction using locally available materials.[8] However, they often lack essential components such as a proper pit size, hygienic slab, and suitable superstructure over their lifespan.[9–11] A survey conducted in Ghana categorized latrine construction into stages: pit level, superstructure (walls) level, roof level, and privacy level. It found that completion rates were highest at the pit level (43.3%), followed by the privacy level (32.2%), roof level (11%), and superstructure level (13%). [12]

In Rwanda, 25% of the population still relies on unimproved latrines, with significant disparities between urban (88% coverage) and rural (62% coverage) households.[13] This discrepancy contributes to public health risks such as diarrheal diseases, which are linked to undernutrition and high mortality rates among children under 5 years of age more prominent in rural setting.[13, 14] Karongi district, in particular, faces challenges, with 32.4% of children affected by stunting, highlighting the urgent need for improved sanitation and nutrition services.[15]

Despite national-level data availability, there is limited understanding of factors influencing different latrine construction levels and associated health hazards at the district level in Rwanda. Therefore, this research aims to identify factors contributing to incomplete construction of pit latrines and their public health risk in rural households of Karongi district, Rwanda. The findings will inform strategies to improve sanitation infrastructure and mitigate health risks, aligning with Rwanda's Fourth Health Strategic Plan (HSSP4) goals for enhanced WASH services and reduced childhood stunting and diarrheal diseases by 2024 and beyond**.**

Methods

Study design and setting

A cross-sectional study was conducted in December 2023 in Karongi district, western part of Rwanda. Karongi district is one of seven districts of the Western Province, divided into 13 administrative Sectors, 88 Cells and 537 Villages which are all delegated entities of the district and hence under its full responsibilities in regards of staffing, administration and financing; and the region is one of the most mountainous, covering 993 km2 at an altitude of 1470 to 2200 meters, and it is located in both Kivu and the Upper Nyabarongo Sub-catchment; it is part of the Congo Nil Crest (Watershed). [16]

Target Population and Eligibility Criteria

KARONGI district has 373,869 inhabitants (NISR, 2022). The population of Karongi district is disproportionally 156073 males (47 %) and 175735 females (53%) grouped into 73326 households. The study was conducted in four sectors which consist of higher population size and occupy the most rural part of the district, these sectors are Rwankuba, Ruhengeri, Rugabano and Bwishyura with 38286 (in 8,323 households), 40337 (in 8,769 households), 34207 (in 7,436 households) and 29312 (in 6,372 households) residents respectively (NISR, 2022). However, determining the sample from this target population was primarily based on the current national coverage on unimproved latrine (25%), since there is lack of documentation on coverage of unimproved latrine at district level. The study included all selected households in study area with functional incomplete pit latrine.

Sample size determination

It was determined using Fisher exact formula which is appropriate when the proportion is known while the target population and other parameters such as mean and variance are unknown [17]. **According to recent Rwanda demographic health survey 2020, the prevalence of unimproved** latrine coverage was 25%.[13]

Thus, the sample size formula is illustrated as:

$$no = \frac{z^2 pq}{e^2}$$

Where;
n= Expected sample size
z= Degree of confidence at 95% that corresponds to 1.96
p= 0.25 (prevalence of use of unimproved latrine)
q= 1-p
d= 0.05 (5% precision), the margin of error that is accepted in this study.
Thus, replacing the values in the formula, we have

$$no = \frac{1.96^2(0.25) * (1 - 0.25)}{0.05^2} = 288$$

Therefore, 288 households were sampled from 30,900 rural households. The sample size for every sector, was found using the stratification method as follows in the following table:

Sector	**Population "Households"**	**Sample size**
Rubengera	8,323	(8,323/30,900) *288 =78
Rwankuba	8,769	(8,769/30,900) *288 = 82
Rugabano	7,436	(7,436/30,900) *288=69
Bwishyura	6,372	(6,372/30,900) *288=59
Total	**30,900**	**288**

Sampling procedure

Cluster random sampling method was employed, and sector villages represented clusters from which 10 villages were randomly selected from each sector. To counteract the potential study design effect, homogeneity within clusters and heterogeneity of clusters were assured, hence effect was considered neutral. The households, as the primary sample units, were randomly selected from each village under the support of head of village to reach household using pit latrine defined as functional and incomplete, preserving villages equal proportions, in turn summing up to a predetermined sector sample size.

