

## Design and construction of household ventilated improved pit latrines: gaps between conventional technical guidelines and construction practices in Cape Coast, Ghana

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### Abstract

This study was conducted to identify the gaps that exist between ventilated improved pit (VIP) latrine construction practices in Cape Coast, Ghana, and conventional technical guidelines, and to assess how any non-compliance with technical guidelines influences the users' perception of odour and fly nuisances. An inspection guide was used to assess 127 VIP latrines, while a questionnaire survey was used to obtain feedback from 211 users of the latrines on their perception of odour and fly nuisance. Not a single latrine was found to be fitted with a vent pipe that satisfied the recommended diameter of 150 mm. Aside from the vent pipe diameter, only 5.5% of latrines complied with all four other design guidelines that were assessed. However, with the exception of failure to install insect screens on vent pipes, which was associated with the users seeing flies in the latrine cubicles, failure to comply with other guidelines did not necessarily lead to significantly higher user perception of the targeted nuisance. The findings of the study suggest that user perception of odour in their latrines may be more influenced by non-structural factors such as the management or cleanliness of the latrines rather than their structural designs.

**Key words:** Cape Coast, fly nuisance, latrine guidelines, odour perception, VIP latrine, ventilated improved pit

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### INTRODUCTION

Access to sanitation facilities is an important barrier to disease transmission and, for that matter, a key determinant of the health of the population (Mara *et al.* 2010; Naughton & Mihelcic 2017). Notwithstanding, open defecation, which is regarded as the riskiest sanitation practice (WHO 2013) is still practised by 892 million people around the world, with Sub-Saharan Africa accounting for a quarter of this population (United Nations 2018). As a consequence, the 2015 Global Burden of Disease Study estimated that 40 million disability-adjusted life years are attributable to lack of access to basic sanitation services alone (GBD 2017).

The search for solutions to the sanitation challenge in Sub-Saharan Africa, as in other resource-constrained regions, tend to focus on on-site sanitation systems due to the absence of sewerage systems in many parts of those regions. Around the world, an estimated 2.7 billion people depend on on-site sanitation systems (Strande 2014). Among users of on-site sanitation systems, over 65% use one form of pit latrine or another (Graham & Polizzotto 2013). In Sub-Saharan Africa, more than half of the urban population use pit latrines (Nakagiri *et al.* 2016). The widespread reliance

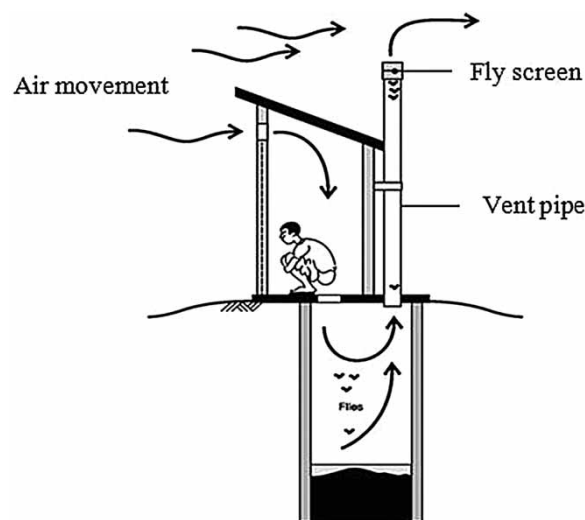
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on pit latrines in resource-constrained settings can be attributed to their numerous advantages: they are cheap, simple to construct, require only a small amount of water (mainly for cleaning purposes) and are compatible with use of various bulky anal cleansing materials (Nakagiri *et al.* 2016).

In Ghana, the various forms of pit latrines constitute the most popular sanitation technologies among the populace, with the previous two national population and housing censuses conducted in 2000 and 2010 estimating their coverage to be 29% and 30% respectively (GSS 2013). For the urban population, the growth in the use of pit latrines between the two censuses was higher than the national average, rising from 16% in 2000 to 26% in 2010. Considering the fact that the proportion of the urban population increased from 44% to 51% between the two censuses (GSS 2014), the 10% growth in the use of pit latrines represents quite a significant growth in the actual number of urban households resorting to the use of pit latrines.

