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Original Article

Profile of antibiotic susceptibility test of bacterial pathogens isolated from the hands of university students in Nigeria

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Abstract

The aim of this study was to assess bacterial contaminants isolated from hands of undergraduate students of Babcock University, Nigeria. A total number of 200 students (100 males and 100 females) were randomly recruited and hand swabs were collected and inoculated on MacConkey and chocolate Agar. The biochemical tests were conducted to identify the bacterial isolates and antibiotic susceptibility testing was carried out using the disc diffusion method. Out of the 200 participants examined, bacterial contaminants were recovered from 154 (77.0%). The most frequently isolated organisms were *Staphylococcus aureus* (32.5%), followed by *Escherichia coli* (26.6%), coagulase negative *Staphylococcus* (20.8%) and then *Klebsiella pneumoniae* (20.1%). The antibiotic sensitivity showed that all coagulase negative *Staphylococcus* isolates were sensitive to ceftriaxone, levofloxacin, ciprofloxacin, imipenem, ofloxacin and azithromycin, but less sensitive to cefuroxime (50.0%) and amoxicillin (60.0%). *S. aureus* was sensitive to levofloxacin, ofloxacin, gentamycin and azithromycin while for Gram negative bacteria, *E. coli* was 100% sensitive to levofloxacin, imipenem, cefuroxime, ofloxacin, and ampiclox, but less sensitive to amoxicillin (20.0%). *Klebsiella pneumoniae* was sensitive to ceftriaxone and gentamycin, 100% and 90.0%, respectively, but less sensitive to amoxicillin (20.0%). In conclusion, some bacteria exist on the hands of undergraduate students of Babcock Students with varied antibiotic susceptibility patterns and therefore institutional implementation of hand hygiene practices should be implement among students in the university.

Keywords: Antibiotic susceptibility, bacterial pathogen, contamination, eye glasses, risk factor

Introduction

Human hands usually harbour microorganisms. Since microorganisms are transferred through hands both intrapersonal and interpersonal, the nature of hand microbial communities and the factors that influence them are critical (Lax et al., 2014). To avoid infections from transient microbes, surfaces must be disinfected, particularly those with which the hands come into contact frequently. While these surfaces cannot be completely free of microorganisms, studies have shown that they can be reduced. The high prevalence of diarrheal diseases and other communicable diseases among schoolchildren may be attributed to a lack of personal and environmental hygiene education and practice (UNICEF, 2008). Even though hand washing is a common practice in Nigerian society, the frequency and form of the practice may not have reached internationally recommended standards. The presence of a high bacterial load on the hands is caused by poor hand hygiene. Majority of research on hand hygiene enforcement have been conducted in hospitals, with just a few studies conducted in schools. Contaminated hands play a critical role in faecal-oral route disease transmission. Hand washing is thought to minimize the spread of infections including diarrhoea and acute respiratory illnesses, unfortunately the level of hand hygiene is very low among many.

Gastro-intestinal and acute respiratory illnesses have been associated with contaminated hands and are common among both the young and elderly in Nigeria. Since microbes may be present on the skin as normal flora, the hand cannot be sterile. However, poor hand hygiene may contribute to high bacterial load on the hands posing a high risk of gastro-intestinal infection through the oral-faecal route if left uncheck. Apart from the need of isolating and characterizing bacterial pathogens found on the hands, the antibacterial susceptibility pattern of these bacterial isolates must be determined.

The identification of risk factors linked to bacterial contamination of the hands would aid in the development of monitoring and preventive measures aimed at preventing gastro-intestinal infections associated with bacterial contamination of the hands. Most studies on the isolation and characterization of bacterial pathogens associated with the hands have been conducted among primary and secondary school study participants, but a few among tertiary institution study participants. This study therefore sought to assess the bacterial profile associated with the hands of undergraduate students in Nigeria.