Study variables and measurements

The outcome variable of interest was whether the pit latrine has attained superstructure level (whose construction level has attained roof structure, given that still lacks other key structures such as door, and ventilation or other finishing inputs) during its utilization. This was a binary variable with categories: (Superstructure) and (sub-superstructure), and was based on observation guide. The cut-off at roof based-superstructure level was determined following persuasive literature findings supporting that the open defecation reduces as a result of relative improvement in latrine use by households when it approaches to its completion level in building structure (Nunbogu et al., 2019). The construction levels of household-owned incomplete pit latrines were observed, and the responses were recorded as a categorical variable with the options "pit/slab level," "wall level," and "roof level." These variables were then condensed to a binary outcome variable

((Superstructure) and (sub-superstructure)) in light of the findings, which showed a significant shift in frequency between wall level and roof level. Social demographic traits such as the head of the household's sex, education level, age group, size of the household, length of residence, number of children under five, and socioeconomic status were among the explanatory variables (Ubudehe). Furthermore, a review of the literature on latrine coverage and use guided the differences in the engagement of men and women in sanitation practices as well as other sociodemographic factors including income, occupation, and education (Armah et al., 2018). Moreover, pit latrine characteristics such as type of pit latrine and construction materials were studied to ascertain plausible relationships assumptions with key explanatory variables (Budhathoki et al., 2017). Knowledge to latrine construction, access to building materials, perceived latrine security from collapse, perceived latrine privacy status, fear of diarrhea acquisition, and open defecation norm were also considered as behavior factors related covariates (Prüss-Ustün et al., 2019) to the outcome, and were assessed in reference to RANAS approach and measured by 3-point Likert scale (Mumu et al., 2022). In addition, research inquired about households' latrine hygiene status and cleanliness, and availability of hand washing facility through observation, and inquire about hand washing practice, accessibility of water source and latrine emptying practice (Kabange, 2019); (Johnston, 2017) by interview as independent health risk variables to the latrine construction level as an outcome variable.

Data collection procedure

To gather quantitative data from household respondents, a semi-structured questionnaire was built and delivered using the Kobo toolbox. The survey included some observations on pit latrine such as the type of pit latrine, level of construction, building materials, hygienic status and hand washing facilities. These tools were developed guided by relevant literature. Three research assistants who were conversant in the local language were taught for two days on proper data collection methods and ethical procedures in order to guarantee the quality of the data gathered. Two community rural villages in sectors other than the study sectors served as the pretest locations for the questionnaire. Each day of the pretest was followed by a debriefing to exchange field experiences and make any required adjustments to the instrument. When the questionnaire was distributed, the data collectors were constantly watched to make sure that any mistakes or omissions were fixed and to maintain the accuracy and completeness of the information. A maximum of fifteen respondents per day were assigned to each data collector, and following each day of data collection, the primary investigator of the study double-checked the observations and interview responses for accuracy.

Reliability of the Instruments of the Study

The reliability of an instrument refers to its ability to consistently produce the same results when used multiple times in the same situation.[18] In research, this means measurements on similar individuals under the same conditions should be consistent. To ensure reliability, Ten percent of participants-comprising 28 households with unimproved pit latrines at the incomplete construction

stage were given the questionnaire. Based on feedback from this pilot study, the tool was adjusted accordingly. The data analysis in SPSS generated a Cronbach's Alpha, which was considered adequate at above 0.7, ensuring the tool's reliability.

Validity of the Instruments of the Study

Validity refers to how accurately a research instrument measures what it is intended to measure [18]. To ensure validity, the questionnaire was created by the researcher after studying pertinent literature and pertinent variables to guarantee the validity of the research tool. Ensuring each question is relevant to the objectives helped ensure the authenticity.