In spite of their popularity, pit latrines, especially in their most basic form, are associated with the nuisance of intense odour and flies (Cotton *et al.* 1995; Obeng *et al.* 2016a) which tend to create a barrier to consistent usage (Obeng *et al.* 2015). This led to the development of the ventilated improved pit (VIP) latrine in which the provision of a vertical vent pipe with an insect screen fixed at the top, as shown in Figure 1, ensures the control of both odour and fly nuisances (Mara 1984). When properly constructed and maintained, the VIP latrine is said to be capable of affording its users most of the health benefits and conveniences of conventional sewerage at a much cheaper cost (Kalbermatten *et al.* 1980; Ryan & Mara 1983a).



**Figure 1** | The ventilation mechanism in a VIP latrine. Source: Harvey *et al.* (2002).

Odour control is achieved through the chimney effect, which allows the circulation of air from the superstructure into the pit via the squat hole and out via the vent pipe (Harvey *et al.* 2002). It is estimated that, a minimum of 10 m<sup>3</sup>/h of air flow through the vent pipe is required to achieve odourless conditions but 20 m<sup>3</sup>/h is recommended to ensure an adequate factor of safety (Ryan & Mara 1983a). The vent pipe is also responsible for controlling fly nuisance by directing flies produced in the pit to the external bright light at the top of the pipe where they are prevented from escaping by the insect screen and become dehydrated or fall back into the pit and die eventually (Brikké & Bredero 2003). To achieve optimum performance, a number of technical guidelines and design criteria are to be followed in the design and construction of the superstructure and the vent pipe. The scientific concepts underlying these technical guidelines have been detailed in classical works such as Kalbermatten *et al.* (1980), Ryan & Mara (1983a, 1983b), Mara (1984), among others, and

more recently by [Obeng \*et al.\* \(2016b, 2019a, 2019b\)](#). While directing the reader to these sources for the details, the most salient for the control of odour and fly nuisances are summarised in [Box 1](#).

**Box 1** | Some key VIP latrine design guidelines

To control the nuisance of odour and flies, the following are key technical guidelines to follow in the design and construction of VIP latrines ([Kalbermatten \*et al.\* 1980](#); [Feachem \*et al.\* 1983](#); [Ryan & Mara 1983a, 1983b](#); [Mara 1984](#); [Franceys \*et al.\* 1992](#); [Cotton \*et al.\* 1995](#)):

- **Diameter of vent pipe:** For a single-pit latrine, a minimum of 150 mm is recommended for PVC pipes, which is the commonest material in use. Where the local wind speeds exceed 3 m/s, 100 mm may be used. The essence of this guideline is to provide an adequate cross-sectional area at the top of the vent pipe over which the action of wind takes place to induce a suction effect in the vent pipe.
- **Effective height of vent pipe:** Defined as the clear distance between the highest point of the roof and the top of the vent pipe, a minimum of 500 mm is recommended to ensure that the top of the vent pipe, where the action of wind is crucial, is free from obstruction from the superstructure itself as well as the surrounding buildings and trees.
- **Insect screen on vent pipes:** This is highly recommended as the main barrier against entry of external flies into the pit through the vent pipe and to prevent escape of pathogen-carrying flies from the pit into the environment.
- **Positioning of windows:** Windows or other openings are to be provided to allow external air to enter the latrine cubicle and down the pit to flush malodorous air through the vent pipe. However, they should be provided only in the windward side of the superstructure. Windows in other sides of the superstructure serve as exit points for air and leads to a drop in the pressure by which the air is pushed through the squat hole.
- **Installation of insect screens in windows:** This is discouraged as it is thought of as reducing the air pressure in the latrine cubicle due to head loss across the screen.

For Ghana, no set of official guidelines for the construction of household VIP latrines was identified other than a variety of support tools prepared by various local and international non-governmental organisations (NGOs), which are essentially based on the above-cited conventional guidelines. Design and construction practices are not uniform, as different households adopt various design criteria that may be informed by their preferences, budgets or recommendations of local artisans. For instance, some latrines are lined while other are unlined; some users prefer seats or raised pedestals while others keep to the traditional squat hole; some have the superstructure built directly on the pit while others have it slightly offset from the pit.

