www.idosr.org Onemu *et al*

©IDOSR PUBLICATIONS

ISSN: 2550-794X

International Digital Organization for Scientific Research IDOSRJSR1.1.3742.100
IDOSR JOURNAL OF SCIENTIFIC RESEARCH 9(1) 37-42, 2024.
https://doi.org/10.59298/IDOSRJSR/2024/1.1.3742.100

Bacterial Colonization of Students' Bath Towels in a Tertiary Educational Centre in Owo, Nigeria

Onemu S. O.[1]; Odeyemi O.[1]; Ademulegun F. G.[1]; Awogbemila H O.[1] and [*]Emmanuel Ifeanyi Obeagu[2]

[1]Department of Medical Laboratory Science, Achievers University, Owo, Nigeria.
[2]Department of Medical laboratory Science, Kampala International University, Uganda.
[*]Corresponding authour: Emmanuel Ifeanyi Obeagu, Department of Medical Laboratory Science, Kampala International University, Uganda.
E-mail: emmanuelobeagu@yahoo.com, obeagu.emmanuel@kiu.ac.ug, 0000-0002-4538-0161

ABSTRACT

Bath towels are designed to assimilate profuse amount of moisture and in the process may also absorb microorganisms that are present. These microorganisms remain viable and multiply within the moist towel to become vehicles for the transmission of infectious agents especially through contaminated hands to food, household items and the surrounding environment. The study was intended to know the level of bacterial colonization of bath towels of students in a tertiary educational institution in Owo, Ondo State. Students' bath towels were swabbed with cotton wool-tipped swab sticks and teased into 5 mL sterile 0.85% sodium chloride. This was diluted ten-folds serially: 10^{-1}, 10^{-2}, 10^{-3}... 10^{-10}, and 0.1 mL each was inoculated onto standard bacteriological media. The cultures were incubated at 37°C overnight before reading. Bacterial counts increased significantly ($p<0.05$) from 3.4×10^{4} in first week of laundry to 2.9×10^{8} in towels laundered after three weeks of use. *Staphylococcus aureus* (74.3%) was the predominant isolate. *Escherichia coli* (20.2%) was the next frequently recovered microorganism. Other isolates were *Klebsiella* species (3.7%) and *Pseudomonas aeruginosa* (1.8%) was the least recovered organism. The isolates were most susceptible to pefloxacin, except *Pseudomonas aeruginosa* that had better susceptibility to gentamycin. The high level of bacterial colonization of bath towels with some of the regular microorganisms implicated in most human diseases brings to fore the urgent need for education on the basics of the bath towel hygiene.

Keywords: Bath towels, colonization, contamination, hands, infection.

INTRODUCTION

Towels are generally produced from cotton fibres that are characteristically designed for use in clammy environments in comparison to other varieties of textiles for every day purpose [1]. As a result of the efficaciousness for imbibition of water and the diaphoretic potential, towels are often employed to rapidly remove copious moisture from the body and hands after washing and surfaces of inanimate objects. This correspondingly leads to the assimilation of microorganisms with films of water and their viability in the textiles become veritable channels for the transmission of infectious agents, including multidrug-resistant, MDR bacterial species [2-4]. The standard towel in the home or public arena has been recognized as being accountable for the transfer of pathogenic microorganisms in the home, healthcare institutions and within the community [5-6]. The realization that re-useable towels contribute to inadequate hand hygiene that is traceable to illnesses in developing countries is central to the drive for the elimination of the re-useable towel from restaurants and other public places [7] and replacement with hand dryers after hand washing [8]. Current literature indicates that antimicrobial impregnated textiles and redesign of the mopping towels are being considered for use in healthcare settings as a sustainable means to put under check the ever rising cases of hospital acquired infections, HAIs world-wide [9-10]. The basic understanding of hygiene as it relates to re-useable towels is purely embedded in the relationship between a constantly clean environment and liberty from infectious agents [11]. The exclusion of infectious agents from all varieties of textiles is an essential component of good laundry practices, in addition to the removal of stains, grit and grease [12]. The desire to eliminate pathogenic microorganisms from all types of clothing and the displacement of hand towels with dryers attained a very high level of consciousness during the SARS-CoV-2 pandemic [13], and the part textiles could play in the spread of infectious materials were made prominent [14]. The study was initiated to evaluate the bacteriological cleanliness of bath towels of students in a tertiary educational institution in Owo, Nigeria.

MATERIALS AND METHODS

Population: This consisted of Achievers University students of both sexes living on campus who gave informed consent and ethical approval was obtained from the Ondo State Ministry of Health (Ref. No. OSHREC 04/09/2023/579 issued September 04, 2023).

Sample Collection: A sterile cotton wool-tipped swab stick was moistened with sterile distilled water, this was used to swab an area of the towel measuring 5 cm by 5 cm, and data on laundry frequency and care were collected.