Moreover, the content validity index was calculated using the following formula:

$$\text{CVI} = \frac{\text{No.of variables regarded relevant by researcher}}{\text{Total No.of variables.}} = \frac{23}{26}$$

The content validity index of more than 70% indicated that the tool is valid and the variables are relevant to the study objectives.

Data analysis

The data underwent visual inspection, coding, and were imported into Epi Info 3.5.1 before exporting to SPSS version 22 for further statistical analysis. Descriptive statistics, including frequencies and proportions were used to summarize sociodemographic characteristics of respondent households and the prevalence of incomplete pit latrine construction. Bivariate analysis examined the relationship between independent variables such as sociodemographic characteristics, behavioural factors, and health risks, with the dependent variable levels of incomplete pit latrine construction (superstructure vs. sub-superstructure). Multinomial logistic regression was employed to assess the degree of association, controlling for confounding factors and effect modification. Adjusted odds ratios (AOR), 95% confidence intervals, and p-values less than 0.05 indicated statistical significance.

Ethical consideration

The execution of the study was facilitated by approvals from Mount Kenya University's (MKU) postgraduate school of public health ethical review committee and the Karongi district mayor's office. Prior to administering the questionnaire, respondents were requested to provide their consent, which was obtained. Participants were assured that the process entailed no risks and that their personal information would remain strictly confidential. They were informed of the voluntary nature of their participation, emphasizing their right to withdraw at any time for any reason. To ensure anonymity, each participant was identified solely by a code number on the questionnaire, with no names disclosed in any publications, presentations, or study reports. Additionally, access to confidential data was restricted to research supervisors exclusively for a duration of ten years.

Result

Demographic Characteristics of Respondents

The study comprised a total of 288 households. The respondents were either heads of households or any family member aged 18 years or older. Our study found that 38.5% of household heads were aged 46 years or older, and the majority of household heads were married (61.1%). Male household heads surpassed females, accounting for 67.7%, and 50.3% had families of five or more members. About 60.8% of household heads had completed at most a primary level of education. The prevailing religious affiliation within the households was Protestant, accounting for 41.3%. The majority of these households had been residing in the area for over a decade, constituting 64.2%, and 47.2% of households were classified in the 3rd *Ubudehe* category (*with the 1st category being the lowest socio-economic class*). [Table 1]

Table 1: Sociodemographic characteristics of the households

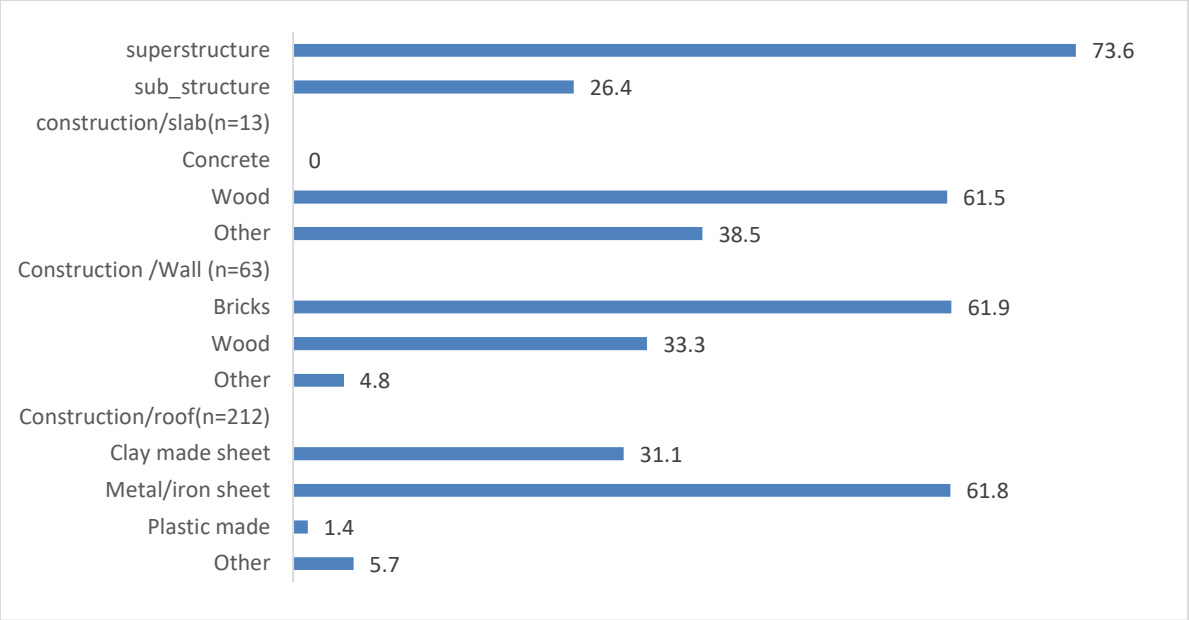
Variables (n=288)	Frequency(n)	Percentage (%)
Level of education of household head		
No Education	87	30.2
Primary	175	60.8
secondary/Tertiary	26	9
The religion of the Head of Household		
Catholic	90	31.3
Protestant	119	41.3
SDA	58	20.1
Other	21	7.3
Time household been resident in the area (in years)		
0-3	37	12.8
4-9	66	22.9
10+	185	64.2
Gender		
Female	93	32.3
Male	195	67.7
Marital status of Head of Household		
Cohabitating (Living together)	50	17.4
Divorced/Separated	12	4.2
Married	176	61.1
Single	14	4.9
Widow	36	12.5
Ubudehe category		
Cat 1	33	11.5
Cat 2	119	41.3