Methods

Study design

This was a cross-sectional institutional based descriptive study conducted among undergraduate students of Babcock University, Ilishan-Remo, Ogun State, Nigeria. The university has nine schools: School of Public and Allied Health, School of Basic and Applied Sciences, School of Education & Humanity, School of Management Science, School of Nursing, School of Law & Security Studies, School of Social Sciences, School of Computing Sciences, Benjamin's Carson School of Medicine and Babcock Business School. A total students was approximately twelve thousands. The study was conducted within the periods of two months (May to June, 2021).

Sample and sampling method

The minimum sample size was calculated as previously described (Sharma et al., 2020). A 95% confidence level and margin of error set at 0.05 were used to calculate the sample size. A total of 200 sample size shall be required for the study. To begin the sampling selection process, five out of the nine schools were choose by simple random sampling technique. Next, the students of these five schools were stratified on the basis of their gender (*i.e.,* stratified sampling). Afterwards, 40 students (20 males and 20 females) were selected randomly from the five schools: School of Public and Allied Health, School of Basic and Applied Sciences, Babcock Business School, Benjamin's Carson School of Medicine and School of Computing Sciences.

Data collection and sample collection

Demographic data and clinical information were collected through face-to-face interview using structured questionnaires. The pre-test questionnaires were administered to the participants directly. The demographic data included occupation, gender, marital status, age, tribe and name of school.

Swab samples were collected from the hand of students. The swab stick was decapitated and the tip aseptically transferred into a tube containing 10 mL of peptone broth processed within 18 h.

Determination of bacterial load and microorganisms identification

The surface viable count was used for the determination of bacterial load (Miles and Misra, 1938). The colonies forming units (CFU) per mL was determined from each sample.

Antibiotic sensitivity testing

Macroscopy and microscopy were adopted for the identification of the bacterial isolates as described previously (Ochei and Kolhatkar, 2006). The antibiotic sensitivity pattern of the bacterial isolates was determined using the disc diffusion technique (Bauer et al. 1966 and Cheesbrough (2006).

Data analysis

One-way to analysis of variance (Anova) and Tukey- Kramer multiples comparisons test were used to test for significant differences of the load, frequency and distribution of bacterial contaminants associated based on the characteristics. Chi-squared test, or Fisher's exact test were used to comparisons between categorical data.

Results

The socio-demographic characteristics of the study participants are presented in Table 1. Majority of them were within the age range of 16-20 years (73.0%), followed by 21-25 years (22.0%) and ≥30 years (5.0%). Majority of the study participants were Christians (68%), Yoruba (56.5%), single (95.0%) and currently in 500 level (35.0%) as at the time of this study.

Table 1. Socio-demographic characteristics of the study participants

Characteristics	Category	Frequency	Percentage
Gender	Female	100	50.0
	Male	100	50.0
Age range	16-20yrs	146	73.0
	21-25yrs	44	22.0
	≥30yrs	10	5.0
Religion	Christianity	136	68.0
	Islam	64	32.0
Tribe	Hausa	6	3.0
	Igbo	81	40.5
	Yoruba	113	56.5
Marital status	Married	10	5.0
	Single	190	95.0
Study level	200	15	7.5
	300	53	26.5
	400	62	31.0
	500	70	35.0

The frequency of bacterial contamination on the hands according to the socio-demographic characteristics are presented in Table 2. Out of the 200 samples, bacterial contaminants were recovered from 154 (77.0%). Our data suggested that gender, age range, tribe, marital status and study level had no association with the occurrences of bacterial contaminants (Table 2).

Out of the 154 bacterial isolates identified, 53.3% and 46.7% were Gram positive and negative, respectively. The most frequently isolated organism was *Staphylococcus aureus* (32.5%), followed by *Escherichia coli* (26.6%), coagulase negative *Staphylococcus* (20.8%) and *Klebsiella pneumoniae* (20.1%) (Figure 1).

