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The Role of Door Handles in the Spread of Microorganisms of Public Health Consequences in University of Benin Teaching Hospital (UBTH), Benin City, Edo State

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Abstract: This study was aimed at investigating the microbial loads of surfaces of door handles at University of Benin Teaching Hospital (UBTH) with a view to understanding their roles in the transmission of pathogenic microorganisms. Eleven (11) sampling units were identified and used for the study. They included: Emergency Ward, Paediatric Ward, Male and Female Surgical Ward, Intensive Care Unit, Theatre Ward, Consultancy Outpatient Department (COPD), Microbiological Laboratory, Revenue Section, Pharmacy Department, and General Toilet. The samples were collected with the aid of sterile swab sticks moistened with sterile normal saline for a period of Six Months (May 2015 – October 2015) and analyzed using standard microbiological methods. Surfaces of door handles of General toilet, Paediatric Ward and Theatre Ward generally had the highest viable bacterial counts, which ranged from 4.03 ± 0.32 - $4.17 \pm 0.27 \times 10^4$cfu/cm^2, while the Intensive Care Unit, Male Surgical Ward and Microbiological Laboratory recorded the least bacterial load that ranged from 3.03 ± 0.03 - $3.30 \pm 0.21 \times 10^4$cfu/cm^2. The bacterial isolates were *Staphylococcus aureus, Pseudomonas aeruginosa, Streptococcus pneumoniae*, *Bacillus subtilis*, and *Escherichia coli*. The most predominant bacterial isolate was *E. coli* (92.00%), while *B. subtilis* (60.01%) was the least. Statistical analysis revealed significant correlation ($p<0.05$) between bacterial isolates and door handles at different sampling units. Findings from this study suggest that hospital door handles harbor a significant variety of pathogenic and non-pathogenic microorganisms of public health value, and thus could act as potential fomites for communicable diseases dissemination. Health-care workers, patients and visitors are encouraged to pay greater attention to personal hygiene practices to avoid the incidence and spread of hospital acquired infections.

Keywords: Hospital, Pathogens, Nosocomial Infections, Wards, Benin City

1. Introduction

Environmental surfaces act as a reservoir for bacterial, fungal and viral proliferation. These organisms can be expelled from an infected or colonized patient through direct contact, aerosol droplet, faeces, or vomit [1]. The major source and spread of community acquired infections are fomites [2, 3]. The role of fomites in the transmission of infection has been debated for many years, however, there is increasing evidence that contaminated inanimate surfaces and especially those frequently touched by hand can contribute to the spread of health-care associated pathogens [4, 5]. One common way by which organisms that are not resident in the hand are picked up is by contact with surfaces such as table tops, hospital door handles, toilet handles and taps in the restrooms [6, 7].

Microbes carried on human skin are of two types, the resident and transient. The dominant resident microbes are

Staphylococcus epiderdimis which is found on almost every hand. It has been estimated that the population of *Staphylococcus epiderdimis* far outnumbered *Staphylococcus* aureus on healthy hands. Others are members of *Corynebacterium* and *Micrococcus* species and certain members of the Enterobacteria caefamily [8].

Human hands usually harbor microorganisms both as part of body normal flora as well as transient microbes contacted from the environment [9]. Pathogens that may be present on the hand as transient type include Escherichia coli, Salmonella species, *Shigella species*, *Clostridium perfringens*, *Giardia lamblia*, Norwalk virus and Hepatitis A virus. Since human hands usually harbour microorganisms both as residents and transients, it is conceivable that the transfer of pathogens could occur between people who access the same area or surfaces. The chance that other persons will acquire these organisms is dependent on how long the organisms can survive in the environment or surfaces [10].

Many reports have demonstrated the important role played by the hospital environment on the development of nosocomial infections (NI's) among both sick patients and healthy people [11-13]. Hospital environment is the most significant reservoir of resistant microorganisms. In the 1950s, extensive contamination of the environmental surfaces by *S. aureus* was documented in the room of patients with staphylococcal infections [14]. The reports revealed that, healthy adults exposed to a hospital environment had four time greater chances of developing NI's by *S. aureus* than those not exposed. Higher indices of environmental contaminations have been reported in patients with methicilin-resistant *S. aureus* in wounds and urine. The frequently contaminated objects in the rooms include bed lines, over bed tables, patient gowns and door handles [15]. It was reported that *S. aureus* appears to be viable on cotton strings and blood protein coagulum for up to six months, while *P. aeruginosa* and *E. coli* could survived longer on similar wet and fibrous surfaces [16]. Vancomycin-resistant enterococcus (VRE) is another microorganism with prolonged survival on hands, gloves and environmental surfaces, predisposing patients to nocosomial infection transmission [17]. Such nosocomial pathogens are transmitted by patients and hospital-care workers through hand shake and direct contact with hospital surfaces such as door handles [18, 19].