Even though there is a growing interest in the use of the technology, the scientific community has not shown much interest in research to enhance the performance and user experience with the VIP latrine in recent times ([Obeng \*et al.\* 2019a](#)). In general, research and development in the use of pit latrines have not been given adequate attention ([Nakagiri \*et al.\* 2016](#)). The need to revive research and development of the VIP latrine is partly fuelled by observation of some modifications to the conventional design of the technology that conflict with established technical guidelines and best practices. Recent studies by [Obeng \*et al.\* \(2019a, 2019b\)](#) provide some insight into how some of these design modifications such as the provision of windows in multiple sides of the superstructure affect the ventilation mechanism, which is the key odour control factor in the VIP latrine. However, their study did not provide any user feedback on how those design modifications may affect the real-life experience of the users in terms of their perception of odour and fly nuisance.

This current study was conducted to identify the gaps that exist between VIP latrine construction practices in Cape Coast, Ghana, and conventional technical guidelines, and to assess how any non-compliance with technical guidelines influences the users' perception of odour and fly nuisances. The study focused on those technical guidelines that are aimed at controlling odour and fly nuisance.

## METHODOLOGY

### The study setting

The study was conducted in selected communities within the Cape Coast Metropolitan Area (CCMA), which is the administrative capital of the Central Region of Ghana. Geographically, the Cape Coast Metropolis is located between 5°07'–5°20'N and 1°11'–1°41'W (CCMA 2014). The City occupies a land area of 122 square kilometres, which is bounded on the south by the Gulf of Guinea (Ghana Districts 2019). The population of Cape Coast, based on Ghana's 2010 population census, is 169,894, comprising 82,810 males and 87,084 females, and has an annual growth rate of 3.1 per cent (GSS 2012). The current population and density are projected to be 186,159 and 1,520/km<sup>2</sup> respectively (City Population 2019). The City has a tropical climate with average minimum and maximum temperatures of 24 and 32 °C respectively and total annual rainfall ranging between 750 and 1,000 mm (CCMA 2014). The average wind speed is 2.8 m/s (Myweather2.com 2019). The topography of the CCMA is generally hilly, reaching up to 60 metres above sea level, with valleys in-between (MOFA, undated). The water table in most communities situated on hills is low and suitable for pit latrines whereas parts of the City that lie in the valleys tend to have high water table and experience water-logged conditions during the rainy season.

No recent data on sanitation coverage in Cape Coast has been published but the 2010 national population and housing census indicates that nearly half of households in the Metropolis have no private sanitation facilities. They either depend on public toilets (40%) or practise open defecation (9%), with 34 and 11% depending on water closet and VIP latrines respectively (GSS 2012). According to the CCMA's Water, Sanitation and Hygiene (WASH) Master Plan (CCMA 2014), the major source of water supply is the Ghana Water Company Limited, the main urban water utility in Ghana, which supplies water through 11,207 house connections and 114 public standpipes. In addition, the Community Water and Sanitation Agency (CWSA), which is responsible for rural and small town water supply in Ghana, facilitates the provision of mechanized boreholes and hand-dug wells for some communities in the Metropolis.

### Sampling of latrines and latrine users

Due to the generally low coverage of household or privately shared latrines, the study adopted a non-probabilistic approach in the identification and selection of VIP latrines. Nevertheless, a conscious attempt was made to represent some specific types of settlements within the City that may have peculiar defecation practices and perceptions about latrine usage. These included communities along the coastal line (Bakaano and Ntsin), where the beaches are often used as open defecation sites and those at the outskirts of the City (Ebubonko and Kwaprow) where surrounding bushes and vegetation may also be used for the same practice. Other communities (Kotokuraba and Ewim) were selected from the Central Business District, which is heavily built-up and leaves no or very limited sites for open defecation, and from the vicinity of the University of Cape Coast and the Cape Coast Technical University (Apewosika, Amamoma and Amissano) to increase the chances of having some study participants with tertiary education.

A latrine was presumed to have been intended to be a VIP latrine if it were found to be fitted with a vent pipe. Random walks were used to literally search for such latrines that were used by single households or privately shared by two or more households. In all, 127 such latrines whose owners gave

consent for inclusion in the study were enrolled. For each latrine, the owner and two other users, a male and a female, were targeted for the latrine users' survey. Where the latrine was shared by more than one household, the two users included at least one tenant or a user outside the latrine owner's household. Based on the composition of the users, their availability and willingness to participate in the study, a total of 211 latrine users were surveyed.

