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ORIGINAL ARTICLE

Factors associated with perception of bad odor by users of ventilated improved pit latrines in Cape Coast, Ghana

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Abstract
Perception of bad odor in sanitation facilities is one of the causes of open defecation, which is a major cause of water pollution in developing countries. This study assessed how users of ventilated improved pit (VIP) latrines in Cape Coast, Ghana, perceive the level of odor in their latrines and identified the factors associated with perception of bad odor. A total of 211 users of 127 VIP latrines were purposively sampled from selected communities within the City. A semi-structured questionnaire was used to obtain information on the users' perception of the odor level measured on an ordinal scale. The questionnaire also enquired the users' characteristics and observations about the hygienic conditions of their toilets. An inspection checklist was used to assess the design and construction features of the latrines as well as the usage and maintenance practices. It was found that having a stake in a latrine's ownership reduces the odds for perceiving bad odor in the latrine while attainment of higher education increases the odds. Furthermore, perception of bad odor was found to be more associated with the usage and maintenance practices (such as fouling of the squat hole or seat with excreta and mismanagement of used anal-cleansing materials) rather than the design and construction of the latrines. The findings of the study underscore the need to accompany the provision of sanitation facilities with user hygiene, as highlighted in the sanitation target of the sustainable development goals, else physical facilities alone cannot provide a guarantee against open defecation.

Keywords Odor perception · Sanitation · Ventilated improved pit latrine · Cape Coast · Ghana

Introduction

Hygienic disposal of human excreta is a key issue in irrigation and drinking water safety management and, hence, a critical determinant of the health and productivity of the populace (Naughton and Mihelcic 2017). This explains the inclusion of the sanitation target (Target 6.2) in the Sustainable Development Goals (SDGs) (United Nations 2015). Under Target 6.2 of the SDGs, the World is seeking to "*achieve access to adequate and equitable sanitation and hygiene for all and end open defecation*" by the year 2030. The sanitation target also includes "*paying special attention to the needs of women and girls and those in vulnerable situations*". Among those in vulnerable situations are the residents of cities in less developed regions of the world, notably Sub-Saharan Africa and Southern Asia, where the attainment of the sanitation target is envisaged to be a major challenge (United Nations 2018). In spite of the concerted international effort and huge investments, the Millennium Development Goals' (MDGs) target on sanitation could not be attained, with 2.3 billion people, mostly from these regions, still lacking access to basic sanitation services and 892 million practising open defecation (United Nations 2018).

The practice of open defecation is recognised by the World Health Organisation (WHO) as the riskiest sanitation practice (WHO 2013). The risk associated with open defecation and indiscriminate disposal of human excreta arises from the damaging effect of the pathogenic content of excreta on human health (Mara et al. 2010). Obviously, open defecation is a major contributory factor to the 40 million disability-adjusted life years which the Global Burden of Disease (GBD) study attributes to lack of access to basic sanitation services around the world (GBD 2017). Hence, the attainment of universal access to basic sanitation facilities and their consistent usage to avoid open defecation is not just a goal in itself but also a means to achieving other goals.

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It is intrinsically linked to the attainment of other SDGs such as ending poverty (SDG 1), ending hunger and achieving improved nutrition (SDG 2) and ensuring healthy lives and promoting well-being (SDG 3) among others (WASHwatch 2019).

The challenge of improving access to sanitation for those in vulnerable situations has not necessarily been a challenge of providing state-of-the-art conventional sewerage with flush toilets as in developed countries. It has often focused on providing access to the very simple and affordable facilities that meet the basic requirement of disposing of excreta in such a way to reduce the risk of faecal–oral transmission to its users and the environment. In Sub-Saharan Africa, for example, pit latrines account for more than half of the sanitation coverage (Nakagiri et al. 2016). Globally, the various forms of pit latrines were estimated to serve a total of 1.77 billion in 2013 (Graham and Polizzotto 2013). Their low cost of construction and maintenance as well as their simplicity of operation, among other advantages, make them most suitable in low-income settings. However, the poor level of service and convenience offered by some of these 'affordable' sanitation technologies raises concerns over whether the proportion of the population that have access to them actually use their facilities consistently. Studies such as Keraita et al. (2013), Obeng et al. (2015) and Nakagiri et al. (2016) have reported various barriers that are associated with the consistent use of pit latrines.

