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ABSTRACT: In Ghana, environmental hygiene remains a major problem and infection control measures are hardly practised, particularly outside of the hospital. To provide evidence for infection control measures at public places of convenience in Accra (capital city of Ghana), this study was performed. The aim of the study was to evaluate microbial contamination of door handles at public places of convenience in Accra and assess the public health risk. A total of 183 swab specimens were collected aseptically from door handles of public places of convenience of shops, schools, hospitals, lorry stations, churches, and markets. The samples were cultured on bacteriological media, and the isolated organisms were identified. The most prevalent bacterial agent isolated was *Bacillus* spp. (55.7%), followed by *Staphylococcus aureus* (20.2%), coagulase-negative staphylococcus spp. (17.1%), *Citrobacter freundii* (6.0%), *Citrobacter koseri* (4.4%), and *Salmonella* Paratyphi A (3.8%). Although in low prevalence, a wide range of enteric bacteria were isolated from door handles, accounting for 12 of the 16 isolated organisms. In conclusion, door handles of places of convenience in Accra harbour several pathogenic microorganisms, especially enteric organisms. This study highlights the need for proper disinfection of door handles of places of convenience in Accra as well as handwashing after visiting such places.

KEYWORDS: *Staphylococcus aureus*, door handles, disinfection, public health

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Introduction

Fomites are a major source of spread of infectious pathogens. This is partly because environmental surfaces of fomites act as a reservoir for a wide range of microbes some of which are pathogenic.[1,2] Some common pathogenic microbes occurring on fomites include *Staphylococcus aureus*, *Clostridium difficile*, and *Pseudomonas aeruginosa*.[2-4] The public health risk of microbial contamination of fomites is evident from the numerous fomite-associated outbreaks that have occurred in several countries.[5] Door handles are perhaps the most susceptible fomites to microbial contamination. This is because doors have large traffic users, who transfer their own microbial flora and other organisms they have picked elsewhere onto door handles. In Ghana, environmental hygiene remains a major problem and infection control measures are hardly practised, particularly outside of the hospital. So far, very little is known about the role fomites such as door handles play in the transmission of microbial pathogens at public places of convenience in Ghana. To provide evidence for infection control measures at such places, this study was performed. The aim of the study was to evaluate the microbial contamination of door handles at public places of convenience in Accra, Ghana, and assess the public health risk.

Methods

Study site and specimen collection

The study was performed in Accra, the capital city of Ghana from May to July 2017. The population of Ghana is about 30 million with 2.5 million living in Accra.[6] Bacterial diseases rank among the leading causes of morbidity in Accra and epidemics of cholera are common reflecting the poor sanitation of the city.[7,8] This was a cross sectional study involving door handles of public places of convenience of 20 sites in Accra. These study sites were selected to represent the various types of public places including shops, schools, hospitals, lorry stations, churches and markets, and also to adequately cover Accra geographically.

A total of 183 swab specimens were collected aseptically from door handles of the public places of convenience that were sampled, and the distribution is shown in Table 1. Briefly, sterile cotton swabs were moistened in peptone water and the cotton part of the swab stick was then rotated firmly over the surface of the door handle. The cotton swab was immediately placed in a labelled bijou bottle containing sterile peptone water, shaken slightly and capped. The swab specimens were subsequently transported to the laboratory for analysis at the Department of Medical Microbiology, University of Ghana Medical School in Accra.

Laboratory analysis

The bottles containing the swab specimens were incubated overnight, and the solutions were mixed thoroughly using a vortex. The mixture was streaked onto blood and MacConkey agar plates aseptically under a Bunsen burner and incubated at 37°C for 18 to 24 hours. Bacterial colonies were identified based on colonial morphology, Gram staining, and a battery of biochemical reactions, such as the triple sugar iron test, catalase test, urease test, indole test, and citrate utilization test.[9,10] Negative controls including a sterile broth and a sterile swab were cultured to ensure no contamination occurred.

Table 1. Sampling of door handles of study sites.

STUDY SITE TYPE	NO. OF SITES SAMPLED	NO. OF DOOR HANDLES SAMPLED
Shopping centre	4	53
School	2	21
Hospital	2	6
Lorry station	2	10
Religious centre	3	33
Open market	2	14
Hostel	3	40
Restaurant	2	6

Abbreviation: No., number.