Doors have large traffic users, who throng in with their own microbial flora and other organisms they have picked elsewhere and deposit them on door handles while going in and out [19]. In hospitals, those surfaces in the vicinity of patients termed "high touch surfaces" could serve as high risk factors for microbial reservoir and route for pathogen transfer [20]. Considering the potential risk hospital door handles might pose to users when contaminated with pathogens, this work was therefore carried out to investigate the microbial loads of hospital door handles and its public health consequence among health-care works and visitors in University of Benin Teaching Hospital (UBTH), Benin City.

2. Materials and Methods

2.1. Study Site

The study site for this research project was University of Benin Teaching Hospital (UBTH), Benin City, Edo State, Nigeria. The study was carried out after permission was obtained from the hospital authorities and ethical clearance from the Committee on Human Research and Publication, University of Benin Teaching Hospital (UBTH), Benin City. Samples were collected from the hospital door handles of eleven (11) units in the hospital, which include: the Emergency Ward, Pediatric Ward, Male and Female Surgical Wards, Intensive Care Units, Theatre, Consultant Outpatient Department (COPD), Microbiological Laboratory, Revenue Section, Pharmacy Department, and General Toilet.

2.2. Samples Collection

A total of 66 samples were collected from door handles from the different sampling units in the hospital for a period of six months between May, 2015 and October, 2015. Samples were collected from door handles with the aid of sterile swab sticks moistened with sterile normal saline. Specimens were labeled appropriately reflecting the number, location, and date and then transported in ice packed box to the Laboratory for microbiological analyses.

2.3. Enumeration of the Microorganisms

Samples were collected from door handles with the aid of sterile swab sticks moistened with sterile normal saline. Each swab stick was incubated overnight in 10^{-1}ml normal saline to encourage the growth of microorganisms. The original samples were serially diluted onto 10^{-2} through 10^{-4} to obtain discrete colonies when plated. Microbial plating was carried out using pour plate methods, plates were incubated at 37°C for 24h, upon incubation, colonies were counted and results were recorded as colony forming units per centimeter square (cfu/cm^2)according to the methods of Public Health England [21].

$$Count = \frac{C}{V\,(n_1 + 0.1n_2)}\ x\ n_3$$

C = the sum of colonies on all plates counted

n_1 = the number of plates counted at the first dilution

n_2 = the number of plates counted at the second dilution

V = the volume applied to each plate

n_3 = the original volume of neat suspension (i.e. 10 for swab, 500 or 100 for the sample)

d = the dilution from which the first count was obtained e.g. 10^{-2} is 0.01 (PHE, 2014)

2.4. Microbiological Analyses

The characteristic distinct colonies were isolated and purified by sub-culturing on nutrient agar to obtain pure culture isolates. The cultural, morphological, biochemical and physiological characterization of the bacterial isolates were carried out according to earlier methods [22].

2.5. Statistical Analysis

Two-way ANOVA without replication was used to determine the significant difference between the frequencies of occurrence of isolates on door handles at different locations in the hospital including general toilet. Data were summarized and analyzed using SPSS software 16 version [23].

3. Results

Table 1 shows the total viable bacterial counts of door handles from the sampling points for a period of six months, between May, 2015 and October, 2015. The bacteria population density isolated in each sampling location varies between the periods of sampling. The General Toilet 4.17 ± 0.18 × 10^4cfu/cm^2 had the highest bacteria load in the month of May while the Intensive Care Unit 3.03 ± 0.03 × 10^4cfu/cm^2 had the least. In June, the General Toilet 4.17 ± 0.18 × 10^4cfu/cm^2 had highest bacteria load while the Male Surgical Ward 3.33 ± 0.13 × 10^4cfu/cm^2 had the least. In July, the Paediatric Ward 4.13 ± 0.20 × 10^4cfu/cm^2 had the highest bacteria load while the Microbiological Laboratory 3.37 ± 0.17 × 10^4cfu/cm^2 had the least. In August, the Theatre Ward 4.03 ± 0.32 × 10^4cfu/cm^2 had the highest bacteria count while the Microbiological Laboratory 3.13 ± 0.07 × 10^4cfu/cm^2 had the least. In September, the General Toilet 4.90 ± 0.55 × 10^4cfu/cm^2 had highest bacteria load while the Intensive Care Unit 3.36 ± 0.22 × 10^4cfu/cm^2 had the least. In October, the General Toilet 4.17 ± 0.27 had the highest bacteria load while the Intensive Care Unit 3.03 ± 0.03 × 10^4cfu/cm^2 had the least.