Among the barriers to use of latrines, user perception of bad odor is frequently cited as a reason for not using available facilities (Appiah and Oduro-Kwarteng 2011; Keraita et al. 2013; Obeng et al. 2015). It tends to compel some expected users of latrines to rather resort to the practice of open defecation (Obeng et al. 2015). Therefore, user perception of bad odor in sanitation facilities could trigger open defecation and derail the attainment of the sanitation target of the SDGs. This makes the identification and control of factors that may increase the chances of a latrine user perceiving bad odor in his or her latrine crucial to the success of the SDG 6 and its interconnected goals such as promotion of healthy lives and well-being.

This study focused on the use of the ventilated improved pit (VIP) latrine whose technical design places emphasis on odor control. The main feature of the VIP latrine that is responsible for controlling odor is the movement of external air into the cubicle through a window or other openings in the superstructure. The air then enters the pit through the squat hole to displace relatively warmer, malodorous air through the vent pipe and into the atmosphere. The scientific principles that govern this process and, hence, the ventilation rate through the vent pipe, are detailed in works such as Kalbermatten et al. (1980), Ryan and Mara (1983a, b), Mara (1984), Cotton et al. (1995) and Obeng et al. (2019a, b). To achieve optimum performance, these published works discuss various design and operational criteria that are to be followed in the construction and usage of the latrine. Among others, they recommend that

- the vent pipe should be installed to an effective height of at least 500 mm (i.e. 500 mm above the highest point of the roof) for slanted roofs; in the case of conical roofs, it should be installed to the apex;
- vent pipes should have a minimum diameter of 150 mm if they are made of PVC pipes but, where the local wind speeds exceed 3 m/s, 100 mm may be used;
- a window or other openings should be provided only on one side (the windward side) of the superstructure but not in other sides; this is to ensure that air entering the superstructure is pushed through the squat hole into the pit rather than escape through openings in other sides of the superstructure;
- the use of insect screens in windows should be avoided to prevent loss of air pressure across the screen; air pressure in the latrine cubicle is understood to be responsible for pushing the air into the pit.

If properly designed and constructed, the VIP latrine is said to be capable of affording its users most of the health benefits and convenience of water-borne sanitation (Kalbermatten et al. 1980; Ryan and Mara 1983a). However, the usage and maintenance practices could potentially create unhygienic conditions and generation of bad odor just as it is with any other sanitation technology. This, probably, underscores the inclusion of hygiene in Target 6.2 of the SDG alongside access to the physical sanitation facility (United Nations 2015). Furthermore, the call to "paying special attention to the needs of women and girls" (United Nations 2015) make it imperative to also assess how user characteristics such as gender and educational background may predispose some user groups to perceiving bad odor in their latrines. Hence, the objective of this paper is to assess how users of VIP latrines in Cape Coast perceive the level of odor in their latrines and to examine any association between the perception of odor and selected user characteristics, latrine design and construction factors as well as usage and maintenance practices.

Materials and methods

Overview of the study area

The Cape Coast Metropolitan Area (CCMA) is the capital of Ghana's Central Region. It has a population of 169, 894 based on Ghana's 2010 population and housing census, with 48.7% males and 51.3% females and an annual growth rate of 3.1 per cent (GSS 2012). The

city is located between 5°07′–5°20′ N and 1°11′–1°41′ W (CCMA 2014) and occupies a land area of 122 km^2, which is bounded on the south by the Gulf of Guinea (Ghana Districts 2019). Cape Coast has a tropical climate with average minimum and maximum temperatures of 24 and 32 °C, respectively, total annual rainfall ranging between 750 and 1000 mm (CCMA 2014) and average wind speed of 2.8 m/s (Myweather2.com 2019).

In the absence of more recent data, estimates of sanitation coverage in Cape Coast are based on Ghana's 2010 national population and housing census, which indicated that nearly half of households in the Metropolis have no private sanitation facilities. Forty percent (40%) of those without their own toilets depend on public toilets while the rest (9%) practise open defecation. In terms of technology options, 34% use water closet toilets while 11% depend on VIP latrines (GSS 2012). Pipe-borne water is supplied by the Ghana Water Company Limited, which is the main urban water utility in Ghana, but their service is supported at the fringes of the Metropolis with mechanised boreholes and hand-dug wells provided by the Community Water and Sanitation Agency (CWSA), which is responsible for rural and small town water supply in Ghana (CCMA 2014).