Processing of Samples: Each sample was teased into 5.0 mL sterile normal saline and thereafter diluted ten-folds, 10^{-1}, 10^{-2}, 10^{-3}…10^{-10}. From each dilution was inoculated 0.1 mL onto well dried plates of nutrient agar (Oxoid CM 003), blood agar (Oxoid CM 0055) and MacConkey agar (Oxoid CM 0037) plates. The plates were incubated at 37^{o}C overnight and examined for growth. Colony forming units (cfu/cm^3) were determined from the nutrient agar and blood agar plates that yielded between 3 and 30 colonies and the mean count was recorded. Characterization and identification of isolates was affected by applying the scheme described by [8] and sensitivity tests were done by the Kirby-Bauer disc diffusion technique.

RESULTS

The microbial load of students' bath towels and frequency of laundry is presented in Table 1.
The bacterial counts in the towels ranged from 3.4 x 10^4 cful/cm^3 for towels that were washed weekly and 3.8 x 10^6- 4.3 x 10^6 cfu/cm^3 with between 59% and 66% for both male and female students respectively washing their towels fortnightly. The number of students that washed their towel after 3 weeks of use were 35% of the males and 19% of females. The microbial counts were not significantly different ($X^{2,}$ p>0.05) for both sexes. There were only two male students who indicated washing their towels once every month with a mean counting 2.9 x 10^8cful/cm3.

Table 1: Frequency and microbial load of students' bath towels

Laundry Interval (weeks)	Microbial load Male (n = 100) No. of cases	Count cful/cm3	Female (n = 100) No. of cases	Count cful/cm3
1	4	3.4 x 10^4	15	3.1 x 10^4
2	59	3.8 x 10^6	66	4.3 x 10^6
3	35	5.7 x 10^7	19	6.1 x 10^7
4	2	2.9 x 10^8	0	0.0

The sex distribution of pathogenic bacterial isolated from both sexes of students is presented in table 2. *Staphylococcus aureus* was the most frequent microorganism isolated (74.3%) with more females' towel colonization (42.7%) compared (31.0%) from the male students. *Escherichia coli* was the next commonest isolate with larger number of isolates 12.6% in males compared to 6.7% from females. *Klebsiella* species colonized more towels from male students while *Pseudomonas aeruginosa* was found in only in male students' towels.

Table 2: Sex distribution of bacterial isolates from body towels of students (%)

Isolate	Sex Male	Female
Staphylococcus aureus (n=76)	32 (31.0)	49 (42.7)
Escherichia coli (n=22)	13 (12.6)	9 (8.7)
Klebsiella species (n=3)	3 (1.9)	1 (1.0)
Pseudomonas aeruginosa (n=2)	2(1.9)	0 (0.0)

The susceptibility of the isolates to antibacterial agents is displayed in table 3. The most valuable antibiotics against *Staphylococcus aureus* were pefloxacin (81.6%), azithromycin (72.5%) and gentamycin (64.5%). The susceptibility of *Escherichia coli* was highest with ofloxacin and pefloxacin while sensitivity profile was seen against *Klebsiella* species with pefloxacin and gentamycin. *Pseudomonas aeruginosa* isolates showed better susceptibility with gentamycin.

Table 3: Antibacterial agent susceptibility tests of isolates

Isolates		OFX	PEF	SPX	CN	CAZ	CTX	AZM	AMP
Staphylococcus aureus (n=76)		44.7	81.6	51.3	64.5	56.6	60.5	72.5	2.7
Escherichia coli (n=22)		65.5	72.2	40.9	45.5	54.5	50.0	40.9	0.0
Klebsiella species (n=3)	33.3	66.7	33.3	66.7	33.3	0.0	33.3	0.0	
Pseudomonas aeruginosa (n=2)	50.0	0.0	50.0	100	50.0	50.0	0.0	0.0	

Ofloxacin (OFX), pefloxacin (PEF), sparfloxacin (SPX), gentamycin (CN), ceftazidime (CAZ), cefotaxime (CTX), azithromycin (AZM), ampicillin (AMP).

DISCUSSION

The bacteriological examination of students' bath towels showed that the towels were colonized by major pathogenic microorganisms that are regularly recorded in many human diseases with counts ranging from 3.4×10^4 to 2.9×10^8 cfu/cm^3. Similar observations have been reported in body towels [15]. Although, much lower bacterial loads have been recorded from other varieties of textiles in the healthcare environment [4]. The bacterial load in these body towels rose significantly ($p<0.05$) with longer intervals of laundry. This indicates that longer laundry internals while in-use correspondingly increases the microbial load. This, thus evolves such towels into fomites status and the consequential risk of being a vehicle for the transmission of infectious microorganisms from contaminated hands to food in the household and surrounding surfaces as other studies have revealed [3,5, 16-17]. Majority of students (89%) in the study population had no clear knowledge of the bath towel hygiene minimum standards - that bath towels should be dried completely after each use and must not be left in the bathroom or in a moist environment and laundered after every three to five uses, but these students had based laundry intervals on when the towel looked physically dirty or developed an unpleasant odor, at which point, the towel has become a fomite with enormous potential for the transference of infectious agents.[11]

