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Assessing Hygiene Risks: Microbial Contamination on Surfaces of Public and Household Latrines at the District Level in Ghana.

Williams Ampadu Oduro[1] *, Eunice Eduful[2]
1.Department of Biological, Environmental and Occupational Health, School of Public Health, University of Ghana, Legon, Accra, Ghana
2.Wisconsin International University College, Ghana
E-mail any correspondence to: williamsnanak@gmail.com

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Abstract

Introduction: Latrines play a critical role in maintaining public health but can also act as reservoirs for microbial contamination, particularly in low-resource settings. This study was carried out in the Akuapem North Municipality in the Eastern Region of Ghana, which included towns such as Akropong, Mampong, Larteh, Adawso and Okorase, to better understand these risks. **Methods:** Using a cross-sectional design, we compared microbial contamination on frequently touched surfaces in both public and household latrines. A total of 200 surface swabs were collected with 80 from public latrines and 120 from household toilets. Samples were analyzed for Escherichia coli, Staphylococcus aureus, and total coliforms using standard culture methods. **Results** were expressed as $\log_{10}$ colony-forming units per square centimeter (CFU/cm²). Mean microbial loads were significantly higher on surfaces of public latrines than on household toilets ($p < 0.05$). Door handles and flush levers showed the greatest contamination, with E. coli reaching 3.82 ± 0.41 $\log_{10}$ CFU/cm² in public latrines compared with 1.61 ± 0.32 $\log_{10}$ CFU/cm² in household toilets. Cleaning frequency and disinfectant use were inversely associated with surface contamination. **Conclusion:** these findings demonstrate that communal sanitation facilities may pose greater hygiene risks than private toilet facilites due to inadequate cleaning and overcrowding. Strengthening sanitation management through regular disinfection, adequate maintenance, and user hygiene education is essential to reduce potential pathogen exposure and improve overall environmental health.

Keywords: Public latrines, Microbial contamination, Escherichia coli, Hygiene practices, High-touch surfaces

Introduction

Access to safe sanitation remains a major public health challenge, particularly for rural households in low- and middle-income countries. Globally, only about 57% of people have safely managed sanitation, while over 1.5 billion lack basic toilet facilities and nearly 419 million still practice open defecation[1]. In sub-Saharan Africa, the situation is even more severe, with nearly 68% of the population lacking adequate sanitation. Poor sanitation contributes to hundreds of thousands of diarrhoeal deaths each year and helps spread intestinal parasites, typhoid, and cholera[2].

Rapid urbanization, population growth, and weak municipal infrastructure have intensified these challenges in Africa. Many urban and peri-urban areas rely heavily on public or communal latrines due to insufficient household toilets[3 4 5]. Poverty, limited space, and land ownership constraints prevent some families from constructing private toilets, making shared facilities a practical solution for millions[6]. However, such facilities can become reservoirs of microbial contamination, especially when poorly managed. According to the United Nations Sustainable Development Goals (SDGs), toilets shared by more than one household are not considered “safely managed” under SDG 6.2.[7]

Public toilets are particularly prone to microbial contamination on high-touch surfaces such as door handles, flush buttons, toilet seats, and nearby walls. Contamination arises from unwashed hands, inadequate cleaning, or aerosolized droplets released during flushing, allowing bacteria such as Escherichia coli, Salmonella spp., and Staphylococcus aureus to persist[8]. Studies in Côte d’Ivoire and Ghana have detected these bacteria on university, market, school, and transport hub toilets[9 10].

Although similar studies have been conducted elsewhere, many have focused on specific institutions such as schools and markets, leaving limited evidence on how public and household toilets compare within the same community. There is also very little research that links microbial contamination with everyday cleaning routines, disinfectant use and the general cleanliness of facilities in mixed urban and rural settings. These gaps make it important to generate context specific evidence that reflects how sanitation is managed in real community environments.

This study addresses these gaps by comparing microbial contamination in both public and household latrines within one municipality and by relating these findings to the way the facilities are maintained. This combined approach provides a clearer and more practical understanding of the factors that influence contamination than what is usually reported in earlier studies.

Despite improvements in sanitation coverage, public toilets remain essential in many Ghanaian communities. According to the 2021 Population and Housing Census, about 59.3% of households had access to a toilet facility, nearly one in four relied on public toilets, and approximately 17.7% had none[11] [12]. The benefits of public toilets are often undermined by inconsistent cleaning, inadequate water or soap supply, and poor maintenance. Studies across several Ghanaian towns report broken infrastructure, foul odors, and irregular disinfection, all of which increase the risk of disease transmission[13].