Study design and operational definitions of variables

The study was designed as a quantitative, cross-sectional study to assess the association between the perception of bad odor by a latrine user and a number of binary factors relating to the characteristics of the user, the design and construction of the latrine, and the usage and maintenance practices of the latrine. Table 1 summarises the definitions of the factors and the pairs of cohorts into which the latrine users were grouped.

Sampling of latrines and study participants

A non-probabilistic approach was adopted in the identification and selection of VIP latrines due to the generally low coverage of sanitation facilities. However, to make the sample representative of the City, some specific types of settlements that may have peculiar defecation practices and perceptions about latrine usage were purposively targeted. These included the Bakaano and Ntsin Communities, which represented communities along the coastal line, where the beaches are often used as open defecation sites, and the Ebubonko and Kwaprow Communities that represent those at the outskirts of the City where surrounding bushes

Table 1 Summary of selected factors and their operational definitions

Factors	Operational definition	Cohorts
User characteristics		
Sex	Sex of respondent	1. Male 2. Female
Residential status	Whether respondent is part of the house (or toilet) owner's family or a tenant	1. Owner or family member 2. Tenant
Attainment of basic education	Whether or not respondent completed basic education (Junior High School)	1. Attained basic education 2. No basic education
Exposure to tertiary education	Whether or not respondent is a graduate/student of a tertiary institution	1. Graduate/tertiary student 2. No tertiary education
Latrine design and construction factors		
Effective height of vent pipe	Whether or not vent pipe reaches recommended height (500 mm above roof)	1. Up to recommended height 2. Below recommended height
Window placement	Whether a window is provided on single or multiple sides of superstructure	1. Window in only one side 2. Windows in multiple sides
Use of window insect screens	Whether or not an insect screen is fitted in window(s)	1. Screen fixed in window(s) 2. No screen in window(s)
Latrine usage and maintenance practices		
User exposure to faeces	Whether or not a respondent saw faeces on toilet seat or squat hole on last visit	1. Saw faeces around seat/hole 2. Saw no faeces
User exposure to urine	Whether or not a respondent saw urine on toilet seat or floor on last visit	1. Saw urine on seat or floor 2. Saw no urine
User exposure to flies	Whether or not a respondent encountered flies in the latrine cubicle on last visit	1. Saw flies in the cubicle 2. Saw no flies in the cubicle
Disposal of used anal-cleansing material (ACM)	Whether or not used ACM is disposed on the floor of the latrine cubicle	1. ACM disposed on the floor 2. No ACM on the floor

and vegetation may also be used for the same practice. The Kotokuraba and Ewim Communities were also selected from the Central Business District to represent heavily built-up areas with no or very limited sites for open defecation. Further, the Apewosika, Amamoma and Amissano Communities were also selected from the neighbourhood of the University of Cape Coast and the Cape Coast Technical University to increase the prospects of having some study participants with tertiary education.

A VIP latrine was identified and classified as such if a latrine were found fitted with a vent pipe and required no water for regular operation other than cleaning purposes. Random walks were used to search for houses with such latrines that were used privately at home and not open to the general public. A total of 127 of such latrines were identified and enrolled with the consent of the owners. For each latrine, the owner and two other users, a male and a female, were targeted for the latrine users' survey. For latrines shared by multiple households, the two users included at least one from a tenant household or outside the latrine owner's household. In all, 211 latrine users who were available and willing to participate in the study were surveyed but one respondent who provided incomplete response to some questions was invalidated and excluded from the analysis, leaving a total of 210 for analysis.

Data collection

Data on the latrine design and construction factors and the usage and maintenance practices were collected by direct observation with the aid of an inspection checklist. On the other hand, user characteristics and perception of the level of odor were obtained through a semi-structured questionnaire. In the questionnaire, the respondents were asked to indicate how the perceived the level of odor in their latrine on the previous visit on an ordinal scale of 'bad', 'just okay' and 'no bad odor'. Those that were not sure of how they perceived the level of odor on their previous visit were recorded as 'not sure' and excluded from the analysis. The questionnaire, which was anonymised to conceal the identities of the respondents, was administered by a field assistant who also conducted the latrine inspection.

Data analysis

For each factor, the respondents were grouped into the two cohorts and the proportions of each cohort that rated their perception of odor in their latrine as being 'bad', on one hand, and 'just okay' or 'no bad odor' on the other hand were recorded. Association between the perception of bad odor and the various factors was determined using the Pearson' Chi-squared test while odds ratios were used to indicate the strength of the association based on 2×2 contingency tables. The analysis was done using the SPSS statistical software. Even though data on the diameters of vent pipes were collected, they were not included in the analysis of the results because all the latrines were found to be fitted with the same size of vent pipes (100 mm) so there was no basis for assessing the effect of the size of vent pipes on user perception of odor.