Table 2 shows the results of the bacteria isolated from the study sites. Five prominent bacterial isolates were encountered. They included *Staphylococcus aureus, Pseudomonas aeruginosa, Streptococcus pneumoniae, Bacillus subtilis* and *Escherichia coli*.

Table 3 shows the percentage frequency of occurrence of bacterial isolates on door handles at different locations. *E. coli* (90.02%) was reported to be the most prevalent isolates from General Toilet (s) during the sampling period, while *B. subtilis* (60.00%) had the least frequency of occurrence (Figure 1). The result obtained from statistical analyses showed that locations significantly influenced the prevalence of the bacteria (P<005).

Table 1. *Total bacterial counts of door handles at different sampling sites in UBTH (×10^4 ± SD cfu/cm^2).*

	May	June	July	August	September	October
Theatre Ward	3.90 ±0.10	3.40 ± 0.29	3.73 ± 0.34	4.03 ±0.32	3.66 ± 0.31	3.10 ± 0.53
Microbiology Lab.	3.33 ± 0.24	3.33 ±0.19	3.37 ± 0.17	3.13 ± 0.07	3.80 ± 0.12	3.30 ± 0.21
Male Surgical Ward	3.10 ± 0.06	3.33 ± 0.13	3.47 ± 0.27	3.93 ± 0.09	3.93 ± 0.09	3.27 ± 0.22
Female Surgical Ward	3.63 ± 0.09	3.53 ± 0.22	3.83 ± 0.03	3.93 ± 0.17	4.50 ± 0.25	3.37 ± 0.27
Pharmacy Dept	3.43 ± 0..22	3.67 ± 0.03	3.43 ± 0.17	3.33 ± 0.18	3.37 ± 0.27	3.30 ± 0.21
Emergency Ward	3.20 ± 0.12	3.43± 0.08	3.50 ± 0.15	3.70 ± 0.06	4.03 ± 0.18	3.53 ± 0.22
Revenue Section	3.30 ± 0.15	3.43 ± 0.14	3.87± 0.33	3.17 ± 0.12	3.40 ± 0.20	3.43 ± 0.12
Paediatric Ward	3.26 ± 0.22	3.67 ± 0.26	4.13 ± 0.20	3.93 ± 0.12	3.60 ± 0.31	3.60 ± 0.06
Intensive Care Unit	3.03± 0.03	3.57 ± 0.29	3.70 ± 0.42	3.20 ± 0.12	3.36 ± 0.22	3.03 ± 0.03
COPD	3.30 ± 0.30	3.50 ± 0.50	3.90 ± 0.43	3.63 ± 0.29	3.60 ± 0.30	3.30 ± 0.21
General Toilet	4.17 ± 0.18	4.17 ± 0.18	3.80 ± 0.43	3.43 ± 0.29	4.90 ± 0.55	4.17 ± 0.27

Values express as mean of triplicate, COPD – Consultancy outpatient department

Table 2. *Characteristics of bacterial isolates at different sampling sites in UBTH.*

Characteristics	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**
Cell morphology	**Cocci**	**Rod**	**Cocci**	**Rod**	**Rod**
Cell arrangement	**Irregular groups**	**Single**	**Chains**	**Short chains**	**Clusters**
Gram reaction	**Positive**	**Negative**	**Positive**	**Negative**	**Negative**
MotilityTest for enzyme	+	+	+	+	+
Catalase production	+	+	-	+	-
Spore formation	-	-	-	+	+
Oxidase test	-	+	-	+	-
Coagulase test	+	-	-	-	-
Citrate utilization	-	+	+	+	-
Indole	-	-	-	-	+
Nitrate reduction	-	-	-	-	+
Acid testSugar fermentation	-	-	-	-	-
Lactose	+	+	-	-	+
Glucose	+	-	+	+	+
Galactose	-	-	-	+	+
Maltose	+	+	+	+	+
Mannitol	+	-	-	-	-
Probable Identity	*Staphylococcus aureus*	*Pseudomonas aeruginosa*	*Streptococcus pneumoniae*	*Bacillus subtilis*	*Escherichia coli*

KEY:+ = Positive; - =Negative

Table 3. *Percentage frequency of occurrence of bacterial isolates on door handles at different locations in UBTH.*

