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Antimicrobial Susceptibility Pattern of Bacteria Isolated from Bath Towels Used by Students of University of Medical Sciences Ondo State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background/Aims: Bath towels are woven pieces of fabric either cotton or cotton-polyester that are used to absorb moisture on the body after bathing. Towels are a prime location for germs, and they can be picked up by contact with wet skin. The aim of this research work is to isolate, identify, and evaluate the occurrence of bacterial contaminations from individual bath towels of students from the University of Medical Sciences Ondo and their harmful consequence to public health. Microbiological screening of seventy-two (72) bath towels from 5 of the university hostels for bacterial contamination was carried out.
Methods: Bacterial isolation, antimicrobial susceptibility test were carried out using basic microbiological techniques. Antimicrobial susceptibility testing was also carried out using Mueller Hinton agar to determine the susceptibility pattern of bacteria isolated.
Results and conclusion: Biochemical analysis of bacterial isolates revealed a general contamination by mainly nine bacterial species associated with human nose, stomach, intestine and skin flora in decreasing frequency of occurrence: *Staphylococcus aureus* (38.8%), *Staphylococcus epidermidis* (18.1%), *Klebsiella pneumoniae* (15.3%), *Shigella* sp. (8.3%), Bacillus sp. (7.0%), Escherichia coli (4.2%), *Pseudomonas aeruginosa*. (4.2%), Micrococcus sp. (2.8%), *Salmonella* sp. (1.4%). Antibiotics susceptibility testing was carried out and recorded on each of the bacterial isolates. Most of the bacterial isolates showed resistance and susceptibility to certain

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antibiotics which helps in the perfect and effective choice of antibiotics if these species cause infections. Therefore, there is a need to adopt adequate measures for the regular cleaning and washing of towels, while also maintaining good personal hygienic practices to prevent the transfer and spread of pathogens from these towels and avoiding sharing of towels.

Keywords: Towels; bacterial isolation; antimicrobial susceptibility; microbiological techniques; isolates, species; antibiotics; personal hygiene.

1. INTRODUCTION

Towels are one of the first things we touch in the morning and one of the last thing we touch before going to bed at night. Dirty towels can carry huge variety of microbes, and they have even been linked to spreading infectious diseases [1]. A towel can't be 100% germ free but the microbial load can be reduced by washing. Towels are such great bacteria traps because every time they are used, the natural skin bacteria and other germs are transferred [2].

Towels offer the perfect environment for bacteria, mold, yeast and other microorganisms to grow because they're often damp, warm and absorbent, and they hang in dark bathrooms. Whenever a towel is used, there is a transfer of microbes form the hand to it [3]. According to Gerba et al., [4], the bathroom is a threatening place for a towel to spend most of its time.

The human body is burdened with microbial life of which are pathogenic and non-pathogenic [5]. Towels among other dirty clothes have the potential of harboring microbes which can cause skin infections when worn or used [6]. The aim of this study is to determine the antimicrobial susceptibility pattern of bacteria isolated from bath towels used by students of University of Medical Sciences Ondo State.

2. MATERIALS AND METHODS

2.1 Study Area and Population Study

The study was conducted from January to March 2021 in the Ondo State University of Medical Sciences Laje, Ondo, Ondo state, Nigeria. It is located at the center of Ondo West Local Government Area of Ondo State, A school with an estimated population of over 3,000 students (inhabitant exclusive).

2.2 Sample Collection and Analysis

A total of one seventy-two (72) students' towels were randomly sampled from at least five (5) school hostels consisting of both male and female, Questionnaires were all administered to them to obtain demographic information. Two methods of collection were adopted; the swabbing method and the soaking or washing method. A sterile cotton swab stick was soaked in sterile or saline water to moisten it. Each student's towel was swabbed at the surface and the edge of each towel was also dipped 2-3 times into a sample bottle containing sterile saline water and squeezed [1].