These sanitation challenges are particularly evident in mixed urban–rural settings in Ghana's Eastern Region, where many residents, students, and visitors rely on public latrines daily. Originally built for short-term use during funerals, festivals, and other gatherings, many of these facilities now serve as permanent sanitation options. Limited maintenance, poor user behavior, and irregular cleaning have worsened their condition, and some users engage in unhygienic acts such as touching or smearing walls, further increasing contamination risks.

Against this background, this study aimed to assess the microbial contamination of frequently touched surfaces in both public and household latrines, identify which surfaces pose the highest infection risk, and examine how maintenance practices affect contamination levels. The findings are expected to inform interventions that improve sanitation and promote safer use of public toilet facilities in Ghana and other developing countries.

Materials and methods

Study Area

The study was conducted in the Akuapem North Municipality, located in the Eastern Region of Ghana. The municipality comprises towns including Akropong, Mampong, Larteh, Adawso, and Okorase. It is a mixed urban–rural area with significant commuter and resident populations, many of whom rely on public latrines. Public latrines in this area vary in design, maintenance, and user traffic, which provides an ideal setting for assessing microbial contamination on frequently touched surfaces.

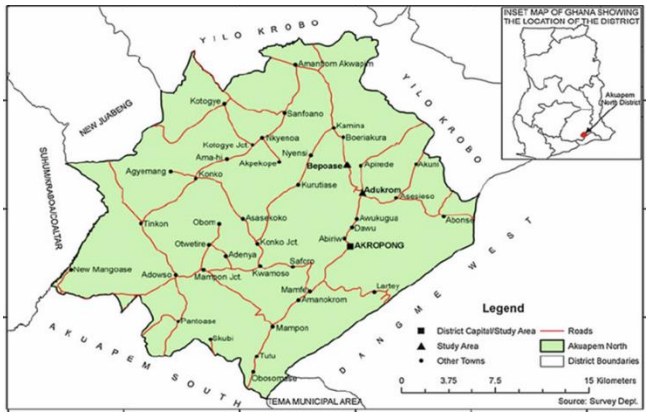

Figure 1. Map of Akuapem North Municipality[14]

Study Design

A cross-sectional survey was conducted to capture a snapshot of microbial contamination on high-touch surfaces in both public and household latrines, as well as hygiene and maintenance practices at a single point in time.

Selection of Public Latrines and Households

Twenty public latrines and 30 household toilets were purposively selected to compare contamination between communal and private facilities. Purposive sampling was used to ensure that the selected sites reflected a range of conditions and usage patterns typical of the municipality. For public latrines, selection criteria included high user traffic, diverse physical conditions (from well-maintained to poorly maintained facilities), accessibility for sampling, and willingness of caretakers to participate. For household toilets, selection aimed to represent different zones of the municipality, varying household sizes, and varying toilet conditions, while ensuring ease of access and consent from household heads. Caretakers and household heads provided verbal consent before sampling.

Sampling Strategy

Four high-touch surfaces per site were swabbed: door handles, flush buttons/levers, squat/seat surfaces, and walls near defecation points. For the walls, 10 cm² area adjacent to the defecation point was swabbed to ensure consistency across sites. Sterile cotton swabs moistened with saline were used, then placed in labeled sterile transport tubes containing buffered peptone water. Tubes were sealed and transported in cool boxes at 4–8 °C and processed within six hours to maintain sample integrity. Negative control swabs were included to ensure no contamination occurred during handling or transport[15] [16].

Sample Size

A total of 200 surface swabs were collected: 80 from public latrines and 120 from household toilets. This allowed sufficient variability to compare contamination across facilities, surface types, and zones.

Microbiological Analysis

Swabs were vortexed in sterile saline, plated on MacConkey agar for E. coli and total coliforms, and Mannitol Salt agar for S. aureus. Plates were incubated at 37 °C for 24–48 hours, and colony counts recorded as $\log_{10}$ CFU/cm². Presumptive colonies were confirmed using standard biochemical tests. Positive and negative controls were run to validate results[17] [18].

Data and Metadata Collection

For each site, data recorded included site type, zone, site identifier, surface type, date/time, observed cleaning frequency, disinfectant use, and visible cleanliness. This allowed stratified and multivariable analyses to explore factors associated with contamination.