Cat 3	136	47.2
Age of Head of Household in years		
15-35	80	27.8
36-45	97	33.7
46+	111	38.5
Number of Household Members		
<4	143	49.7
5+	145	50.3

The prevalence of incomplete construction levels of pit latrine in Karongi district

According to [figure 1], a significant percentage (73.6%) of the surveyed households' pit latrines successfully reached the superstructure (roof-based) level during their construction. Among this group, 61.8% chose to employ metal/iron sheets for roofing. On the other hand, pit latrines at the sub-superstructure level accounted for 26.4%, encompassing wall and slab sub-levels. In the wall construction phase, bricks were predominantly utilized, constituting 61.5%, while at the slab stage, wood was the primary material employed, also constituting 61.5%. Single pit typology predominated at 66.9%, followed by pour flush pit latrines at 27.8%, and double pit latrines at 5.9%.

Figure 1: Proportion of pit latrine construction levels and distribution of the construction materials



Bivariate Analysis between Demographic characteristics related to pit latrines construction

Bivariate analysis was used to examine sociodemographic characteristics linked to incomplete pit latrine construction at the household level. Various variables were explored to assess their association, and only one variable demonstrated statistical significance (P-value ≤0.05). The household's socioeconomic level, or "Ubudehe category," was the variable showing a significant connection with a P-value of less than 0.05. The crude association analysis, as shown in Table 2, revealed a statistically significant relationship between the "*ubudehe*" category and the incomplete construction levels. Notably, 81.6% of households' pit latrines in Ubudehe category 3 (social class of upper-middle wealth households) were significantly present at the superstructure level compared to other Ubudehe categories, with a P-value of 0.01.[Table 2]

Table 1: Bivariate analysis of the socio-demographic characteristics

Variable(s) n=288	**Superstructure n (%)**	**Sub-superstructure, n (%)**	**p-value**
Level of education			0.13
No education	58(66.7)	29(33.3)	
Primary	132(75.4)	43(24.6)	
secondary/Tertiary	22(84.6)	4(15.4)	
Religion of household			0.636
Catholic	65(72.2)	25(27.8)	
Protestant	92(77.3)	27(22.7)	