2.3 Microbial Enumeration and Biochemical Detection of the Isolates

Each medium was prepared in a conical flask by mixing 28g of nutrient agar in 1000ml of distilled water, 36g of eosin methylene blue agar in 1000ml of distilled water, 51.55g of MacConkey agar in 1000ml of distilled water, and was then dissolved on a hot plate for miscibility, plugged with cotton wool, covered with foil paper, sealed with paper tape and then sterilized in an autoclave at 1210C for 15minutes. To assess the presence and degree of microbial contamination on bath towels, standard pour plate and streak methods were employed. The pour plate method has an advantage over other methods such as microscopy and spectrophotometry, because only live colony forming units (CFUs) are counted hence bacteria injured and killed during laundering are not counted while streak plate method enables one to select and work with individual colonies. Non selective nutrient agar was used for general bacterial isolation because most common species and even some fastidious forms will grow on this medium. Conventional methods was adopted for confirmatory tests for all suspected isolates using selective medium, gram staining, catalase, citrate utilization, indole and urease tests [7].

2.4 Preparation of Inoculum

A sterile inoculating loop was used to touch four or five isolated colonies of the organism on the agar plate. The organism was then suspended in

2 ml of sterile saline in a test tube. The test tube was then placed on a vortex mixer to allow for a smooth suspension. The turbidity was then compared with the already prepared 0.5 McFarland standard [1].

2.5 Antibiotics Sensitivity Testing

Antibiotics sensitivity test was carried out using Adenola et al., [8] methods. A 0.5-ml aliquot of a 0.048 mol/liter BaCl2 (1.175% wt/vol BaCl2 • 2H20) was added to 99.5 ml of 0.18 mol/liter H2SO4 (1% vol/vol) with constant stirring to maintain a suspension. The correct density of the turbidity standard was verified by measuring absorbance using a spectrophotometer with a 1-cm light path and matched cuvette. The absorbance at 625nm was 0.08 to 0.13 for the 0.5 McFarland standards. Barium sulfate suspension in 4- to 6ml aliquots was transferred into screw-cap tubes of the same size as those used in standardizing the bacterial inoculums. The tubes were tightly sealed and stored in the dark at room temperature. A sterile swab was dipped into the inoculum tube. It was then inoculated on the solidified surface of the Muller Hinton agar plate by streaking the swab three times over the entire agar surface. The plates were allowed to sit at room temperature for at least 3 to 5 minutes for the surface of the agar plate to dry. A sterile forceps was used to place the appropriate antimicrobial-impregnated disks on the surface of the agar. Once all disks were in place, the plates were inverted and placed in an incubator at a 37°C for 16 to 24hours, after which the plates were checked and measured for the zone of inhibitions [9].

2.6 Statistical Analysis

Isolates were classified as resistant, intermediate and sensitive using the CLSI 2016 guide for the interpretation of zones of inhibition.

3. RESULTS

3.1 Duration of Usage and Cleaning of Bath Towels of UNIMED Students

It was observed that the duration that has the highest percentage of 33% are students who wash their towels every two weeks and the least duration with a percentage of 2% are students who has never washed their towels.

3.2 Microbial Loads of Towels Used by Male and Female Students at UNIMED, Ondo State

It was observed that the microbial load for female was higher than that of the male. The mean microbial loads in towels used by females range from 32±11.31 to 302.5±53.03 while the mean microbial loads in towels used by males range from 22.5±6.364 to 289±15.556. This indicates that female's towels had the highest microbial load compare to the males towels.

3.3 Identification of the Bacteria Isolated From UNIMED Students Towels

Nine bacterial species were isolated and identified from sampled bath towels. The bacterial species were associated with human gut and skin flora as follows: *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Salmonella* sp., *Escherichia coli*, *Pseudomonas aeruginosa*, *Shigella* sp., *Bacillus* sp., *Micrococcus* sp., and *Klebsiella pneumoniae*.

3.4 Frequency of Bacterial Isolates in UNIMED Students Towels

Staphylococcus aureus (38.8%) had the highest percentage frequency in student's towel, while *Salmonella sp.* (1.4%) had the lowest percentage frequency in student's towel.

3.5 Antibiotics Sensitivity Test of the Gram Positive Bacterial Isolates

The zone of inhibition ranged from 8mm to 22mm. It was recorded that the isolates recorded the highest number of sensitivity with Levofloxacin (34), the highest number of intermediate with Ciprofloxin (33) and highest number of resistance with Norfloxacin (33) when compared with CLSI standards of antibiotics zone of inhibition diameter measurement.