Data Analysis

Data were cleaned in Excel and analyzed in SPSS version 25. Microbial counts were expressed as $\log_{10}$ CFU/cm² and summarized as mean ± SD. The Shapiro–Wilk test was used to check whether the data followed a normal distribution. For normally distributed data, independent-samples t-tests were conducted, and 95% confidence intervals (CI) were calculated to show the precision of the mean differences. For data that were not normally distributed, the Mann–Whitney U test was used. Statistical significance was considered at $p < 0.05$.

Ethical Considerations

Although this study involved only environmental

sampling and did not collect human specimens or personal identifiers, ethical approval was obtained from the Ghana Health Service Ethics Review Committee (Ref. No. GHS/RDD/ERC/Admin/App/23/008). In addition, formal authorization for the research was secured from the Akuapem North Municipal Environmental Health Office. Permission from public latrine caretakers and household heads was also obtained prior to sample collection to ensure adherence to local administrative and ethical standards.

Results

Surface microbial contamination

Microbial contamination was detected on all sampled surfaces of both public latrines and household toilets, with significantly higher counts observed in public latrines ($p < 0.05$) (Table 1). Door handles showed the highest contamination levels, with mean E. coli and total coliform counts of 3.82 ± 0.41 and 4.53 ± 0.48 $\log_{10}$ CFU/cm², respectively, in public latrines, compared with 1.61 ± 0.32 and 2.01 ± 0.38 $\log_{10}$ CFU/cm² in household toilets. Similarly, flush buttons or levers demonstrated elevated microbial loads in public latrines (E. coli: 3.54 ± 0.37; total coliforms: 4.05 ± 0.42 $\log_{10}$ CFU/cm²) relative to household toilets. Squat or seat surfaces and wall areas also retained notable contamination, though at slightly lower levels than contact surfaces such as handles and flush levers.

S. aureus counts followed a similar trend, ranging from 0.91–2.12 $\log_{10}$ CFU/cm² in public latrines and 0.43–0.83 $\log_{10}$ CFU/cm² in household toilets. These differences were statistically significant across all surface types ($p < 0.05$).

Table 1. Microbial contamination of public latrines and household toilets in Akuapem North Municipality (mean ± SD, $\log_{10}$ CFU/cm²)

Surface type	Microorganism	Public latrine (Mean ± SD)	Household toilet (Mean ± SD)	p-value
Door handles	*E. coli*	3.82 ± 0.41	1.61 ± 0.32	<0.001
	S. aureus	2.12 ± 0.36	0.83 ± 0.22	<0.001
	Total coliforms	4.53 ± 0.48	2.01 ± 0.38	<0.001
Flush buttons/levers	*E. coli*	3.54 ± 0.37	1.39 ± 0.29	<0.001
	S. aureus	1.91 ± 0.25	0.72 ± 0.19	<0.001
	Total coliforms	4.05 ± 0.42	1.76 ± 0.31	<0.001
Squat/seat surfaces	*E. coli*	2.73 ± 0.33	1.19 ± 0.25	0.002
	S. aureus	1.64 ± 0.28	0.63 ± 0.18	0.004
	Total coliforms	3.21 ± 0.35	1.37 ± 0.27	0.003
Wall areas (10 cm²)	*E. coli*	1.82 ± 0.27	0.81 ± 0.21	0.005
	S. aureus	0.91 ± 0.15	0.43 ± 0.12	0.008
	Total coliforms	2.09 ± 0.24	0.88 ± 0.19	0.006

Note. Values represent mean ± standard deviation (SD) of microbial counts expressed as $\log_{10}$ CFU/cm². p-values were obtained using independent-samples t-tests (or Mann–Whitney U tests for non-normally distributed data). Statistical significance was set at $p < 0.05$.

Cleaning frequency and disinfection practices

Figure 2 illustrates the mean microbial loads ($\log_{10}$ CFU/cm²) on public latrine surfaces according to cleaning frequency and disinfectant use. Surfaces cleaned once daily recorded a mean microbial load of approximately 3.61 $\log_{10}$ CFU/cm², whereas those cleaned twice daily showed a slightly lower mean of 3.45 $\log_{10}$ CFU/cm². Similarly, facilities that did not use disinfectants exhibited higher microbial loads (3.63 $\log_{10}$ CFU/cm²) compared with those that applied disinfectants (3.41 $\log_{10}$ CFU/cm²). Although these differences are statistically significant, the absolute reductions in microbial load are relatively small.