### Data collection methods

A latrine inspection guide was developed to assess the design and construction of the latrines. The design of the inspection guide was informed by a prior review of conventional VIP design and construction guidelines as summarised in [Box 1](#). The assessment was limited to those technical guidelines that are aimed at controlling odour and fly nuisance; namely, the diameter and height of the vent pipe, positioning of windows or other openings in the superstructure and the installation of insect screens at the top of the vent pipe and in windows or openings.

A questionnaire survey was used to obtain feedback from the latrine users regarding their perception of the level of odour and fly nuisance on their latrine. For the perception of odour, the users were asked to indicate how they found the level of odour in their latrine on their previous visit on a three-level ordinal scale as 'bad', 'just okay' or 'no bad odour'. For fly nuisance, the users were asked to indicate whether or not they saw flies in their latrine cubicles on their previous visit.

### Data analysis

The data was analysed to determine the proportions of latrines that satisfied each of the design criteria that were assessed. The feedback (perception of odour and fly nuisance) of users of latrines that failed to satisfy a particular guideline was compared to that of those whose latrines satisfied the guideline. This was done to determine any association between non-compliance to the guideline and the nuisance (odour or flies) that the guideline is intended to prevent.

For various groups of users, a composite (or average) perception of odour was determined following a procedure adopted by [Obeng \*et al.\* \(2016a\)](#). The three levels of odour perception ('bad', 'just okay' and 'no bad odour') were assigned numerical values of 1, 2 and 3 respectively, which were then used to determine a composite odour perception for various groups that were compared. Thus, a composite odour perception close to 1 indicates that most of the members of the group perceived the odour level on their latrines as being bad while a figure close to 3 indicates that most members perceived that there was no bad odour in their latrines. A test for normality of the odour perception data indicated that they were not normally distributed so a non-parametric method (Wilcoxon's test) was used to compare the odour perception of various pairs of groups.

Association between latrine designs and the users' perception of fly nuisance was tested based on the proportions of users in compliance and non-compliance groups who reported seeing flies in their latrines on their previous visit. Test for association was done using odds ratios based on  $2 \times 2$  contingency tables. The analysis of the data was done by a combination of Microsoft Excel and SPSS statistical software.

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## RESULTS AND DISCUSSION

### Diameter of vent pipes

All the VIP latrines found in the study communities were fitted with 100 mm diameter polyvinyl chloride (PVC) vent pipes. This appears to represent the general choice for VIP latrine vent pipes in Ghana as [Obeng \*et al.\* \(2019a\)](#) reported that all VIP latrines they found in Prampram, another

Ghanaian community in the Greater Accra Region, were fitted with 100 mm diameter vent pipes. The use of the 100 mm diameter vent pipes in an environment where the average wind speed (2.7 m/s) is less than 3.0 m/s may not be able to ensure effective odour control (Mara 1984), but there were no latrines with bigger vent pipes to allow a comparison of the respective users' perception of odour.

This study investigated the potential influence of economic factors on the seemingly universal choice of 100 mm diameter pipes instead of the recommended 150 mm with a survey of nine PVC pipe retail shops identified in the major shopping centres of Cape Coast. The survey revealed that the recommended 150 mm diameter pipes may not be easily adopted by low-income households because they are significantly more expensive and not readily available. While the average cost of a 3-metre long, 100 mm diameter PVC pipe in Cape Coast was found to be twenty-eight Ghana cedis sixty-five pesewas (GH¢ 28.65), which is equivalent to US\$5.31 (XE Corporation 2019), that of the same length of 150 mm diameter pipe is US\$15.97, or 300% the cost of the 100 mm diameter pipe. The extra US\$10.66 is about 540% of Ghana's daily minimum wage of US\$1.97 (Government of Ghana 2018). Beside the cost, only four out of the nine identified shops regularly dealt in that size of pipe, with the others explaining that they do not keep them in stock because of their low patronage, which may be attributable to their fewer applications in the Ghanaian construction industry. Outside the city centre, especially in small towns and rural settings, prospective VIP builders would most likely have to incur the additional cost of commuting to city centres to purchase a 150 mm diameter PVC pipe.