3.6 Antibiotics Sensitivity Test of the Gram Negative Bacterial Isolates

The zone of inhibition ranged from 10 mm to 22 mm. These results distinguished the resistant, intermediary and susceptible bacteria to the standard antibiotics disc used. It was recorded that the isolates recorded the highest number of sensitivity with Ofloxacin (13), the highest number of intermediate with Ciprofloxin (16) and

highest number of resistance with Nalidixic acid (22) when compared with CLSI standards of antibiotics zone of inhibition diameter measurement.

Table 1. Duration of usage and cleaning of bath towels

Duration	Male	Female	Total	Percentage %
Every week	9	15	24	33
Two (2) weeks	5	18	23	32
Monthly	6	12	18	25
Two (2) months	3	2	5	7
Six (6) months	-	1	1	2
Never	1	-	1	2
Total	24	48	72	100

Table 2. Microbial loads of towels used by male and female students at UNIMED, Ondo State

	Plate no.	Mean ± S.D	Plate no.	Mean ± S.D	Plate no.	Mean ± S.D
Female	3	164.5±13.435	21	215.5±4.95	45	196.5±34.648
	4	32±11.314	22	263±2.828	46	211±32.527
	7	56±5.657	25	162±19.799	47	139.5±23.335
	8	39±15.556	26	248.5±2.121	48	104.5±19.092
	9	91±4.243	27	226.5±36.062	49	140.5±6.364
	10	133±7.071	28	256±176.777	50	47±0
	11	35±11.314	29	207±15.556	53	106±12.728
	12	117.5±9.192	30	216±83.439	54	85.5±4.95
	13	193±19.799	31	252.5±3.536	55	289±15.556
	14	171±55.154	32	134.5±47.376	56	97±9.899
	15	199±1.414	35	235±21.213	57	109.5±14.849
	16	272.5±24.749	36	173±4.243	58	218±11.314
	17	93.5±37.477	39	154±15.556	61	39.5±17.678
	18	302.5±53.033	40	400.5±9.192	62	178±9.899
	19	80±49.497	41	194±24.042	65	181.5±6.364
	20	57.5±26.163	42	218±11.314	66	68±2.828
Male	1	89.5±0.707	37	128.5±2.121	63	100±12.728
	2	128±15.556	38	186±56.569	64	61±36.77
	5	45±8.485	43	78±1.414	67	135±1.414
	6	59.5±3.536	44	107.5±17.678	68	22.5±6.364
	23	127.5±7.778	51	68.5±30.406	69	216.5±21.92
	24	101.5±4.95	52	112±2.828	70	46.5±3.536
	33	167±4.243	59	87.5±3.536	71	289±15.556
	34	137±9.899	60	68±5.657	72	131.5±10.607

S. D= Standard Deviation

Table 3. Frequency of bacterial isolates in UNIMED students towels

Bacterial Isolates	Male	Female	Total	Frequency %
Klebsiella pneumonia	2	9	11	15.3
Escherichia coli	1	2	3	4.2
Shigella sp.	3	3	6	8.3
Staphylococcus aureus	9	19	28	38.8
Staphylococcus epidermidis	5	8	13	18.1
Micrococcus sp.	-	2	2	2.8
Salmonella sp.	1	-	1	1.4
Bacillus sp.	3	2	5	7.0
Pseudomonas aeruginosa	-	3	3	4.2
Total	24	48	72	100