The distribution of occurrence of bacterial contaminants on the hands according to the demographic characteristics of the study participants is presented in Table 3. The occurrence of *S. aureus* was non-significantly ($P>0.05$) higher among females compared to their male counterparts and also among those belonging to the age 16-20 years. However, it was significantly higher ($p<0.05$) among 300 and 500 level students.

Table 2. Frequency of occurrence of bacterial contamination on the hands according to the demographic characteristics of the study participants

Variable	Category	No of participants examined n (%)	No of hands not contaminated n (%)	No of hands contaminated n (%)	P-value
Gender	Female	100 (50.0)	24 (12.0)	76 (38.0)	0.737
	Male	100 (50.0)	22 (11.0)	78 (39.0)	
	Total	200 (100.0)	46 (23.0)	154 (77.0)	
Age range	16-20yrs	146 (73.0)	37 (18.5)	109 (54.5)	0.416
	21-25yrs	44 (22.0)	7 (3.5)	37 (18.5)	
	30 Above	10 (5.0)	2 (1.0)	8 (4.0)	
	Total	200 (100.0)	46 (23.0)	154 (77.0)	
Religion	Christianity	136 (68.0)	28 (14.0)	108 (54.0)	0.237
	Islam	64 (32.0)	18 (9.0)	46 (23.0)	
	Total	200 (100.0)	46 (23.0)	154 (77.0)	
Tribe	Hausa	6 (3.0)	1 (0.5)	5 (2.5)	0.854
	Igbo	81 (40.5)	20 (10.0)	61 (30.5)	
	Yoruba	113 (56.5)	25 (12.5)	88 (44.0)	
	Total	200 (100.0)	46 (23.0)	154 (77.0)	
Marital status	Married	10 (5.0)	2 (1.0)	8 (4.0)	0.817
	Single	190 (95.0)	44 (22.0)	146 (73.0)	
	Total	200 (100.0)	46 (23.0)	154 (77.0)	
Study level	200	15 (7.5)	2 (1.0)	13 (6.5)	0.823
	300	53 (26.5)	13 (6.5)	40 (20.0)	
	400	62 (31.0)	15 (7.5)	47 (23.5)	
	500	70 (35.0)	16 (8.0)	54 (27.0)	
	Total	200 (100.0)	46 (23.0)	154 (77.0)	

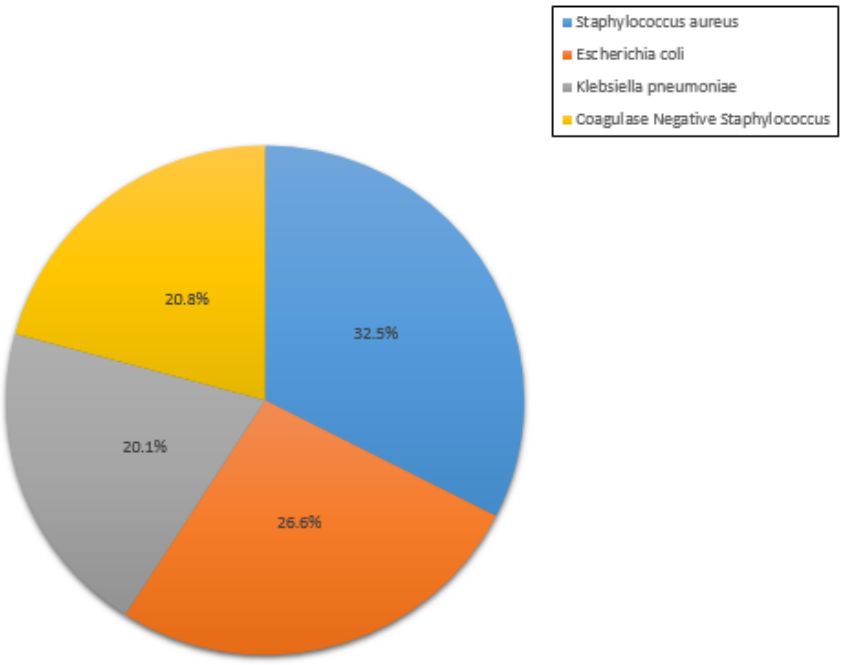

Figure 1. A pie chart showing the frequency of the bacterial type recovered from the hands of the study Participants.