Results and discussion

Overview of latrine users' perception of odor

Figure 1 shows the distribution of the three levels of odor perception ('bad', 'just okay' and 'no bad odor') among the latrine users. Over 80% of the latrine users perceived the level of odor in their latrines to be either just okay or no bad odor at all. It is noted that those who perceived bad odor in their latrines (18%) are less than those who perceived no bad odor. Nearly two-third (63%) of the users found the level of odor in their latrines to be just okay.

This result is consistent with the assertion that the VIP latrine design concept is capable of addressing the challenge of bad odor that is associated with the simple pit latrine (Mara 1984; Obeng et al. 2016). Obeng et al. (2016) established a significant correlation between the perception of odor measured on the same scale adopted in this study and the concentration of hydrogen sulphide gas measured in latrine cubicles in Southern Ghana. The study reported that the average concentration of the gas measured in VIP latrines (0.03 ppm) was within the WHO threshold of the

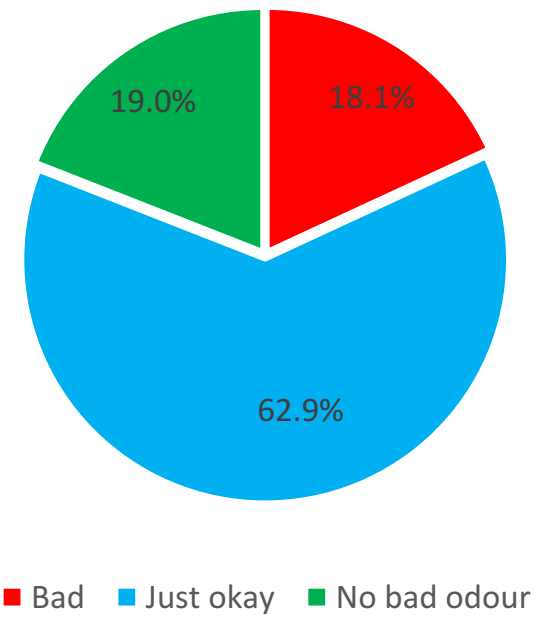

Fig. 1 Overview of latrine users' perception of odor level

gas for the prevention of "substantial complaints about odor annoyance" (0.05 ppm) (WHO 2000). In that study, the average concentration of the gas measured in simple pit latrines was 0.13 ppm. The analysis of factors that could potentially contribute to the perception of bad odor among some of the users is presented in the next section.

Potential factors associated with perception of bad odor

Latrine user characteristics and odor perception

Among the latrine user characteristics that were examined, the residential status of the user and exposure to tertiary education have significant association with the perception of bad odor while sex and the attainment of basic education have no significant association with perception of bad odor. It can be seen from Table 2 that latrine users who either owned or had some ownership stake in the latrine as a member of the landlord's family have a reduced odds for perceiving bad odor in their latrines as compared to tenants (OR 0.28; CI 0.14, 0.59). The result implies that landlords or their family members are only 28% likely to perceive bad odor in their latrines as compared to tenants. This suggests that a sense of ownership of a latrine facility boosts a user's tolerance for the level of odor and could be a key to consistent usage and prevention of open defecation. This supports arguments for each household to have their own latrine as emphasised during the Millennium Development Goals era.

It is also seen from Table 2 that users who have been exposed to tertiary education, i.e. either graduates or students of tertiary institutions are more than 200% more likely to perceive bad odor in their latrines as compared to those who have no exposure to tertiary education (OR 2.17; CI 1.01, 4.70). The tendency for highly educated people to perceive bad odor in their VIP latrines may be attributed to a generally higher sense of personal hygiene which makes them demand a higher level of service from their sanitation facility. It may also be attributed to their exposure to the use of water closet toilets, which perform better in the control of odor, in their institutions of higher learning and hence makes them intolerant of the odor level in the VIP latrines. In their study, Obeng et al. (2016) found the average concentration of hydrogen sulphide in water closet toilets to be 0.01 ppm as compared to 0.03 ppm found in VIP latrines.