Table 4. Antibiotics sensitivity test of the Gram positive bacterial isolates

		Antibiotics concentration Zone of inhibition (mm)									
S/N	**Isolates**	**CH 30mcg**	**CPX 10mcg**	**E 30mcg**	**LEV 20mcg**	**CN 10mcg**	**APX 20mcg**	**RD 20mcg**	**AMX 20mcg**	**S 30mcg**	**NB 10mcg**
1.	*Staphlococcus aureus*	10(R)	20(I)	20(I)	20(S)	20(S)	-	15(R)	15(I)	18(S)	-
2.	*Staphlococcus aureus*	-	21(S)	20.5(I)	20(S)	-	-	19(I)	19.5(S)	15(S)	16(I)
3.	*Staphlococcus epidermidis*	11(R)	14(R)	11(R)	20(S)	11(R)	14.5(I)	20(S)	-	-	-
4.	*Staphlococcus aureus*	-	17(I)	16(I)	16(I)	16(S)	-	11(R)	-	21(S)	-
5.	*Staphlococcus epidermidis*	22(S)	20(I)	18(I)	18(I)	19(S)	-	15(R)	-	21(S)	-
6.	*Staphlococcus aureus*	14.5(I)	20(I)	11(R)	21(S)	10.5(R)	12.5(R)	21(S)	11(R)	15(S)	-
7.	*Staphlococcus aureus*	14(I)	19(I)	12(R)	21(S)	11(R)	12(R)	20(S)	10.5(R)	16(S)	-
8.	*Staphlococcus aureus*	14(I)	20(I)	11(R)	20(S)	10.5(R)	12.5(R)	21(S)	11(R)	15(S)	-
9.	*Staphlococcus epidermidis*	20(S)	20(I)	20(I)	20(S)	19(S)	16(I)	19(I)	14(I)	10(R)	19.5(S)
10.	*Staphlococcus aureus*	20(S)	20(I)	14(I)	20(S)	20(S)	15.5(I)	20(S)	17(I)	21.5(S)	10.5(S)
11.	*Staphlococcus aureus*	17(I)	20(I)	17(I)	19(S)	19(S)	14(I)	24(S)	10.5(R)	20(S)	-
12.	*Staphlococcus epidermidis*	-	18.5(I)	-	16.5(I)	-	-	15(R)	-	11(R)	-
13.	*Staphlococcus aureus*	14(I)	20(I)	20(I)	20(S)	19(S)	16(I)	19(I)	19(S)	19(S)	18(S)
14.	*Staphlococcus epidermidis*	20(S)	21(S)	17(I)	19(S)	20(S)	12.5(R)	24(S)	15(I)	18.5(S)	-
15.	*Micrococcus sp.*	14(I)	20(I)	-	20(S)	-	-	21(S)	-	9(R)	-
16.	*Staphlococcus aureus*	-	-	-	-	-	-	-	-	-	-
17.	*Staphlococcus aureus*	17(I)	20(I)	17(I)	19(S)	19(S)	14(I)	24(S)	10.5(R)	20(S)	-
18.	*Staphlococcus aureus*	14(I)	20(I)	20(I)	20(S)	`19(S)	16(I)	19(I)	19(S)	19(S)	18(S)
19.	*Micrococcus sp.*	16(I)	20(I)	18(I)	21(S)	-	-	17.5(I)	-	16(S)	-
20.	*Staphlococcus aureus*	-	20(I)	18(I)	17(I)	-	-	17.5(I)	-	-	-
21.	*Bacillus sp.*	8(R)	16(I)	-	20(S)	-	-	16.5(I)	15(R)	14(I)	-
22.	*Staphlococcus aureus*	22(S)	20(I)	18(I)	18(I)	19(S)	-	15(R)	-	21(S)	-
23.	*Staphlococcus aureus*	10(R)	20(I)	14(I)	21(S)	20(S)	10(R)	20(S)	20(S)	15(S)	-
24.	*Bacillus sp.*	-	15(R)	-	13(R)	-	-	16.5(I)	15(I)	14(I)	-
25.	*Bacillus sp.*	11(R)	21.5(S)	15(I)	20(S)	17(S)	14(I)	20(S)	15(I)	21(S)	16(I)
26.	*Staphlococcus aureus*	-	20(I)	18(I)	20.5(S)	-	-	21.5(S)	22(S)	17(S)	11(R)
27.	*Staphlococcus epidermidis*	16.5(I)	16.5(I)	16.5(I)	16(I)	-	-	15(R)	9(R)	18(S)	-
28.	*Staphlococcus aureus*	-	-	-	-	-	-	-	-	-	-
29.	*Staphlococcus aureus*	-	17(I)	16(I)	16(I)	16(S)	-	11(R)	-	21(S)	-
30.	*Staphlococcus epidermidis*	-	16(I)	-	21.5(S)	-	-	21.5(S)	-	15(S)	-