SDA	41(70.7)	17(29.3)	
Other	14(66.7)	7(33.3)	
Time household been resident in the area			0.426
0-3	24(64.9)	13(35.1)	
4-9	50(75.8)	16(24.2)	
10+	138(74.6)	47(25.4)	
Gender			0.877
Female	69(74.2)	24(25.8)	
Male	143(73.3)	52(26.7)	
Marital status of Head of Household			0.327
Cohabitating (Living together)	35(70)	15(30)	
Divorced/Separated	7(58.3)	5(41.7)	
Married	134(76.1)	42(23.9)	
Single	8(57.1)	6(42.9)	
Widow	28(77.8)	8(22.2)	
Ubudehe/Social category			**0.01***
Cat 1	20(60.6)	13(39.4)	
Cat 2	81(68.1)	38(31.9)	
Cat 3	111(81.6)	25(18.4)	
Age of head of household head			0.901
15-35 Years	58(72.5)	22(27.5)	
36-45	73(75.3)	24(24.7)	
46+	81(73)	30(27)	
Household Members			0.642
<4	107(74.8)	36(25.2)	
5+	105(72.4)	40(27.6)	

Behavioral factors associated with incomplete construction levels of pit latrine in Karongi district

[Table 3] presents the behavioral aspects associated with incomplete pit latrine construction levels, using estimates of measures of association. The Risks, Attitudes, Norms, Abilities, and Self-regulation (RANAS) model was crucial in assessing the behavioral factors affecting the extent of pit latrine construction in the research area. The analysis primarily focused on risk perception among households with incomplete pit latrine construction. Key findings included households' perception of latrine privacy and latrine security (risk of collapse) as significant risk factors

associated with incomplete construction, and "access to building materials" as a significant ability and/or attitude factor.

Among households with pit latrines at the sub-superstructure level, 40.3% were significantly concerned about latrine security, compared to 38% who were less concerned (p-value <0.001). Additionally, 41.7% thought their latrine privacy was inadequate, while 12.7% were neutral (p-value <0.001). Furthermore, 36.7% reported difficulty accessing construction materials, while 13.4% found them very accessible (p-value <0.001). These findings highlight significant associations between behavioral factors and incomplete pit latrine construction levels.

Table 2. Bivariate analysis of the behavioural factors and public health risk associated with incomplete construction levels of pit latrine in Karongi district

Variable(s) n=288	**Superstructure n (%)**	**Sub-superstructure n (%)**	**p-value**
Practice of hand washing			0.231
Rare	66(68)	31(32)	
Sometimes	81(74.3)	28(25.7)	
Always	65(79.3)	17(20.7)	
Perceived latrine privacy status			**<0.001**
Poor	81(58.3)	58(41.7)	
Neutral	124(87.3)	18(12.7)	
Good	7(100)	0(0.00)	
Perceived latrine Security			**<0.001**
Unconcerned	101(89.4)	12(10.6)	
Concerned	71(59.2)	49(40.3)	
Neutral	40(59.2)	15(27.3)	
Perceived frequency encounter feces in open space			0.682
Rarely	96(75.6)	31(24.4)	
some times	97(72.9)	36(27.1)	
Often	19(67.9)	9(32.1)	
Perceived Knowledge to construct latrine			0.276
Not knowledgeable	136(70.8)	56(29.2)	
Somewhat knowledgeable	56(77.8)	16(22.2)	
Knowledgeable	20(83.3)	4(16.7)	
Hand Washing Facility at the entry point			**0.004**

Fair (Presence of either water-containing or/non-water hand washing facility or soap stationed)	38(95)	2(5.0)	
Present (at least the presence of a functioning HW-facility containing clean water stationed)	2(66.7)	1(33.3)	
None	172(70.2)	73(29.8)	
Latrine hygiene and cleanliness			**0.001**
Good	2(66.7)	1(33.3)	
Poor	70(89.7)	8(10.3)	
Very poor	140(67.6)	67(32.4)	
How deal with waste from your filled pit latrine?			**0.024**
Dig new pit	134(68.7)	61(31.3)	
Manual emptying of contents immediately	63(84)	12(16)	
Render contents safe to empty manually	15(83.3)	3(16.7)	
Perceived access to water source for domestic use			0.204
Hardly accessible	109(69.4)	48(30.6)	
Somewhat accessible	90(78.3)	25(21.7)	
Very accessible	13(81.3)	3(18.8)	
Perceived access to construction materials for building			**<0.001**
Hardly accessible	95(63.3)	55(36.7)	
Somewhat accessible	99(84.6)	18(15.4)	
Very accessible	18(85.7)	3(14.3)	