Table 3. Distribution of occurrence of bacterial contaminants on the hands according to the demographic characteristics of the study participants

Variable	Category	Coagulase negative *Staphylococcus*	*E. coli*	*K. pneumoniae*	*Staph. aureus*	P-value
Gender	Female	18 (11.7)	19 (12.3)	12 (7.8)	27 (17.5)	0.608
	Male	14 (9.1)	22 (14.3)	19 (12.3)	23 (15.0)	
Age range	16-20yrs	25 (16.2)	27 (17.5)	22 (14.3)	35 (22.7)	0.579
	21-25yrs	6 (3.9)	10 (6.5)	9 (5.8)	12 (7.8)	
	30 Above	1 (0.7)	4 (2.6)	0 (0)	3 (2.0)	
Religion	Christianity	22 (14.3)	28 (18.2)	24 (15.6)	34 (22.1)	0.672
	Islam	10 (6.5)	13 (8.4)	7 (4.5)	16 (10.4)	
Tribe	Hausa	1 (0.7)	1 (0.7)	0 (0)	3 (2.0)	0.909
	Igbo	14 (9.1)	15 (9.7)	12 (7.8)	20 (13.0)	
	Yoruba	17 (11.0)	25 (16.2)	19 (12.3)	27 (17.5)	
Marital status	Married	1 (0.7)	4 (2.6)	0 (0)	3 (2.0)	0.410
	Single	31 (20.1)	37 (24.0)	31 (20.1)	47 (30.5)	
Study level	200	8 (5.2)	2 (1.3)	3 (2.0)	0 (0)	0.003*
	300	6 (3.9)	10 (6.5)	4 (2.6)	20 (13.0)	
	400	8 (5.2)	16 (10.4)	13 (8.4)	10 (6.5)	
	500	10 (6.5)	13 (8.4)	11 (7.1)	20 (13.0)	

The bacterial load on the hands of the study participants according to their socio-demographic characteristics is presented in Table 4. Out of the 154 participants with positive hand swab culture, 49 (31.8%) had significant bacterial load (>10^5 CFU/ml), whereas the remaining 105 (68.2%) had non-significant bacterial load (<10^4 CFU/ml) (Table 4).

Table 4. Bacterial load on the hands of the study participants according to their socio-demographic characteristics

Variable	Category	<10^4 CFU/mL n (%)	>10^5 CFU/mL n (%)	Total n (%)	P-value
Gender	Female	50 (32.5)	27 (17.5)	77 (50)	0.395
	Male	55 (35.7)	22 (14.3)	77 (50)	
Age range	16-20yrs	73 (47.4)	36 (23.4)	109 (70.8)	0.042
	21-25yrs	26 (17.0)	11 (7.1)	37 (24.0)	
	30 Above	6 (3.8)	2 (1.3)	8 (5.2)	
Religion	Christianity	78 (50.7)	30 (19.5)	108 (70.1)	0.219
	Islam	27 (17.5)	19 (12.3)	46 (29.9)	
Tribe	Hausa	4 (2.6)	1 (0.7)	5 (3.2)	0.167
	Igbo	47 (30.5)	13 (8.4)	60 (39.0)	
	Yoruba	54 (35.1)	35 (22.7)	89 (57.8)	
Marital status	Married	6 (3.9)	2 (1.3)	8 (5.2)	0.883
	Single	99 (64.3)	47 (30.5)	146 (94.8)	
Study level	200	7 (4.6)	5 (3.2)	13 (8.4)	0.019*
	300	29 (18.8)	10 (6.5)	39 (25.3)	
	400	28 (18.2)	20 (13.0)	48 (31.2)	
	500	41 (26.6)	14 (9.1)	54 (35.1)	

There was no significant difference in the bacterial load found on the hands of the study participants on the basis of gender, whereas the occurrence of significant bacterial load was significantly higher among participants aged 16-20 years and 400 level students (Table 4).