		Antibiotics concentration Zone of inhibition (mm)									
S/N	**Isolates**	**CH 30mcg**	**CPX 10mcg**	**E 30mcg**	**LEV 20mcg**	**CN 10mcg**	**APX 20mcg**	**RD 20mcg**	**AMX 20mcg**	**S 30mcg**	**NB 10mcg**
31.	*Bacillus sp.*	16(I)	20(I)	8(R)	21(S)	-	-	17.5(I)	-	16(S)	-
32.	*Staphlococcus aureus*	15(I)	18(I)	27(S)	19(S)	19(S)	12.5(R)	21(S)	14(I)	17(S)	15(I)
33.	*Bacillus sp.*	15(I)	18(I)	21(I)	19(S)	19(S)	12.5(R)	21(S)	11(R)	17(S)	15(I)
34.	*Staphlococcus epidermidis*	20(S)	18(I)	16(I)	20(S)	20(S)	20(S)	20(S)	19(S)	17(S)	15(I)
35.	*Staphlococcus aureus*	11(R)	21.5(S)	15(I)	22(S)	17(S)	14.5(I)	20(S)	15(I)	21(S)	16(I)
36.	*Staphlococcus epidermidis*	10(R)	20(I)	20(I)	20(S)	20(S)	-	15.5(R)	15(I)	18(S)	-
37.	*Staphlococcus aureus*	14(I)	20(I)	20(I)	20(S)	19(S)	16(I)	19(I)	19(S)	19(S)	18(S)
38.	*Staphlococcus epidermidis*	8.5(R)	-	10(R)	19(S)	-	-	17(I)	-	21.5(S)	-
39.	*Staphlococcus aureus*	20(S)	20(I)	14(I)	20(S)	20(S)	15.5(I)	20(S)	17(S)	21.5(S)	10.5(R)
40.	*Staphlococcus epidermidis*	20(S)	20(I)	20(I)	20(S)	19(S)	16(I)	19(I)	14(I)	19(S)	19.5(S)
41.	*Staphlococcus aureus*	14(I)	20(I)	11(R)	20(S)	10.5(R)	12.5(R)	21(S)	11(R)	15(S)	-
42.	*Staphlococcus aureus*	11(R)	14(R)	11(R)	20(S)	11(R)	14.5(I)	20(S)	-	-	-
43.	*Staphlococcus epidermidis*	22(S)	20(I)	18(I)	18(I)	19(S)	-	15(R)	-	21(S)	-
44.	*Staphlococcus aureus*	19(S)	-	-	10(R)	18(S)	15(I)	-	-	-	-
45.	*Staphlococcus epidermidis*	11(R)	14(R)	13(R)	20(S)	11(R)	14(I)	20(S)	11(R)	13(I)	13(I)
46.	*Staphlococcus aureus*	-	21(S)	20.5(I)	20(S)	-	-	19(I)	19.5(S)	15(S)	16(I)

*Key: **-** no inhibition; S- Suseptible; I- Intermediate; R- Resistant; CPX= Ciproflox; NB= Norfloxacin; CN= Gentamicin; AMX= Amoxicillin; S= Streptomycin; RD= Rifampicin E= Erythromycin; CH= Chloramphenicol.; APX= Ampiclox; LEV= Levofloxacin*

Table 5. Antibiotics sensitivity test of the Gram negative bacterial isolates

		Antibiotics concentration Zone of inhibition (mm)									
S/N	**Isolates**	**OFX 10mcg**	**CEP 10mcg**	**PN 30mcg**	**S 30mcg**	**SXT 30mcg**	**CPX 10mcg**	**AU 30mcg**	**CN 10mcg**	**PEF 10mcg**	**NA 30mcg**
47.	*Klebsiella pneumoniae*	20(S)	-	-	12(I)	21	14(R)	-	-	-	-
48.	*Escherichia coli*	20(S)	18	16(I)	20(S)	20	20(I)	20(S)	19(S)	17	15(I)
49.	*Shigella sp.*	20(S)	18	12(R)	19(S)	16	15(R)	17(I)	18(S)	15	-
50.	*Shigella sp.*	19(S)	14	-	19(S)	19	19(I)	17(I)	12(R)	10	-
51.	*Pseudomonas aeruginosa*	15(I)	-	-	16(S)	20	20(I)	15(I)	-	-	-
52.	*Escherichia coli*	21(S)	16.5	17(S)	19(S)	20	20(I)	20(S)	20(S)	16	11(R)
53.	*Klebsiella pneumonia*	-	-	-	14.5(I)	15	17(I)	-	15(S)	-	-
54.	*Pseudomonas aeruginosa*	13.5(R)	-	-	16(S)	22	20(I)	15(I)	-	-	-