Bacterial isolates	Sampling site (%)											
	PD	**ICU**	**ML**	**EW**	**COPD**	**PW**	**RS**	**MSW**	**FSW**	**TW**	**GT(s)**	**Total**
P. aeruginosa	15	51	81	66	16	33	12	20	23	50	81	67
S. pneumoniae	66	33	70	50	16	66	13	35	32	15	23	63
B. subtilis	83	16	50	33	10	61	23	27	45	62	45	60
S. aureus	81	50	70	83	23	12	81	52	50	64	82	87
E. coli	50	70	50	31	12	81	40	62	63	53	90	92

Key: PD - Pharmacy Department, ICU - Intensive Care Unit, ML - Microbiological Laboratory, EW - Emergency Ward, COPD - Consultancy Outpatient Department, PW - Pediatric Ward, RS - Revenue Section, MSW - Male Surgical Ward, FSW -Female Surgical Ward, TW - Theatre Ward, GT - General Toilets

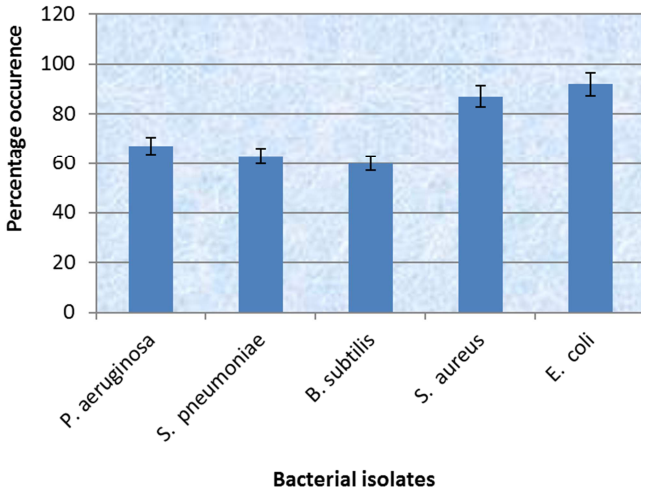

Figure 1. *Mean Percentage frequency of occurrence of bacterial isolates.*

4. Discussion

Inanimate environmental surfaces such as hospital door handles can become directly contaminated with microorganisms after frequent exposure to health-care givers, patients, and visitors. Although, much about the transmission of hospital acquired infection among health-care workers, patients, and visitors remains unknown, several facts have been established by existing data. Jonathan [24] reported that several nocosomial pathogens were shed by patients and health-care workers during interactions as well as during uncontrolled movement of visitors in and out of different sections in the hospital. They acquire these pathogens via contact with contaminated hospital surfaces at concentration sufficient for transmission [12, 25].

The microbiological analyses of samples from the different hospital units at UBTH in this study showed that door locations played significant role in the distribution of microorganisms. Generally, it was found that samples analyzed from toilet door handles recorded the highest bacterial load. This could be attributed to the high rates of exposure of the door handles to large traffic users who throng in and out without proper hand hygiene, thereby disseminating their flora to the door handles. This submission is in concordance with the findings of Nworie et al., [26], who reported that toilet environments usually contain higher microbial loads than other facilities within any public centres. Environmental factors such as relatively high humidity and moisture content can play crucial role in influencing microbial transfer rates on fomites or hands. It was found that greater microbial carriage and dissemination occurred typically at relative humidity of 79.5% than at 57% [27]. Also previous studies have shown that moist fomites or hands influence microbial transfer more than dry hands or surfaces [28, 29]. Hence, the relatively high microbial load of the bacterial pathogens from the samples collected from the hospital toilet door handles could have been facilitated by the relatively high humid nature of the toilet environment that probably encourages microbial replication and development. It also suggests poor hand hygiene practices after making use of the toilet as well as lack of adequate cleaning and sanitation of facilities.

This study also revealed a significant difference in the levels of contamination levels of door handles at locations between clinical areas and wards, especially between the operating theatre and paediatric ward which recorded one of the highest bacterial population densities. The high level of contamination observed at door handles between clinical areas may be an indication of high inflow and outflow of patients and health care-givers that normally use the routes for routine work. However, relatively lower rate of microbial contaminations were observed from the intensive care unit, male surgical ward and microbiological laboratory. This could be attributed to a relatively higher level of compliance to environmental and hand hygiene practices which encompasses hand washing with antimicrobial soap and clean water, as well as appropriate use of gloves during ward activities. A similar submission was made by an earlier reporter, who recommended strict personal and environmental sanitation within and around hospital wards to prevent horizontal dissemination of pathogens [12, 13].