Table 5. Risk factors associated with the occurrence of bacteria pathogens on the hands of the study participants

Questionnaire	Response	No of study participants n (%)	Non-pathogenic n (%)	Pathogenic n(%)	No of Isolates n (%)	P-value
Is hand hygiene really necessary in day-to-day life?	Yes	200 (100.0)	32 (16.0)	72 (36.0)	104 (52.0)	
	No	0 (0)	0 (0)	0 (0)	0 (0)	
How do you maintain your hand hygiene?	All of the above	78 (39.0)	14 (7.0)	28 (14.0)	42 (21.0)	0.884
	Use of hand sanitizers only	45 (22.5)	7 (3.5)	14 (7.0)	21 (10.5)	
	Wash with both water and soap	77 (38.5)	11 (5.5)	30 (15.0)	41 (20.5)	
How often do you remember to wash hands after using the toilet?	Always	30 (15.0)	2 (1.0)	8 (4.0)	10 (5.0)	0.220
	Often	118 (59.0)	22 (11.0)	43 (21.5)	65 (32.5)	
	Rarely	52 (26.0)	8 (4.0)	21 (10.5)	29 (14.5)	
How often do you wash your hand after each daily activity?	Always	109 (54.5)	19 (9.5)	39 (19.5)	58 (29.0)	0.640
	Often	39 (19.5)	8 (4.0)	14 (7.0)	22 (11.0)	
	Rarely	52 (26.0)	5 (2.5)	19 (9.5)	24 (12.0)	
Do you check the expiry date before purchasing hand sanitizers?	No	115 (57.5)	13 (6.5)	46 (23.0)	59 (29.5)	0.084
	Yes	85 (42.5)	19 (9.5)	26 (13.0)	45 (22.5)	
Do you think that hand cleansing can be achieved more rapidly using hand sanitizer than the conventional hand washing with soap and water?	Yes	200 (100.0)	32 (16.0)	72 (36.0)	104 (52.0)	
	No	0 (0)	0 (0)	0 (0)	0 (0)	
Is the use of hand sanitizers being more effective against microbes than hand washing?	Yes	99 (49.5)	17 (8.5)	35 (17.5)	52 (26.0)	
	No	101 (50.5)	15 (7.5)	37 (18.5)	52 (26.0)	0.904
How many times do you use hand sanitizer in a day?	2-4 times in a day	100 (50.0)	16 (8.0)	37 (18.5)	53 (26.5)	0.953
	5-7 times in a day	100 (50.0)	16 (8.0)	35 (17.5)	51 (25.5)	
Where do you use hand sanitizers mostly?	Both at home and public places	109 (54.5)	20 (10.0)	42 (21.0)	62 (31.0)	0.295
	Only at public places	91 (45.5)	12 (6.0)	30 (15.0)	42 (21.0)	
Do you carry a pocket hand sanitizer around?	Yes	87 (43.5)	19 (9.5)	30 (15.0)	49 (24.5)	0.137
	No	113 (56.5)	13 (6.5)	42 (21.0)	55 (27.5)	
How often do you have access to hand sanitizers in public places?	Always	83 (41.5)	17 (8.5)	27 (13.5)	44 (22.0)	0.539
	Often	35 (17.5)	6 (3.0)	12 (6.0)	18 (9.0)	
	Rarely	82 (41.0)	9 (4.5)	33 (16.5)	42 (21.0)	
Do you wash hands after using the toilet?	Yes	200 (100.0)	32 (16.0)	72 (36.0)	104 (52.0)	
	No	0 (0)	0 (0)	0 (0)	0 (0)	
Do you use handkerchief to dry hands after washing?	Yes	54 (27.0)	3 (1.5)	22 (11.0)	25 (12.5)	0.050
	No	146 (73.0)	29 (14.5)	50 (25.0)	79(39.5)	

The risk factors associated with the occurrence of bacteria pathogens on the hands of the study participants are presented in Table 5. All the participants (100%) agreed that hand hygiene really necessary in day-to-day life. Majority of them (39.0%) indicated that they employed a combination of hand hygiene measures including the use of hand sanitizer, as well as washing with soap and water (Table 5).