		Antibiotics concentration Zone of inhibition (mm)									
S/N	**Isolates**	**OFX 10mcg**	**CEP 10mcg**	**PN 30mcg**	**S 30mcg**	**SXT 30mcg**	**CPX 10mcg**	**AU 30mcg**	**CN 10mcg**	**PEF 10mcg**	**NA 30mcg**
55.	*Klebsiella pneumoniae*	20(S)	-	-	12(I)	24	15(R)	-	-	-	-
56.	*Shigella sp.*	12(R)	-	-	13(I)	18	20(I)	12(R)	15(S)	-	-
57.	*Klebsiella pneumoniae*	12(R)	-	11(R)	12(I)	18	14(R)	-	-	-	-
58.	*Pseudomonas aeruginosa*	16(I)	-	-	11(R)	20	18(I)	-	17(S)	-	-
59.	*Salmonella sp.*	21(S)	-	17(S)	11(R)	16	17(I)	17(I)	22(S)	-	-
60.	*Klebsiella pneumoniae*	16(I)	14	-	14(I)	18.5	17(I)	17(I)	-	-	-
61.	*Klebsiella pneumoniae*	21(S)	14	17(S)	18(S)	20	20(I)	-	19(S)	13.5	-
62.	*Klebsiella pneumoniae*	15(I)	12	-	13(I)	15	16(I)	14(I)	17(S)	16	13(R)
63.	*Klebsiella pneumoniae*	13(R)	15	13(R)	12.5(I)	19	19(I)	11(R)	13(I)	11	-
64.	*Klebsiella pneumoniae*	11(R)	12	-	13.5(I)	14	14(R)	-	-	-	-
65.	*Klebsiella pneumoniae*	21(S)	16.5	17(S)	19(S)	20	20(I)	20(S)	20(S)	16	11(R)
66.	*Shigella sp.*	20(S)	19	17(S)	10(R)	20	21(S)	17.5(I)	-	-	13(R)
67.	*Shigella sp.*	19(S)	14	-	19(S)	19	19(I)	17(I)	12(R)	10	-
68.	*Shigella sp.*	20(S)	18	12(R)	19(S)	16	15(R)	17(I)	18(S)	15	10(R)
69.	*Escherichia coli*	20(S)	18	16(I)	20(S)	20	20(I)	20(S)	19(S)	17	15(I)
70.	*Klebsiella pneumonia*	12(R)	-	11(R)	12(I)	18	14(R)	-	-	-	-

*Key: **-** no inhibition; S- Suseptible; I- Intermediate; R- Resistant; OFX= Ofloxacin; CPX = Ciproflox ; CN= Gentamycin; S= Streptomycin; AU = Augumentin; PEF= Reflacine; CEP= Ceporex; NA= Nalidixic acid; SXT= Septrin; PN= Ampicillin*

4. DISCUSSION

Results of the questionnaires administered showed that total bacterial count showed that 33% of respondents wash their towels every week, 32% wash them every two weeks, 25 percent monthly, 7 percent every two months and 2 percent every 6 months. 2 percent admitted to never washing their towels. The total bacterial count showed female towels to have more bacterial contamination than those of the male. This could be due to contamination from vaginal associated bacterial specie from female discharge and this agrees with a research done by Flores et al., [10]. During the course of administering the questionnaires a student admitted to never using the towel since it was new but just hanging it on the bathroom door. After carrying out the various tests it was noticed that it had the least microbial count but organisms were still on the towel. This could be due to the fact that the towel was newly bought and had never been put to use.