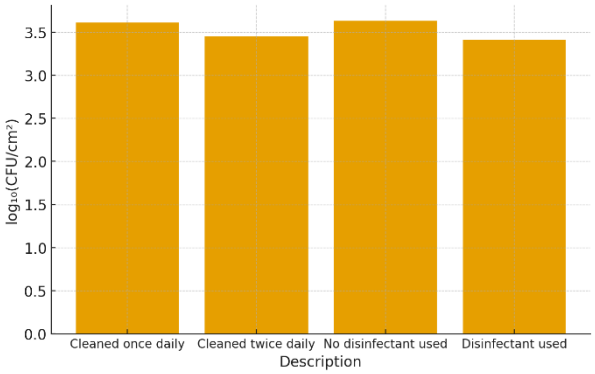

Figure 2. Cleaning frequency and disinfectant use across public latrines and household toilets

Comparison of overall contamination between facility types

Table 2 compares mean microbial loads on selected surfaces of public latrines and household toilets. All surfaces showed detectable contamination, with public latrine surfaces consistently exhibiting higher mean counts ($p < 0.05$). Door handles recorded the highest levels (4.20 ± 1.10 $\log_{10}$ CFU/cm²) in public latrines which is approximately double those in household toilets (2.10 ± 0.72 $\log_{10}$ CFU/cm²). Similar trends were observed for toilet seats/squat areas and flush buttons/levers. The overall mean microbial load (3.74 ± 1.02 $\log_{10}$ CFU/cm²) in public latrines was nearly twice that of household toilets (1.86 ± 0.65 $\log_{10}$ CFU/cm²).

Table 2. Comparison of Mean Microbial Loads ($\log_{10}$ CFU/cm²) Between Public Latrine and Household Toilet Surfaces

Surface Type	Public Latrine (Mean ± SD, $\log_{10}$ CFU/cm²)	95% CI	Household Toilet (Mean ± SD, $\log_{10}$ CFU/cm²)	95% CI	p-value
Door handles	4.20 ± 1.10	3.96–4.44	2.10 ± 0.72	1.97–2.23	<0.001
Toilet seats/squat area	3.68 ± 0.89	3.49–3.87	1.92 ± 0.55	1.82–2.02	0.002
Flush buttons/levers	3.42 ± 0.80	3.25–3.59	1.74 ± 0.61	1.63–1.85	0.004
Walls near toilet area	3.18 ± 0.76	3.01–3.35	1.68 ± 0.58	1.58–1.78	0.005
Overall mean	**3.74 ± 1.02**	**3.52–3.96**	**1.86 ± 0.65**	**1.74–1.9)**	**<0.001**

Note: Values are presented as mean ± standard deviation (SD) of microbial counts in $\log_{10}$ CFU/cm². The 95% confidence intervals (CI) indicate the range within which the true mean is likely to fall. P-values were obtained using independent-samples t-tests, and statistical significance was set at $p < 0.05$.

Discussion

Public latrines showed significantly higher microbial contamination than household toilets. All 200 swab samples, including 80 from public latrines and 120 from household toilets, showed bacterial presence, with public facilities consistently carrying higher loads. Door handles, flush levers, and walls near defecation points were the most contaminated surfaces, highlighting the areas of greatest exposure risk.

The predominance of E. coli, Staphylococcus aureus, and total coliforms indicates persistent fecal and skin-associated contamination. These findings align with studies in similar contexts. Chijioke and Adaeze[19] reported significant contamination on hostel toilet door handles, mainly S. aureus, while Donkor et al.11 found that 20.2% of public toilet door handles in Ghana were contaminated with the same bacteria. This reflected limited cleaning and poor hygiene practices. Frequent contact with inadequately washed hands is likely a key factor in microbial transfer20.

Quantitative analysis confirms substantial disparities between facility types. The overall mean microbial load in public latrines (3.74 ± 1.02 $\log_{10}$ CFU/cm²) was about twice that observed in household toilets (1.86 ± 0.65 $\log_{10}$ CFU/cm²), yieldng a mean ratio of 2.01 (95% CI: 1.77–2.29). Similarly, E. coli counts on public latrine door handles (3.82 ± 0.41 $\log_{10}$ CFU/cm²) were 2.37 times higher (95% CI: 2.10–2.68) than those on household door handles (1.61 ± 0.32 $\log_{10}$ CFU/cm²). S. aureus loads followed a comparable trend, with public latrine surfaces showing values roughly 2.5 to 3.0 times higher than those from household toilets. These confidence intervals confirm that the observed differences were not random but reflect consistent and significant disparities between facility types.

Surface type and design influence microbial persistence. Walls near defecation points recorded notable bacterial loads, likely due to aerosolized droplets generated during flushing21 22. In contrast, flush buttons and levers showed lower contamination, possibly because their smooth surfaces are easier to clean, less exposed to fecal matter, and made of materials less conducive to microbial survival8. This observation highlights the role of surface type, design, and material in bacterial persistence.