The above analysis suggests that there is a need to explore other opportunities for enhancing the ventilation rate other than simply recommending the use of 150 mm diameter vent pipes. Other opportunities may include identification of cheaper materials to fabricate bigger vent pipes or use of extraction units on top of the 100 mm diameter pipes. Nevertheless, the cost of such alternatives should be proven to be significantly lower than US\$10.66 and more readily available.

### Effective height of vent pipes

The effective heights of the vent pipes ranged between –100 mm (i.e. 100 mm below the highest point of the roof) and 1,250 mm, with an average of 504 mm. Table 1 summarises the proportions of latrines that met the recommended effective height of 500 mm and those that did not.

**Table 1** | Proportions of latrines with and without recommended heights of vent pipes

Observation	Frequency (N)	Percentage (%)	Remark
Effective height < 500 mm	60	47.2	47.2.2% non-compliance
Effective height ≥ 500 mm	67	52.8	
Total	127	100	

Those latrines that do not comply with the guideline are likely to have the top of their vent pipes, where the action of air provides the suction effect to draw malodorous air from the pit, obstructed by the superstructure itself, surrounding buildings and trees (Mara 1984). Based on the assumption behind the guideline, users of those latrines are likely to perceive bad odour in their latrines if all other factors are held constant. To verify this, the study sought to assess any association between non-compliance to this design guideline and the users' perception of odour. Table 2 presents a comparison of the composite odour perception of users of the latrines that failed to meet the minimum height and that of those whose latrines met the recommended height.

It is seen from the table that there is no significant difference between the odour perceptions of users of the two categories of latrines. This confirms the findings of Obeng *et al.* (2019b) who studied the influence of vent pipes installed to effective heights of 250 mm, 500 mm, 750 mm and 1,000 mm

**Table 2** | Comparison of odour perception on VIP latrines meeting and not meeting the recommended effective height for vent pipes

User group	N	Composite odour perception		
		Mean (SD)	Mean rank	Z-score <sup>a</sup> (p-value)
H <sub>eff</sub> <sup>b</sup> < 500 mm	107	2.037 (0.6131)	107.88	0.674 (0.500)
H <sub>eff</sub> ≥ 500 mm	103	1.981 (0.6101)	103.02	
Total	210	2.010 (0.6108)		

<sup>a</sup>Based on the Wilcoxon signed-rank test.

<sup>b</sup>H<sub>eff</sub> = effective height.

above the highest point of an experimental VIP latrine and concluded that the height of the vent pipe had no significant influence on the ventilation rate through the vent pipe and, hence, the odour control function of the technology. However, Obeng *et al.* (2019b) recommended that the existing guideline is adhered to in order to direct malodorous air into the atmosphere.

### Provision of insect screens on vent pipes

Table 3 presents the proportions of VIP latrines that were found to have insect screens fitted on their vent pipes.

**Table 3** | Proportions of latrine with and without insect screens on vent pipes

Observation	Frequency (N)	Percentage (%)	Remark
No insect screen on vent pipe	84	66.1	66.1% non-compliance
Insect screen on vent pipe	43	33.9	
Total	127	100	

It is seen from Table 3 that two-thirds of the latrines had no insect screens fitted on their vent pipes, which means flies produced in the pit could easily escape to the environment without being trapped in the vent pipe. This defeats the primary function of a sanitation facility as a barrier to disease transmission (Mara *et al.* 2010). Beside this, flies in the environment that would be attracted to the odour emanating from the top of the vent pipe would not be restrained from entering the pit. This could increase the chances of fly nuisance in the latrine cubicle. This suspicion was investigated by comparing the proportions of users of latrines without insect screens on vent pipes who reported seeing flies in their latrine cubicles with those whose latrine vent pipes were fitted with insect screens. As seen in Table 4, a person who uses a VIP latrine with a vent pipe without an insect screen is more likely to see flies in his or her latrine cubicle than one who uses a latrine with the vent pipe fitted with an insect screen (odds ratio = 2.129; *p*-value = 0.008). It is noted, however, that the presence of flies in the cubicle could also be influenced by the intensity of light in the latrine cubicles since flies are attracted to light (Mara 1984). Unfortunately, light intensity in each of the latrine cubicles could not be measured in this study.