Latrine design and construction factors

None of the latrine design and construction factors, namely effective height of vent pipe, window placement and installation of insect screens in windows, was found to be significantly associated with perception of bad odor. Generally, these factors could be associated with the perception of odor in a VIP latrine due to their known potential to influence the ventilation rate through the vent pipe (Mara 1984). Nevertheless, their effect on the ventilation rate has been found to be less important as compared to the diameter of the vent pipe and the local wind speed whose combined effect has been found to explain 78% of variations in the ventilation rate (Obeng et al. 2019b). Unfortunately, all the latrines sampled in this study were fitted with the same size of vent pipe (100 mm) so the effect of the size of the vent pipe could not be assessed. Thus, the confounding effect of the local winds and the common diameter could render the effect of the other design and construction factors insignificant.

Besides the above explanation, the height of the vent pipe, in particular, has been found to have no significant effect on the ventilation rate and only needs to be high enough to direct malodorous air from the latrine pit into the atmosphere rather than to be dispersed in the immediate surroundings of the latrine (Obeng et al. 2019b). Regarding the placement of windows, recent studies have discovered that, even though placing windows in only the windward side of the superstructure achieves better ventilation through the vent pipe, the placement of windows in multiple sides of the superstructure has also been found to be capable of achieving the recommended ventilation rate and, therefore, poses no risks of development of offensive odor in the latrine (Obeng et al. 2019a, b). Furthermore, it has been found that the advantage of providing a window in only one side of the superstructure is completely reversed in the event where the only side with the window fails to be the windward side, probably due to ignorance, or changes in the local wind direction after the latrine has been constructed.

It is imperative to note that only less than one-fifth of the users perceived bad odor in their latrines in spite of all the latrines not satisfying the minimum size of vent pipes. With the average wind speed being less than 3 m/s, it is expected that 150-mm instead of 100-mm vent pipes would be used (Mara 1984). Apart from this, it is also noted that perception of bad odor among the 18% of users is not even associated with failure to comply with the technical guidelines that were examined. These findings imply that it is more important to get people to build toilets, in the first place, without any overbearing emphasis on satisfying some technical guidelines, probably, other than those related to ground water pollution.

Latrine usage and maintenance practices

All the usage and maintenance practices that were examine are significantly associated with perception of bad odor. These factors, namely exposure of faeces or urine on the seat or floor, presence of flies in the cubicle and the management of used anal-cleansing material are directly related to the hygienic use and cleanliness of the latrines.

Table 2 Analysis of association between odor perception and selected factors

Factor	Did latrine user perceive bad odor?			Pearson χ^2 (p value)	Odds ratio[a] (95% CI)
Cohort 1 Cohort 2	Yes *N* (% within cohort)	No *N* (% within cohort)	Total (% of cohort in sample)		
Sex					
Male	19 (20.4)	74 (79.6)	93 (44.3)	0.614 (0.433)	1.32 (0.66–2.68)
Female	19 (16.2)	98 (83.8)	117 (55.7)		
Total	38 (18.1)[b]	172 (81.9)[b]	210 (100)		
Residential status					
Landlord or family member	14 (10.8)	116 (89.2)	130 (61.9)	12.358 (0.000)**	0.28 (0.14–0.59)
Tenant	24 (30.0)	56 (70.0)	80 (38.1)		
Total	38 (18.1)	172 (81.9)	210 (100)		
Attainment of basic education					
Attained basic education	33 (18.3)	147 (81.7)	180 (86.1)	0.02 (0.887)	1.08 (0.38–3.03)
No basic education	5 (17.2)	24 (82.8)	29 (13.9)		
Total	38 (18.2)	171 (81.8)	209 (100)		
Exposure to tertiary education					
Graduate/tertiary student	13 (28.3)	33 (71.7)	46 (22.0)	4.03 (0.045)*	2.17 (1.01–4.70)
No tertiary education	25 (15.3)	138 (84.3)	163 (78.0)		
Total	38 (18.2)	171 (81.8)	209 (100)		
Effective height of vent pipe					
Up to recommended height	20 (19.4)	83 (80.6)	103 (49.0)	0.238 (0.625)	1.19 (0.59–2.41)
Below recommended height	18 (16.8)	89 (83.2)	107 (51.0)		
Total	38 (18.1)	172 (81.9)	210 (100)		
Window placement					
Window in only one side	25 (18.5)	110 (81.5)	135 (70.3)	0.016 (0.899)	0.95 (0.43–2.09)
Windows in multiple sides	11 (19.3)	46 (80.7)	57 (29.7)		
Total	36 (18.8)	156 (81.2)	192 (100)		
Use of window insect screen					
Screen fixed in window(s)	6 (20.0)	24 (80.0)	30 (14.3)	0.086 (0.770)	1.16 (0.44–3.06)
No screen in window(s)	32 (17.8)	148 (82.2)	180 (85.7)		
Total	38 (18.1)	172 (81.9)	210 (100)		
User exposure to faeces					
Saw faeces around seat/hole	12 (35.3)	22 (64.7)	34 (16.6)	7.580 (0.006)**	3.04 (1.34–6.89)
Saw no faeces	26 (15.2)	145 (84.8)	171 (83.4)		
Total	38 (18.5)	167 (81.5)	205 (100)		
User exposure to urine					
Saw urine on seat or floor	16 (34.8)	30 (65.2)	46 (22.2)	11.518 (0.001)**	3.56 (1.67–7.61)
Saw no urine	21 (13.0)	140 (87.0)	161 (77.8)		
Total	37 (17.9)	170 (82.1)	207 (100)		
User exposure to flies					
Saw flies in the cubicle	28 (30.4)	64 (69.6)	92 (44.9)	15.647 (0.000)**	4.51 (2.05–9.90)
Saw no flies in the cubicle	10 (8.8)	103 (91.2)	113 (55.1)		
Total	38 (18.5)	167 (81.5)	205 (100)		
Disposal of used ACM					
Used ACM disposed on the floor	19 (26.0)	54 (74.0)	73 (34.8)	4.750 (0.029)*	2.19 (1.07–4.46)
No used ACM on the floor	19 (13.9)	118 (86.1)	137 (65.2)		
Total	38 (18.1)	172 (1.9)	210 00)		