Data analysis

The data collected in the study were entered into MS Excel and analysed using STATA 12.0. Descriptive analysis was conducted on the various bacterial agents isolated from the door handles, including their frequencies and prevalence. Subsequently, the chi-square test was used to compare bacterial contamination of door handles at the various sites using a significance level of $P < .05$.

Ethical approval

Approval for the conduction of this study was given by the Ethical and Protocol Review Committee of the School of Biomedical and Allied Health Sciences, College of Health Sciences, University of Ghana. Consent for collection of samples was also sought from the appropriate authorities at the various sampling sites.

Results and Discussion

Of the 183 swab samples collected from door handles, 181 (98.9%) were culture positive and 16 different bacterial agents were isolated (Table 2); the 2 culture-negative samples were from the hospital. The most prevalent bacterial agent isolated was *Bacillus* spp. (46.8%), followed by *Staphylococcus aureus* (17%), coagulase-negative staphylococcus spp. (6%), *Citrobacter freundii* (5.1%), *Citrobacter koseri* (3.7%), and *Salmonella* Paratyphi A (3.2%). These organisms accounted for 82% of microbial contamination of the door handles. The distribution of organisms isolated from the different types of study sites is reported in Table 3. Although there was no significant difference among the various sites for any particular bacterial agent, the variety of bacteria isolated varied significantly. *Bacillus* spp. was the only organism that was isolated from all the 8 study site types. Shopping centres as well as religious centres haboured the most variety of organisms; 12 of the 16 organisms were isolated from each of the 2 sites. On the other hand, restaurants haboured the least variety of organisms; 4 of the 16 organisms were isolated at this site.

Table 2. Bacteria isolated from door handles of places of convenience.

BACTERIA	N	%
Bacillus spp.	102	55.7
Staphylococcus aureus	37	20.2
Citrobacter spp.	15	8.2
Coagulase-negative staphylococcus species	13	7.1
Citrobacter freundii	11	6.0
Citrobacter koseri	8	4.4
Salmonella Paratyphi A	7	3.8
Escherichia coli	5	2.7
Klebsiella spp.	5	2.7
Shigella sonnei	3	1.6
Enterobacter spp.	3	1.6
Salmonella spp.	3	1.6
Pseudomonas aeruginosa	2	1.1
Proteus mirabilis	2	1.1
Micrococcus spp.	1	0.5
Salmonella Typhi	1	0.5

Abbreviations: N, number; spp., species.

The microbial flora of door handles in this study somewhat concurs with that of 5 other studies that were performed in different parts of the world.[11-16] *Bacillus spp.*, the predominant organism in the current study was the second most common in a study in Bangladesh.[14] *Staphylococcus aureus*, which was the second most common organism in the current study, was the most predominant in 5 studies performed in Nigeria, Malawi, Saudi Arabia, and Lebanon. Like a study in Saudi Arabia,[16] coagulase-negative staphylococci were commonly isolated from door handles. Although in low prevalence, a wide range of enteric bacteria were isolated from door handles in our study, which concurs with the previous studies.[11-16] The overall prevalence of all enteric bacteria in this study was calculated to be 36%; *Citrobacter* spp. was the most common organism isolated, followed by *Salmonella* spp.

The types of bacteria isolated from the door handles reflect the sources and nature of contamination of the door handles. The occurrence of several different enteric organisms in this study suggests that faecal contamination played an important role in microbial contamination of the door handles.[17,18] In the context of this study, it is likely that people who used toilets for defecation did not wash their hands at all or did not wash properly and transferred enteric bacteria to the door handles.

Table 3. Distribution of bacteria isolated from door handles based on sampling sites.