Cleaning practices and disinfectant use reduce microbial loads, but their effectiveness is limited if not properly implemented. As shown in Fig. 2, surfaces cleaned once daily or without disinfectants had higher contamination (3.61 $\log_{10}$ CFU/cm²) compared with those cleaned twice daily with disinfectants (3.45 $\log_{10}$ CFU/cm²). Although the numerical difference appears small (mean difference = 0.16 $\log_{10}$ CFU/cm²; 95% CI: 0.10–0.22), this represents roughly a 1.45-fold reduction in bacterial load, an effect that becomes meaningful when sustained over time. Similar findings were reported by Hamed et al.23 and Mraz et al.24. This confirms that frequent cleaning combined with effective disinfectants significantly reduces microbial presence. However, routine cleaning without appropriate disinfectants may be insufficient to control contamination in heavily used shared facilities.

Behavioral factors and facility management further influenced contamination levels. Overcrowding, overuse of public toilets originally designed for transient use, and inconsistent cleaning likely contributed to higher bacterial presence. Similar patterns were observed in Côte d'Ivoire, where 60–70% of public toilet surfaces were contaminated9. Studies from Nepal also showed that effective maintenance and responsible user behavior can substantially reduce contamination, even in communal facilities25.

The high microbial load in public facilities has important public health implications. E. coli can cause urinary tract infections, gastroenteritis, and systemic illnesses, while S. aureus, including methicillin-resistant strains (MRSA), is associated with skin, wound, and

bloodstream infections26 27. The surface loads recorded in this study (3–4 $\log_{10}$ CFU/cm² for E. coli on door handles and flush levers) are considered high and have been associated in previous studies with an increased risk of pathogen transmission via hand contact8 20. Even though no formal global “safe threshold” exists for public surfaces, quantitative microbial risk assessments and field studies indicate that contamination levels in this range can facilitate transfer of bacteria to users, particularly in high-use, low-resource settings where hand hygiene is limited (QMRA studies; shared sanitation blocks studies). The difference in average microbial load between public and household toilets (1.88 $\log_{10}$ CFU/cm², 95% CI: 1.50–2.20) indicates that surfaces in public facilities carry almost 100 times more bacteria, which poses a higher risk of exposure especially for children and individuals with limited hygiene awareness, who may easily transfer pathogens from contaminated surfaces to their mouths or food. In low-resource settings, such exposures can lead to severe infections due to limited access to clean water, healthcare, and hygiene materials.

Maintaining good sanitation and hygiene is essential for reducing microbial contamination. While public latrines are essential for many communities, their safety depends on regular cleaning, proper disinfection, and a continuous supply of water and soap. Hygiene education is also necessary to minimize microbial contamination. Promoting hygiene education and supporting household-level sanitation could reduce reliance on shared facilities, limit infection risks, and promote safer and more sustainable sanitation practices.

Limitations

This study provides a snapshot of microbial contamination at a single time point and focused only on culturable bacteria, so non-culturable microorganisms and viruses may have been missed. The study was conducted within one municipality, the results may not be fully generalizable to other settings with different sanitation systems, environmental conditions, or hygiene behaviors. Finally, the study also did not directly assess user behavior or adherence to hygiene practices, which can significantly influence contamination levels.

Conclusion

Public latrines in the Akuapem North Municipality had higher bacterial contamination than household toilets, with door handles, flush levers, and walls being the most affected. Insufficient cleaning, inconsistent disinfection, and overcrowding sustain microbial persistence in communal facilities. Regular cleaning with effective disinfectants, hygiene education, and reliable water and soap provision are critical public health interventions. Supporting household-level sanitation could reduce reliance on public facilities and lower infection risks. Communal sanitation facilities, while essential for many communities, pose a significantly higher hygiene risk than household facilities due to manageable factors such as infrequent cleaning and lack of disinfectants. Future studies should adopt longitudinal designs and molecular methods to better understand microbial dynamics and evaluate the impact of hygiene interventions over time.

Funding

The study was self-funded.

Data availability

The datasets generated and/or analyzed in this study are not publicly accessible but can be made available by the corresponding author upon reasonable request.

Consent for publication

Not applicable

Conflict of interest

There are no conflicting interests declared by the authors.

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Author contributions

Williams Ampadu Oduro designed the study and drafted the paper, Eunice Eduful collected and the cleansed the data, Williams Ampadu Oduro revised the draft paper and wrote the manuscript. All authors reviewed the manuscript.

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