Faecal organism could have probably gotten to the towel through different means such as the toilet being the top germiest spot in the bathroom and in 95% of school hostels, the toilet and bathroom are always built together. From the toilet atmosphere, to the wall, to the floor, to inanimate objects then to the towels. This is related to Twumwaa et al. [1] findings in which they attributed the presence of *E. coli* on towels sampled from both male and female hostel bathrooms to proximity of the bathrooms to toilets.

Towels are one of the top germiest spots in a bathroom. Other means of transmission of microbes to towels in bathroom can be from hand cleaning on the towel after using the toilet, splashing of water from the body to the towels, door and door knobs, walls, plastics and so on [2]. Many microorganisms are found on towels in which some are pathogenic that causes diseases when they find their way into the system through cuts or abrasions, some microbes are opportunists such as the normal flora of the skin that do not cause infection except found in a wrong place or in the system while some do not cause infection or diseases. The isolated pathogens from the towels are consistent with findings of other researchers [1,2,10]. After series of biological and biochemical tests carried out on the towel samples, organisms found on them were normal flora of the body, organisms found in human gut or intestine, mouth, nose, stomach, skin, armpit, groin areas, soil, water, dust.

Staphylococcus aureus having the highest percent of occurrence of 38.8% could be due to the fact that it is a normal flora of the skin and nose. This is similar to Twumwaa et al., [1] findings in which they reported *Staphylococcus aureus* to have the highest occurrence in sampled bathroom towels. The presence of *Staphylococcus aureus* on bath towels means that bath towels can be sources of staphylococcal food poisoning and if found in the urinary tract can cause urinary tract infection (UTI) since Staphylococcus aureus is pathogenic if found in those areas [11]. This bacterial species causes boils and localized swollen areas of tissue. It can also lead to blood stream invasion, fever and general malaise [12]. They could have been transferred to the towel during the cause of cleaning the body or face and could have found its way into the body system through cuts, abrasion, scrape, open wounds and they cause infections like boils, skin swelling and redness, painful rash, scalded skin syndrome bacteremia.

Staphylococcus epidermidis as reported by [13] could enters the sebaceous gland and damages the hair follicles by producing lipolytic enzymes that change the sebum from fraction to dense (thick) form leading to inflammatory effect). Klebsiella pneumonia (an organism associated with the intestine) with a total frequency of 15.3% found on the towel might be as a result of faecal contamination of the towels by faecal materials from the anus or hands of the user. The risk is higher for immuno suppressed individuals. Klebsiella pneumonia can infect the lungs, bladder, brain, liver, eyes, blood, and wounds. It causes different type of infection such as pneumonia, urinary tract infection, skin or soft tissue infection, meningitis, blood infection [14]. *Pseudomonas aeruginosa* with a frequency of 4.2% is an opportunistic human pathogen that is found in soil, water and plant. It is “opportunistic” because it seldom infects healthy individuals. It is pathogenic if it enters the body via wounds, abscesses and burns. They can be found in the bath towels through the use of dirty water for either washing or bathing [15]. *Escherichia coli* are a pathogenic bacterium with a frequency of 4.2%. This bacterial species causes gastroenteritis which is an inflammation of the stomach and intestines and causing vomiting and diarrhea. Members of Escherichia coli are almost universal inhabitants of the intestinal tract of

humans and they may play a nutritional role in the intestinal tract by synthesizing vitamins, particularly vitamin K. Though *Escherichia coli* species are rarely pathogenic they have shown some implications in diarrhea in infants and urinary tracts in older people [16]. Micrococci is a Gram positive cocci bacterium with frequency 2.8% that is found in the human skin, animal and dairy products [17]. They are found in many other places in the environment, including water, dust, and soil. Micrococcus specie. can grow well in environments with little water or high salt concentrations including clothes and towels. It can cause pulmonary infections, recurrent bacteremia, septic shock, septic arthritis, endocarditis, meningitis, and cavitating pneumonia (immunosuppressed patients) [18]. Salmonella specie is a Gram negative rod bacteria with frequency 1.4% that causes of food poisoning and salmonellosis. It can be found in the intestines of animals and it is spread through their feces. Salmonella poisoning can be passed from person to person when the hand is not thoroughly washed after a bowel movement [19]. The presence of Bacillus species could be due to their ubiquitous nature and they are sporulating organisms, so their spores might have been carried by wind. These Bacillus have been shown to cause food poisoning [20]. Shigella specie with a frequency of 8.3% causes diarrhea in humans. It is found in the stool (feaces) of infected people, in food or water contaminated by an infected person, and on surfaces that have been touched by infected people. It could have found its way to the bath towel through stool samples [21].