BACTERIAL AGENT*	SAMPLING SITE							
	RESTAURANT	HOSPITAL	SCHOOL	HOSTEL	OPEN MARKET	LORRY STATION	SHOPPING CENTRE	RELIGIOUS CENTRE
Bacillus spp.	+	+	+	+	+	+	+	+
Staphylococcus aureus	+	+	+	+	–	–	+	+
Citrobacter spp.	+	–	+	–	+	–	+	+
Coagulase-negative staphylococcus species	–	+	+	+	+	–	+	+
Citrobacter freundii	–	+	+	–	+	+	+	+
Citrobacter koseri	+	–	–	–	+	–	+	+
Salmonella Paratyphi A	+	–	+	+	–	+	+	+
Escherichia coli	–	–	–	+	+	–	–	+
Klebsiella spp.	–	+	+	+	–	–	+	+
Shigella sonnei	–	–	–	+	–	–	+	–
Enterobacter spp.	–	+	–	+	–	–	–	+
Salmonella spp.	–	–	+	–	–	–	+	–
Pseudomonas aeruginosa	–	–	–	–	–	–	+	+
Proteus mirabilis	–	–	–	–	–	+	+	–
Micrococcus spp.	–	–	–	–	–	–	–	–
Salmonella Typhi	–	–	–	–	–	–	–	+

Abbreviation: spp., species.
'+' indicates presence of the bacterial agent.
'–' indicates absence of the bacterial agent.
*Chi-square analysis did not show significant differences among the various sampling sites for any particular bacterial agent, but the variety of bacterial agents isolated varied significantly at $P = .03$.

Majority of *Bacillus* spp. are environmental organisms, and their predominance on door handles in this study indicates the environment played a major role in microbial contamination of the door handles.[19,20] Notably *Staphylococcus aureus* and coagulase-negative staphylococcus spp. are normal flora of the anterior nares and skin, and their occurrence on door handles could be traced to these sources.[21-24] It is common practice for people to pick their noses and carry staphylococci on their fingers, and thereby contaminate door handles.

Several pathogenic bacteria were isolated in this study, and it is important to discuss their clinical and public health significance. *Staphylococcus aureus* causes several invasive infections, including meningitis, septicaemia, urinary tract infection, and pneumonia.[23] It is also implicated in toxin-related infections including food poisoning, scalded skin syndrome, and toxic shock syndrome.[23] *Staphylococcus aureus* is mainly transmitted by direct contact, and therefore, fomites could play an important role in its transmission. In Ghana, there have been several outbreaks of *Staphylococcus aureus* in the last few years, placing this organism high on the agenda of public health issues.[24] *Salmonella* Typhi, *Salmonella* Paratyphi, and *Shigella sonnei* are transmitted oro-faecally, and therefore, their occurrence on door handles in this study poses little public health risk unless connected with food. Transfer of these organisms and other food-borne pathogens from door handles and other fomites to food is highly probable in Accra, given the informal food vending system characterized by poor hygienic practices of the vendors. *Salmonella* Typhi and *Salmonella* Paratyphi cause typhoid fever, while *Shigella sonnei* causes shigellosis (bacillary dysentery), both of which are endemic in some parts of Ghana. A leading cause of premature death in Ghana is from gastrointestinal illnesses, and therefore, reducing the spread of these enteric pathogens on common surfaces has the potential to save lives. Occurrence of *Staphylococcus aureus* and *Citrobacter freundii* on door handles in hospitals in this study is of concern, given the association of these organisms with hospital-acquired or nosocomial infections.[3]

Both organisms are known to cause a variety of hospital-acquired infections of the respiratory tract, urinary tract, and the blood. A systematic review showed that several nosocomial pathogens, such as *Staphylococcus aureus* and *Clostridium difficile*, can survive for several months on fomites,[3] a feature that is partly due to biofilm formation.[25] Thus, strict disinfection control policies are needed in hospitals to prevent hospital-acquired infections. In this study, the practice of disinfection may explain the 2 culture-negative samples from the hospital.

There are a few limitations of the study. First, we may have missed some organisms on the door handles which are not culturable or do not grow under the conditions or on the media that were used in the study. Second, this study does not provide any information on viruses, which would be an area worth studying by the research community.

Conclusions

In conclusion, door handles of places of convenience in Accra harbour several pathogenic microorganisms, which originate from three main sources, including the environment, faecal contamination, and human fingers. This study highlights the need for proper disinfection of door handles of places of convenience in Accra as well as handwashing after visiting such places. It is recommended that disinfection of door handles is emphasized in the duties of cleaners and custodial staff. Also in the future, new building doors should be designed to open automatically in high throughput areas.

Author Contributions

ESD conceived and designed the study; NESA and AA collected and analysed the study samples; ESD and NESA undertook data analyses. ESD drafted the manuscript. All authors revised and approved the manuscript.

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