Only 99 (49.5%) of them agreed that hand sanitizers are more effective against microbes than the conventional hand washing. Out of the 200 study participants, 39 (19.5%) often wash their hands after each daily activity; the highest had (54.5 %) always washes their hands after each activity. All participants agreed that they wash hands after using the toilet; and 54 (27%) agreed that they use handkerchief to dry hands after washing while 146 (73%) agreed that they use handkerchief to dry their hands after washing (Table 5).

The antibiotic sensitivity pattern of Gram-positive bacterial isolates recovered from the hand swabs of the study participants are presented in Figure 2. Coagulase negative *Staphylococcus* was most sensitive (100%) to ceftriaxone, levofloxacin, ciprofloxacin, imipenem, ofloxacin, erythromycin, gentamycin and azithromycin, but least sensitive to cefuroxime (50.0%) and amoxicillin (60.0%). Meanwhile, *S. aureus* was most sensitive to levofloxacin, ofloxacin, gentamycin and azithromycin.

Among Gram-negative bacterial isolates recovered from the hand swabs (Figure 3) *E. coli* was most sensitive (100%) to levofloxacin, imipenem, cefuroxime, ofloxacin, and ampictox, but least sensitive to amoxicillin (20.0%). Meanwhile, *K. pneumoniae* was most sensitive to ceftriaxone and gentamycin, 100% and 90.0%, respectively, but least sensitive to amoxicillin (20.0%).

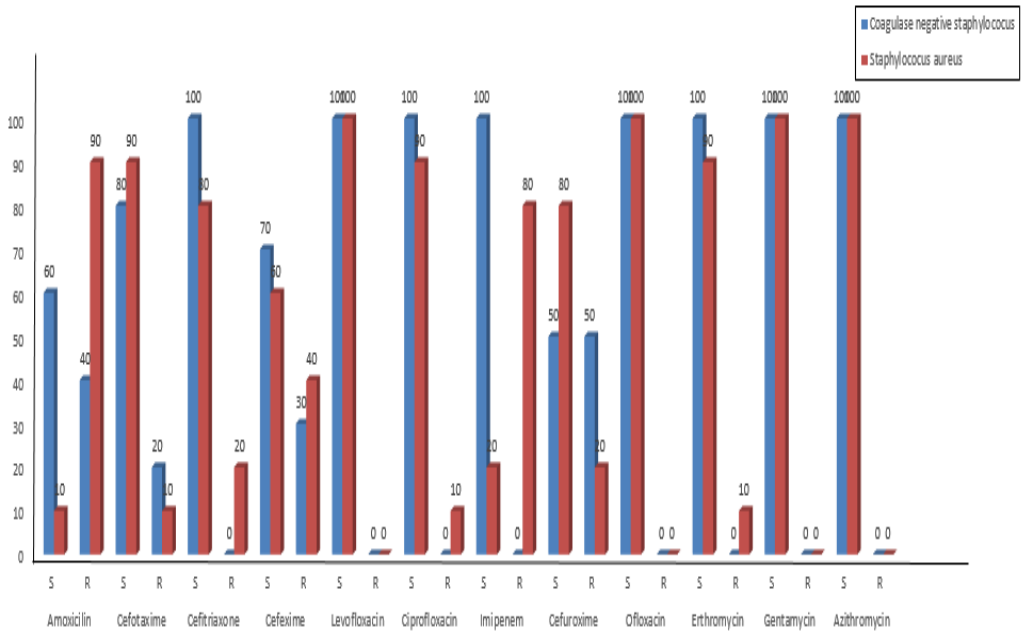

Figure 2. A histogram showing the antimicrobial sensitivity pattern of Gram positive isolates