**Table 4** | Association between absence of insect screen on vent pipe and user encounter with flies

User group	Users who saw flies	Users who saw no flies	Total	Odds ratio (p-value)*
Latrines with vent pipes without insect screens	66	62	128	2.129 (0.008)*
Latrines with vent pipes fitted with insect screens	26	52	78	
Total	92	114	206	

\*significant at 1% confidence level.

Since fly nuisance has been cited by some latrine users as a reason for avoiding latrines to practise open defecation (Obeng *et al.* 2015), it is important for latrine builders to comply with this seemingly simple guideline, which could influence consistent usage of latrines.

### Positioning of windows or openings in the structure

Table 5 presents the proportions of VIP latrines that had windows or other openings provided in multiple sides or only one side of the superstructure.

**Table 5** | Proportions of latrines with multiple and single windows in the superstructure

Observation	Frequency (N)	Percentage (%)	Remark
Windows in multiple sides	39	30.7	30.7% non-compliance
Windows in a single side	88	69.3	
Total	127	100	

Theoretically, the latrines with windows provided in multiple sides would be less efficient in odour control compared to those in which windows are provided in a single side. This assumption was verified by comparing the composite odour perception of users of these latrines with that of those whose latrines had a window or other openings provided only in one side. The result of this comparison is presented in Table 6.

**Table 6** | Effect of provision of windows or openings in single or multiple sides of the superstructure on the users' perception of odour

User group	N	Composite odour perception		Z-score <sup>a</sup> (p-value)
		Mean (SD)	Mean rank	
Windows in multiple sides	57	2.053 (0.6660)	109.22	0.630 (0.529)
Windows in a single side	153	1.993 (0.5905)	104.11	
Total	210	2.010 (0.6108)		

<sup>a</sup>Based on the Wilcoxon signed-rank test.

It can be observed from Table 6 that the provision of windows in multiple sides of the superstructure had no significant influence on the users' perception of odour. This complements the findings of Obeng *et al.* (2019a) that providing windows in multiple directions could still achieve the recommended ventilation rate and therefore poses no risks of odour nuisance even when 100 mm diameter vent pipes are used. However, this observation may have been facilitated by the appreciably high wind speed in Cape Coast (2.7 m/s), which is approaching the benchmark figure of 3.0 m/s (Mara 1984). The relatively poorer perception of odour by users of latrines with windows in single sides of the superstructure, which are expected to offer a better odour control, could be the result of other confounding factors such as the management (cleanliness) of the latrines. It could also be the result of some of those latrines having the side with the windows not being in the windward side of latrines, which has been found to achieve a much lower ventilation rate in the vent pipes than those with windows in multiple sides (Obeng *et al.* 2019a). In this study, the orientation of windows or openings relative to the wind direction at each of the latrine locations was not monitored. It is also noted that, the analysis of user perception of odour did not take into consideration the possibility of some latrine drop holes being covered when not in use. Such a practice is known to interrupt the ventilation process in the VIP latrine and potentially lead to odour generation (Mara 1984).



### Installation of insect screens in windows or openings

The proportions of latrines with and without insect screens installed in the windows are presented in Table 7, indicating that about 13% of latrines had no insect screens in their windows.

**Table 7** | Proportions of latrines with and without insect screens installed in windows

Observation	Frequency (N)	Percentage (%)	Remark
Windows without insect screens	17	13.4	13.4% non-compliance
Windows with insect screens	110	86.6	
Total	127	100	

Some owners of the latrines explained that they installed insect screens in the windows to prevent entry of flies as well as rodents and reptiles, which scare some prospective users, especially children, from using the latrines. Good as the intention may be, this practice is not encouraged because it has been found to significantly reduce the ventilation rate through the vent pipe (Obeng *et al.* 2019a, 2019b). However, as seen in Table 8, even though users of those latrines perceived relatively poorer levels of odour in their latrines, the difference with the odour perception of those whose latrine windows had no insect screens installed in them was not significant.

**Table 8** | Effect of installation of insect screens in windows on the users' perception of odour

User group	N	Composite odour perception		Z-score <sup>a</sup> (p-value)
		Mean (SD)	Mean rank	
Windows without screens	57	1.967 (0.6149)	101.83	- 0.415 (0.678)
Windows with screens	153	2.017 (0.6116)	106.11	
Total	210	2.010 (0.6108)		

<sup>a</sup>Based on the Wilcoxon signed-rank test.