Most of these normal flora and opportunistic bacteria causes little or no problem or infection to the body but can turn deadly of the bacterial find their way deeper into the body by entering into the bloodstream, joint, bones, lungs or heart [18]. They cause severe infection in immune compromised individuals. The disparity in the antibiotic susceptibility pattern of Staphylococcus in which some were susceptible to some antibiotics leaving others resistant could be due to the fact that the bacteria were of different strains.

Both strains of Staphylococcus were noticed to be highly resistant to Norfloxacin, Ampliclox and Chloramphenicol, intermediate to Ciproxin and Erythromycin, highly susceptible to Streptomycin, Levofloxacin and Gentamicin. According to the antimicrobial sensitivity result *Klebsiella pneumonia* was highly resistant to Nalidixic acid, Ampicillin and Ofloxacin, intermediate to Streptomycin and Ciprofloxacin, highly susceptible to Gentamicin and Ofloxacin. *Pseudomonas aeruginosa* was susceptible for Streptomycin and Gentamycin, intermediate to Ciprofloxacin and Ofloxacin, highly resistant to Ampicillin and Nalidixic acid. *E. coli* was susceptible to Streptomycin, Augmentin, Gentamycin, intermediate to Ciprofloxacin, highly resistant to Nalidixic acid. *Micrococcus* sp. was susceptible to Levofloxacin, Ciprofloxacin, Rifampicin and Streptomycin, intermediate to Chloramphenicol, Ciprofloxacin and Erythromycin, resistant to Norfloxacin, Amoxicillin, Gentamycin and Ampliclox. *Salmonella* sp. is susceptible to Gentamycin, Ofloxacin and Streptomycin, intermediately to Ciprofloxacin and Augmentin, highly resistant to Streptomycin, Ceporex and Nalidixic acid. *Shigella* sp. was susceptible to Ofloxacin, Streptomycin, Gentamycin, intermediately to Augmentin and Ciprofloxacin and resistant to Nalidixic acid and Ampicillin. *Bacillus* sp. were resistant to norfloxacin, chloramphenicol, erythromycin, gentamycin, susceptible to ampiclox, streptomycin and ciprofloxacin. The difference between male and female data using ANOVA is highly significant. This is related to Ojo et al., [9] findings in which they reported most of *Staphylococci* isolates showed high resistance pattern to gentamicin, ciprofloxacin, norfloxacin, rifampicin, chloramphenicol and ampiclox.

5. CONCLUSION

Majority of the isolated bacterial species were mainly gut-associated bacteria, suggesting feacal contamination and daily contact by hands. The others were skin-associated bacteria (*Staphylococcus aureus*, *Micrococcus* sp., *Bacillus* sp.), suggesting routine touch by hands, and soil-associated bacteria (*Pseudomonas aeruginosa*, *Micrococcus* sp.) suggesting contamination from settling dust particles or water. This study is advantageous for public health safety, as the results reveal the presence of bacterial pathogens on individual bath towels. This helps in creating awareness on the spread and transfer of pathogens from dirty and shared towels.

Most of the bacterial isolates showed resistance and susceptibility to certain antibiotics which helps in the perfect and effective choice of antibiotics if these species cause infections. Therefore, there is a need to adopt adequate measures for the regular cleaning and washing

of towels, while also maintaining good personal hygienic practices to prevent the transfer and spread of pathogens from these towels and avoiding sharing of towels.

Laboratory laundering which involves the use of bleaching agent could be a solution in order to continually remove microbes on bath towels. The risk of poisoning due to chemicals during disinfecting of towels with bleaching agent such as sodium hypochloride and rinsing them thoroughly would be reduced and at the same time it will prevent the towels from becoming shelter to pathogenic microorganisms. Bleaching towels however would lead to their quick disintegration and the need to purchase new ones frequently. It is advisable to use this method of laundering even though it led to the frequent purchasing of towels, as compared to normal laundering which do not eliminate microbes completely.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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