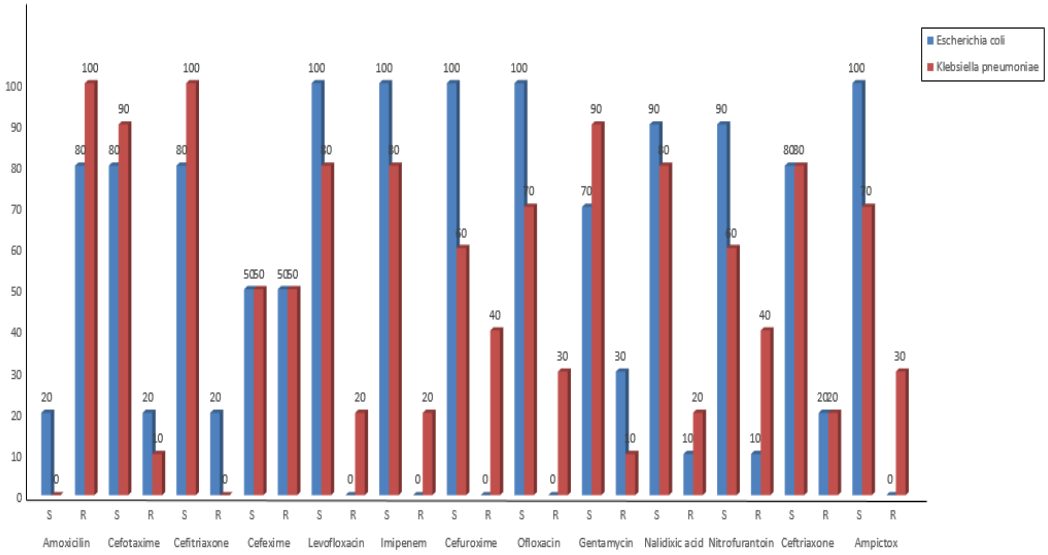

Figure 3. A histogram showing the antimicrobial sensitivity pattern of Gram-negative isolates.

Discussion

This current study assessed the bacterial contaminants associated with the hands of undergraduate students of Babcock University. The proportion of participants with contaminated hands found in this study was higher (77%) than the 61% reported by Ray et al. (2016) in Bangalore and Kolkata, India, but lower than the 81.0% and 88.0% reported by Vivas et al. (2010) and Ogba et al. (2018), respectively, among school children in Angolela and Nigeria, respectively. The reason for these differences may be due to differences in geographical location, study population, age and level of personal hygiene amongst others.

Despite the campaign of hand hygiene practice in schools with the advent of COVID-19 outbreak in Nigeria, bacterial hand carriage among undergraduate students of Babcock students was still high (77.0%). This may be due to relaxation in strict adherence to non-pharmaceutical COVID-19 intervention measures including the use of hand sanitizers, as well as limited availability of water and soap, and hand sanitizers in designated areas on the university. In this study, there is no significant difference in the frequency of occurrence of bacterial contaminants on the hands of the participants based on their gender distribution; unlike that of Ogba et al. (2018) who reported the highest occurrence of bacterial isolates among the male participants (62.1%), when compared to their female counterparts (37.8%). Cruz et al. (2015) opined that females had a higher knowledge and positive attitude towards hand hygiene than males in their study among Saudi Nursing students.

According to Ogba et al. (2018), a higher frequency of hand bacterial contaminants (42.0%) was recovered from participants between the age 5-7 years; whereas in this study, participants within the age 16-20 years, had the highest frequency of hand bacterial contaminants (54.5%). This may be due to the fact that majority of the subjects were in this age group, 146 (73.0%).