Regarding the claim that installation of insect screens in windows could prevent entry of flies into the latrines, Table 9 shows that the odds for a user of a latrine with insect screens in the windows seeing flies in the latrine is actually lower (0.55) than those whose latrine windows were not fitted with insect screens (0.86) but the odds ratio (0.638) is not statistically significant ( $p = 0.179$ ). This suggests that the use of insect screens may probably be good for preventing entry of rodents and reptiles but not necessarily control fly nuisance. As discussed above, the VIP latrine mechanism for controlling flies in the latrine cubicle is the installation of an insect screen on the vent pipe but not in the windows or openings.

**Table 9** | Association between installation of screens in windows and user encounter with flies

User group	Users who saw flies	Users who saw no flies	Total	Odds ratio (p-value)
Latrines with insect screens in windows	11	20	31	0.638 (0.179)
Latrines without insect screens in windows	81	94	175	
Total	92	114	206	

### Implications of findings on improving the performance of the VIP latrines

Aside from the diameter of the vent pipe, only 7 of the 127 latrines, representing 5.5%, complied with all the remaining four technical guidelines that were assessed. The fixing of an insect screen on vent pipes, which is probably the easiest of the guidelines to comply with, was rather the most violated. Among 60 latrines with vent pipes installed to the recommended height, only 15, representing 11.8% of the total, were fitted with insect screens. The generally low level of compliance with technical guidelines may be attributed to lack of knowledge of the relevant guidelines among building craftsmen in Ghana. It was observed from interactions with latrine owners that there are essentially no specialised VIP latrines builders per se available. The majority of prospective households seeking to build a latrine have to rely on general building craftsmen, mostly informally trained, who dominate the largely unregulated grass-root building industry in Ghana.

Some prospective house builders may be able to afford the services of building and construction technicians who obtain a basic formal training in building and construction from second-cycle technical and vocational education and training (TVET) institutions. However, an examination of the curriculum of those institutions by this research team revealed that there are no specific contents on the fundamental design and construction principles of VIP latrines or other non-sewered sanitation systems that are commonly adopted by low-income Ghanaian households. This calls for action to bridge the gap between the TVET institutions and Ghana's tertiary institutions that are involved in the training of WASH professionals, to incorporate basic competences of latrine construction in the curriculum of the TVET institutions.

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### CONCLUSIONS AND RECOMMENDATIONS

A gap exists between the practice of VIP latrine construction in Cape Coast and conventional technical guidelines. Not a single latrine is fitted with a vent pipe of the recommended diameter of 150 mm, with the failure to install an insect screen on vent pipes being the second most violated technical guideline. Aside from the vent pipe diameter, only 5.5% of latrines complied with all the remaining four design guidelines that were assessed. Only some 12% of latrines have vent pipes fitted with an insect screen and installed to the recommended height of 500 mm. However, failure to comply with a particular design guideline did not necessarily lead to significantly higher user reports or perception of the nuisance which the guideline aims at controlling, with the exception of the failure to install an insect screen on vent pipes, which was significantly associated with the users seeing flies in the latrine cubicles. The findings of this study suggest that user perception of the level of odour in their latrines may be more influenced by non-structural factors such as the management or cleanliness of the latrines rather than their structural design.

It is recommended that VIP latrine builders and users are educated on the importance of the seemingly simple act of maintaining an insect screen on the vent pipe in order to control the nuisance of flies in their latrines and protect public health. Furthermore, considering the universal use of 100 mm diameter PVC pipes as VIP latrine vent pipes and the potential economic barriers against the use of the preferred 150 mm diameter pipes, further research to improve the ventilation function of the technology should focus on other strategies or design modifications that may enhance the ventilation rate with the use of 100 mm diameter vent pipes. The use of air extraction units on 100 mm diameter vent pipes, for example, should be explored. As used in the enviroloo toilet ([Enviro Loo 2013](#); [Averda South Africa 2018](#)), an air extraction unit at the top of the vent pipe serves as an extractor fan and enhances the suction effect of external air to draw out malodorous air from the pit of the latrine. It is also imperative to incorporate basic competences of latrine construction in the training of building and construction technicians in Ghana's TVET institutions.

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