Public health risk linked to incomplete construction levels of pit latrine

Among households with pit latrines at the sub-superstructure level, 29.8% lacked hand washing facilities at the entrance, a significantly higher percentage compared to the three households equipped with such facilities (p-value = 0.004). Regarding hygiene and cleanliness, 66.3% of households using pit latrines at the superstructure level considered their latrine to be in good condition, compared to 32.4% of those using latrines at the sub-superstructure level; this difference was statistically significant (p-value = 0.001). For waste disposal from filled pit latrines, 31.3% of households with sub-superstructure level latrines chose to dig a new pit for a new latrine, a statistically significant method (p-value = 0.024). However, households at both construction levels equally practiced manual emptying and rendering the contents safe as alternatives for managing human waste when the latrine fills up. (See table 3)

Multivariate analysis for socio-demographic, behavioural factors and health risk of incomplete construction levels.

[Table 4] presents the adjusted association of socio-demographic, behavioral, and public health risk factors with incomplete pit latrine construction levels, highlighting statistically significant variables post-adjustment.

Table 3: Multivariate analysis for socio-demographic, behavioural factors and health risk of incomplete construction levels.

Model type	**Restricted model**		**Adjusted model**		
Predictor(s)	**COR**	**P-value**	**AOR**	**P-value**	**95% CI [,]**
Ubudehe category					
Ubudehe 1	2.88	0.012	2.20	0.131	(0.79,6.08)
Ubudehe 2	2.08	0.013	1.90	0.059	(0.97,3.82)
Ubudehe 3(Ref)	1.00		1.00		
Perceived latrine Security (collapse)					
unconcerned (Ref)	1.00		1.00		
Concerned	5.81	<0.001	3.70	0.003	**(1.56,8.95) ***
Neutral	3.15	0.008	2.90	0.036	**(1.07,7.90) ***
Perceived latrine privacy					
Poor	4.90	<0.001	3.20	0.004	**(1.44,6.99) ***
Neutral	omitted		omitted		
Good	omitted		omitted		
Very good (Ref)	1.00				
Perceived access to construction materials for building					
Hardly accessible	3.20	<0.001	1.20	0.376	(0.34,1.49)
Somewhat accessible (Ref)	1.00		1.00		
Very accessible	0.91	0.897	0.90	0.833	(0.14,4.66)
How deal with waste from your filled pit latrine?					

Dig new pit	2.38	0.013	4.00	0.001	**(1.77,9.20) ***
Manual emptying of contents (Ref)	1.00		1.00		
Render contents safe to empty manually	1.05	0.945	1.20	0.823	(0.23,6.03)
Latrine hygiene and cleanliness					
Good (Ref)	1.00		**1.00**		
Poor	4.37	0.249	19.00	0.354	(0.59,4.34)
Very poor	4.18	<0.00 1	1.60	0.122	(0.45,803)
Hand Washing Facility at the entry point					
Fair (Ref)	1.00		1.00		
Present	9.50	0.114	3.90	0.46	(0.10, 151.9)
None	8.06	0.005	3.60	0.143	(0.64, 20.03)

While the socio-economic category (*Ubudehe*) initially showed an association in bivariate analysis, this association did not persist after adjusting the odds ratios. Households' risk perception emerged as a significant factor influencing pit latrine construction levels. Concern about latrine security (risk of collapse) among households, whether expressing concern or neutrality, showed 3.7- and 2.9-times higher likelihoods of being associated with sub-superstructure construction level pit latrines compared to those perceiving no concern (OR: 3.7, 95% CI: 1.56-8.95 and OR: 2.9, 95% CI: 1.07-7.90) respectively.

Regarding privacy perceptions of households' pit latrines, those perceiving poor privacy were 4.9 times more likely to have sub-superstructure level pit latrines than those perceiving neutral or good privacy (OR: 4.9, 95% CI: 1.44-6.99). Lastly, in terms of managing filled pit latrines, households opting to "dig a new pit" were 4.0 times more likely to have sub-superstructure construction levels, with an odds ratio (OR) of 4.0 and a 95% confidence interval (CI) ranging from 1.77 to 9.20.