**Significant at 1% confidence level; *significant at 5% confidence level; source: computations from own field data, 2019

[a]Odds ratio for cohort 1 with reference to cohort 2. [b]Percentage of bad odor within both cohorts 1 and 2

Users who reported seeing faeces exposed around the squat hole or seat and those who saw urine on the seat or floor were more than 300% and 350% respectively more likely to perceive bad odor in the latrines. As flies are attracted to bad odor, the presence of flies in the latrine cubicle is also strongly associated with the perception of bad odor (OR 4.51; CI 2.05–9.90). Furthermore, the disposal of used anal-cleansing material on the floor, instead of dropping them in the latrine in accordance with sound hygienic practice (Mara 1984), makes the users 219% more likely to perceive bad odor.

These findings reveal the important role the hygienic maintenance of latrines play in the prevention of bad odor as compared to the technical design and construction of the latrine. This justifies the specific mention of hygiene for all in the sanitation target of the SDGs (United Nations 2015). It also underscores the need to accompany the provision of physical facilities with hygiene and user education to ensure that the users will adopt the best usage and maintenance practices. In other words, it affirms the assertion that sanitation is not just a device but rather "*a process whereby people demand, effect and sustain a hygienic and healthy environment for themselves*" (UNICEF 1997; pg. 2).

Conclusions

From the results of this study, it can be concluded that having a stake in the ownership of a latrine reduces the odds for perceiving the facility as smelling bad and would, therefore, encourage regular usage. Hence, people should be encouraged to build their own latrines or pull resources together with other households to build and co-own latrines. It is also concluded that the perception of odor in VIP latrines is more associated with the usage and maintenance practices of the latrine such as user attitudes and regular cleaning to prevent exposure of faeces and urine as well as the management of used anal-cleansing materials rather than the design and construction of the latrine. Thus, people will be more likely to use toilets that are hygienic and well maintained. Hence, in promoting regular latrine usage, emphasis should be placed on the usage and maintenance practices of the latrine users more than strict adherence to design and construction codes. The study also concludes that providing well-designed latrines without a corresponding hygiene and user education to instil a sense of personal hygiene and cleanliness in the users could still lead to problems of bad odor and may not necessarily lead to the prevention of open defecation. The findings of this study justify the inclusion of hygiene for all in the sanitation target of the sustainable development goals.

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Compliance with ethical standards

Conflict of interest The author declares that this work was funded from his own resources and has no conflict of interests.

Ethical approval Human respondents of the study were not subjected to any form of treatment or trial so no ethical clearance was sought. Questionnaires were anonymised to conceal the identities of the respondents.

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