It was observed that E. coli (92.02%) had the mean highest frequency of occurrence on the door handles, and this was followed by *S. aureus* (87.00%), *P. aeruginosa* (67.00%), *S. pneumonia* (63.00%), and *B. subtilis* (60.00%) being the least. The finding of E. coli as the most frequent bacterial contaminant in this study is at variance with previous works in Nigeria that reported *S. aureus* as the most prevalent contaminants of door handles. In their study, Onwubiko and Chinyeaka [30], reported *S. aureus* 33(25.0%) as the most frequently isolated bacteria from door handles of a tertiary Institution at Umuahia, Abia State, Nigeria. The other

isolates they reported, in decreasing order of frequencies were coagulase negative *Staphylococcus* (CoNS), 28(21.2%), *Streptococcus* species 22(16.6%), *Bacillus* species 22(16.6%), *Enterococcus feacalis* 6(4.8%), *Klebsiella* species 3(2.2%), E. coli 4(3.0%), *Proteus mirabilis* 4(3.0%), *Proteus vulgaris* 6(4.6%), and *Pseudomonas aeruginosa* 2(1.5%) being the least. Similarly, *Staphylococcus* species (43.3%) were reported as the most prevalent bacterial contaminants of doors handles of Secondary Schools in Bokkos Local Government of Jos Plateau State, Nigeria [31]. The other microbial contaminants reported, in decreasing order of prevalence, were *Candida* species (10%), *Escherichia coli* (16.7%), *Citrobacter* species (1.7%), *Klebsiella* species (20%), Proteus species (6.7%) and *Salmonella* species (1.7%). In addition, *Staphylococcus* species were also reported as the most frequent contaminants of door handles of public conveniences, hospital equipments and surfaces [32, 33]. Thus, this is a significant finding in this study and of great public health concern. Apart from the fact *E. coli* are the major indicators of faecal contamination and poor hand hygiene; they possess diverse strains with potent virulence and toxic factors. They are mainly responsible for urinary, gastrointestinal and urogenital ailments of humans [8]. Therefore, *E. coli* could be transferred horizontally to patients, visitors, or health care workers, who come in contact with such door handles without strict personal hygiene.

Also, the significant levels of *S. aureus* contamination observed in this study are worth-nothing, because they were reportedly carried by 30-50% of healthy humans as normal flora and one of the frequently implicated bacteria in hospital-acquired infections [34]. They are also known to cause diverse human ailments ranging from minor skin infection such as pimples and boil to a number of life threatening diseases like bacteraemia and sepsis, toxic shock syndrome (TSS), pneumonia, meningitis, osteomyelitis, endocarditis [35].

The presence of P. *aeruginosa, S. pneumonia* and *B. subtilis* isolates is also of public health significance. *P. aeruginosa* has been found to be a major opportunistic pathogen and reportedly identified as one of the vital causes of infection-related mortality among seriously ill and immunocompromised patients [36]. These pathogens were found to be the leading causes of wound infection and diarrhoea especially in developing countries. They are best described as classic opportunistic nosocomial pathogens which can cause a wide spectrum of infection and morbidity in immune compromised patient. *Streptococcus pneumoniae* are also major pathogens that are often implicated in community-acquired pneumonia, sinusitis, otitis media and meningitis among the critically ill, the very young, and the elderly [37, 38]. *Bacillus* species are mainly soil flora but have been implicated in some clinical manifestations such self-limiting food poisoning, ocular infections, meningitis, endocarditis, osteomyelitis, and bacteremia [39]. It is therefore surprising that inanimate surfaces and environments of hospital, where patients seek medical attention have an important influence on the risk of acquiring infection that may further complicates their health conditions. The presence of these bacterial isolates from door handles used on daily basis by patients, health care givers and visitors alike is worrisome, in the light of the fact that some of the isolated bacteria have been reported to demonstrate multi-drug resistance to currently available chemotherapeutic agents [37, 38, 40, 41].

5. Conclusion

This study has revealed that door handles of different sections in hospital environment are contaminated by a variety of pathogenic and non-pathogenic microorganisms. This most frequent bacterial isolates was *E. coli*, and followed by *S. aureus, P. aeruginosa, S. pneumoniae* and *B. subtilis* being the least. Hence, door handle surfaces within could therefore act as potential fomites for communicable diseases dissemination. Health-care workers, patients and visitors are encouraged to pay strict attention to personal hygiene practices to avoid the incidence and spread of hospital acquired infections.

Recommendations

The following recommendations were adduced:

(a). Frequent cleaning and disinfection of all hospital door handles.

(b). Strict compliance with recommended hand hygiene practices within the hospital vicinity as recommended by WHO/CDC (c). Education of patients and visitors on potential microbial hazards associated with direct or indirect contact with hospital surfaces (d). Implementation of evidence-based infection prevention measures that will reduce the risk of transmission of pathogens through door handles and other hospital surfaces.

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