Discussion

This study focused on Karongi district's rural households in Rwanda, examining the prevalence, contributing factors, and public health risks associated with inadequate pit latrine construction. Among 288 surveyed households, findings revealed that the most common incomplete construction level for pit latrines was the superstructure, observed in 73.6% of cases. This aligns closely with the 79.2% reported in a similar survey conducted on latrine completion levels in Northern Ghana.[12] Furthermore, the current study showed that sub-superstructure levelled pit latrines accounted for 26.4 %, which is closer to Rwanda national survey finding of 28% of rural households-latrines with poor slabs and superstructure deficiencies.[19]

The current study examined factors significantly influencing the construction levels of pit latrines. It found that households perceiving higher risks and expressing concerns about latrine security (specifically collapse risks) were more likely to have pit latrines at the sub-superstructure level. Similarly, those who rated their own pit latrine privacy as poor also had a higher prevalence of sub-superstructure level latrines. Additionally, the practice of digging new pit latrines was predominantly observed among households with sub-superstructure level latrines compared to those with pit latrines that reached the roof level (superstructure) (see Table 4).

The study employed the RANAS (Risks, Attitudes, Norms, Abilities, and Self-regulation) model systematically to assess variables related to the construction state of pit latrines in the study area. This approach facilitated the analysis and quantification of various behavioral characteristics. Regarding risk factors, the findings highlighted a significantly heightened perception of latrine collapse risk among households with sub-superstructure level latrines. Furthermore, the study revealed that households with sub-superstructure level latrines were notably dissatisfied with the privacy status of their latrines, rating it as poor. Nevertheless, the study underscores latrine privacy as a critical motivating factor for latrine construction. In a study conducted in Ethiopia, the expectation of privacy offered by walls, roof, and door increased the likelihood of completing a latrine by nearly 60%.[20]

The current findings align with the contradicting fact that, although it is widely acknowledged, a household's behavior can be stimulated and shaped by the individual perceived risk of a practice.[8] A significant portion of households with pit latrines held at the sub-superstructure level significantly perceived the risk of latrine collapse and poor latrine privacy. This paradoxical phenomenon is explained by the evidence that the adoption of healthy behavior is dependent upon multiple factors such as ability, social norms and self-efficacy maintained over time.[8] Moreover, a qualitative study conducted in Benin suggested that the primary motivation for latrine construction, which extended beyond health risks, was often driven by a person's sense of self-worth or prestige, rather than solely their perception of danger.[21]

Attitude and ability factors, such as cost to access latrine building materials and knowledge of latrine construction were measured to ascertain households' confidence and ability that influence beliefs or perceptions and potential trade-offs between costs and benefits of constructing pit latrine to its optimal level.[22] The same elevated ratios among households relying on sub-superstructure level pit latrines still perceived access to latrine construction materials to be expensive (36.7%), and not knowledgeable about latrine construction (28.2%). However, the measure of the knowledge in this study has not exclusively determined the specific technical parameters regarding latrine construction, hence submitting to the future studies to properly quantify knowledge to the best insight's basis fitting rural population and other similar contextual aspects.

Social norms play a crucial role in influencing behavioural change. In this study, when asked about the frequency of encountering faeces in the open environment, a higher percentage of households (32.1%) with sub-superstructure level pit latrines reported encountering this phenomenon often, compared to 24.4% who reported encountering it rarely. This finding aligns with the RANAS Theory, which asserts that norms widely accepted by the majority of the population tend to shape

habits over time. [23]. Households using sub-superstructure level pit latrines in this survey might have considered open defection practice as typically acceptable in community, hence discoursing the effort to build latrine towards completion level.