Furthermore, majority of the isolates recovered from this study were Gram positive (53.3%). This agrees with the work of Ogba et al. (2018), who reported a higher percentage of Gram-positive isolates (68.9%) compared to the Gram negative (31.1%). Also, four (4) types of bacterial isolates were recovered in this study: two of which were Gram positive (*S. aureus* and coagulase negative *Staphylococcus*) and the other

two Gram negative (*K. pneumoniae* and *E. coli*). On one hand, this study partly agrees with the work of Ogba et al. (2018) who also reported four bacterial types: Gram positive (*S. aureus*) and three Gram negative (*E. coli, Proteus vulgaris* and *Pseudomonas aeruginosa*) from the hands of primary school children in Calabar municipality, Nigeria. However, on the other hand, the study differs from another study that reported eight bacterial types of which seven Gram positive and one Gram negative.

The reason for the differences in these various studies may include: diversity in the normal flora of the study participants, nature of study population and their socio-demographic characteristics, varied levels of personal hygiene and environmental sanitation amongst others.

The most frequently isolated bacterial contaminant observed among the participants in this study was *S. aureus* (32.5%), whereas the least isolated was *K. pneumoniae* (20.1%). This agrees with the study by Ray et al. (2016) who reported 44% and 7%, respectively, but on the other, it disagrees with the study by Al Momani et al. (2019), who reported *S. epidermidis* (33.7%) and *Bacillus cereus* (4.5%) as the most and least frequently isolated bacteria, respectively.

Based on the data, the need for availability of hand sanitizers in public places likes the university environment. The advent of the COVID-19 pandemic has made the use of hand sanitizers very popular. In this study, 41.5% of the participants indicated that they always have access to hand sanitizers in public places. This was found to be higher than the 18% reported by Ray et al. (2016), who indicated availability of soap at hand washing facility at school, but less than the 52.0% who indicated that they have access to tap water for the purpose of hand hygiene as reported by Ogba et al. (2018). Also, the proportion of students (38.5%) in this study who indicated that they used soap and water for the purpose of hand hygiene is less than the 52% reported by Ray et al. (2016).

Still, forty-nine (49, 31.8%) out of the 154 participants with positive culture had significant bacterial load ($>10^5$ CFU/ml), particularly among those within the age range 16-20 years. This may be due to the fact that majority of the subjects were in this age group, 109 (70.7%). Contaminated hands play a major role in faecal–oral transmission of diseases (Ray et al., 2016). The presence of a high bacterial load on the hands is caused by a very poor hand hygiene. Therefore, proper hand hygiene is very central to preventing faecal–oral transmission of diseases. Identified risk factors associated with occurrence of these bacterial isolates amongst others include: frequency of hand hygiene, type of hand hygiene measures employed and lack of access to hand sanitizer in public places. All the bacteria isolates recovered from the participants in this study are pathogenic in nature or at least, are potential pathogens in humans.

Conclusion

The outcome of this study underscores the fact that the human hands are potent vehicles for the transmission of infectious agents like bacteria. Hence, the need for proper and consistent hand hygiene and this measure should be implemented not only by the individual but also by the institution through regulations.

Authors' contributions

Conceptualization: JCI and SOAA; Data Curation: SOAA and SSE; Formal Analysis: MOD and OGO; Funding Acquisition: SOAA; Investigation: SOAA, SSE, OGO and EEJ; Methodology: SOAA, SSE and MOD; Project Administration: JCI and SSE; Resources: SOAA and SSE; Software: CAO and NIO; Supervision: JCI and SSE;

Validation: CAO, EEJ and NIO; Writing – Original Draft Preparation: SOAA and SSE; Writing – Review & Editing: JCI, SOAA and SSE.

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Conflict of interest

There is no conflict of interest reported by the authors.

Ethical approval

This study was approved by the Babcock University Health Research Ethics Committee (BUHREC 565/21)

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