This study sought health risks linked to incomplete construction level of pit latrine, and digging new pit latrine followed by immediate pit emptying emerged as significant variable in relation to sub-superstructure level pit latrines. However, it was discovered that the impact of transitional time, specifically the duration of building new latrine was noted to contribute to an escalation in open defecation instances [24]. Thus, the delayed or extended period of digging new pit during the transition from an old to a new latrine may intensify the prevalence of open defecation practices in Karongi district, rural area, thus posing significant environmental health risks. Furthermore, traditional method of manual pits emptying was the second most common option to manage filled pits, despite such approach was reported being hazardous, since often is done with bare hands and no other protection equipment in most rural settings [25]. In the study area, traditional emptying using manual method is anticipated to rise given that flush pour pit latrine type was ranked second after basic pit latrine, and this follows the agricultural advantage in producing locally affordable fertilizers. On the other hand, this region is so mountainous making possible human waste washed into rivers and lac Kivu down hills. The study, therefore, recommends future research in the same region to explore the practice of emptying the filled pits and lay the ground for safe soil and water environment.

Observations of latrine cleanliness in sub-superstructure level pit latrines revealed a stark disparity, with 61 households rated as "very poor" compared to only 1 household rated as "good." These latrines were characterized by their shallow depth, unclean conditions, infestations of flies, and unpleasant odors. Concerningly, these findings echo similar challenges identified in Ethiopia, where a majority (42%) of pit latrines exhibited similar issues of dirtiness, shallowness, foul odors, fly infestations, and inadequate sanitation facilities.

Moreover, the study highlighted critical issues related to access to water sources (barely accessible for 30.6% of households), availability of essential handwashing facilities like Kandagira ukarabe and soap (absent in 29.8% of households), and the infrequent practice of handwashing among households (reported as rarely practiced by 32%). These factors underscore the broader challenges faced by households in maintaining proper sanitation and hygiene practices, including the prevalence of open defecation within the study area. [26]. These results emphasize the significance of understanding factors and health risk linked incomplete construction of pit latrines in rural households, to ensuring that everyone has access to improved latrine facilities in their households, ultimately contributing to the elimination of open defecation.

Conclusion

The study, conducted among 288 households, found that 73.6% successfully completed their pit latrines to the superstructure (roof-based) level, while 26.4% remained at the sub-superstructure level. This underscores the need for rural households to prioritize upgrading their pit latrine construction levels to ensure access to basic sanitation facilities. Drawing on the RANAS theory, the study highlighted that perceptions of latrine security risks (collapse concerns) and poor latrine

privacy were statistically associated with sub-superstructure construction levels. Conversely, households achieving desired construction levels were influenced by factors including risk perception, attitudes/abilities (access to materials, construction knowledge), norms (societal views on open defecation), and self-regulation.

Concerns were also raised regarding health risks associated with managing filled pit latrines, particularly through practices like digging new pits and immediate manual emptying, which is prevalent among households with sub-superstructure level latrines. Additionally, challenges such as limited access to clean water sources and infrequent handwashing persisted among these households, exacerbating risks of hygiene-related diseases. In conclusion, the study emphasizes the urgent need to improve pit latrine construction levels and address associated public health risks in rural households of Karongi and similar communities. Efforts should focus on community education and interventions aimed at abandoning incomplete pit latrine constructions to enhance sanitation and hygiene practices effectively.

Recommendations

This study recommends that the authorities of Karongi district to intensify sanitation awareness initiatives, focusing on educating communities about risk awareness. These initiatives should integrate closely related subjects such as community norms, cues to attitudes and abilities, and self-efficacy among individual families to promote complete levels of pit latrine construction. Furthermore, the findings suggest establishing supportive mechanisms to regulate the emptying of filled pits to mitigate associated health risks. Given the projected increase in pour flush pit latrine typologies that require regular emptying for sustainability, proactive measures are crucial.

Suggestions for Further Study

Based on the observed prevalence of two major construction levels, future studies should investigate detailed variations in these levels to provide deeper insights into the causal relationships behind incomplete construction levels and their contributing factors. Additionally, this study did not focus on determinants of specific technical parameters related to latrine construction. Therefore, future research should address these aspects to further enhance understanding and inform effective interventions.

Authors' Contributions

This work was carried out in collaboration between all authors. VT, and AH who participated in conceiving the study and in the development of data collection tools. RN participated in the data analysis. Authors read and approved the final manuscript.

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Conflicts of Interest

All authors declare no conflict of interest.

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