Four genera of pathogenic microorganisms were isolated with *Staphylococcus aureus* (74.3%) being the predominant isolate. *Staphylococcus aureus* is a regular human colonizer that can be found in the anterior nares of as much as 60% in some populations and associated with a wide range of human infections that can vary from minor superficial to severe illnesses that could lead to fatality [18-21]. Transference of *Staphylococcus aureus* through contaminated hands from such towels to food may serve as antecedent to food-borne diarrheic illness that has been observed from other studies [7]. *Escherichia coli* (20.2%) was the next most frequently encountered microorganism and as a typical enteric bacterium, represents a sign of faecal contamination of the towels. Studies have revealed that the presence of intestinal bacteria in towels play a definite role in the contamination process in a household.[16] *Escherichia coli* in the hands can be transferred to food and where this involves an enteropathogenic strain of *Escherichia coli* (EPEC) into infant formula, the initiation of a devastating form of infant diarrhea becomes inevitable [22-23]. The presence of *Escherichia coli* in bath towels particularly of female students is portentous of infection risk as one the primary microorganisms that is often incriminated in asymptomatic urinary tract infections in young non-pregnant and pregnant women [24-26]. The colonization of bath towels by *Klebsiella* species further buttresses the degree of unhealthiness of these towels. *Klebsiella* species generally colonize the intestinal tracts of humans, animals and bodies of natural waters and decaying organic matters. Many species are reputed for multidrug resistance. The presence of *Klebsiella* species in bath towels is a reflection of the poor sanitary conditions that may pose infection hazard especially from contaminated hands acting as channels for infection [27-28]. The ability of *Klebsiella* species to initiate human infections when introduced through a vulnerable site and, coupled with the observation that this microorganism is capable of posing a peculiar clinical difficulty due the ample endowments for intrinsic multidrug resistance [29-34] and most species are also implicated in both community acquired, CA and hospital acquired, HA urinary tract infections [35-39]. Although, *Pseudomonas aeruginosa* was the least in the proportion of isolation and was also recovered from towels used by male students that were not washed until after three weeks of use, shows that *Pseudomonas aeruginosa* will regularly colonize unsanitary bath towels. *Pseudomonas aeruginosa* is an important organism which is notoriously very resistant to many antimicrobial agents and a major agent in HAIs [38-41]. This makes such colonization of bath towels a prime source of infection risk [37-41].

CONCLUSION

Each of the isolated microorganism from the bath towels are some of the most frequent initiators of human infections globally that can be both opportunistic in the community infections and in the hospital environments. This study further accentuates the urgency to create greater awareness to members of the community on the essence of the bath towel hygiene and the guiding principles for a healthy bath towel.

REFERENCES

1. Kato H, Okino N, Kyitori Y, Izucoa Y, Wado Y, Maki M, Yamamoto T, Yano T. Analysis of biofilms and bacteria communities in the towel environment with daily use. *Scientific Report*, 2023; **13**: 7611 doi.10.1038/s41598-023-34501-4.
2. Hanczvikkel A, Toth A.Quantitative study about the role of environmental conditions in the survival capacity of multidrug resistant bacteria. *J. Infect. Public Health*, 2018; **11**(6): 801-806.
3. Stephens B, Azimi P, Theommes MS, Heidarinejad M, Allen JG, Gilbert JA. Microbial exchange via fomites and implications for human health. *Current Pollution Reports*, 2019; **5**: 198-213.
4. Varshney S, Sharma S, Gupta D. Surveillance of bacterial load and multidrug resistant bacteria in bedsheets in a primary health care unit. *Int. J. Environ. Health Res.* 2021; **32**(9): doi.org/10.1080/09603123.2021.193780.
5. Pease, H. D. and Himebaugh, L. C. (2011). Hygiene of the towel. *Am. J. Public Health* **20**(8): 820-832.
6. Dixit S, Varshney S, Sharma S.Textiles as fomites in healthcare system. *Appl. Microbiol. Biotechnol.* 2023; **107**: 3887-3897.
7. Kim S, Brown AC, Murphy J, Oremo J, Owuor M, Ouda R, Person B, Quick R. Evaluating the impact of antimicrobial hand towels on hand contamination with *Escherichia coli* among mothers in Kisumu County, Kenya 2011-2012. *Water Research*, 2019; *157*: 564-571.
8. Reynoids KA, Sexton JD, Norman A, McClelland DJ. (2021). Comparison of electric hand dryers and paper towels for hand hygiene: A critical review of the literature. *J. Appl. Microbiol.* 2021; **130**(1): 25-39.
9. Wiencek M. Beyond the naked eye biofilm and microbial diversity in re-laundered mops and towels used in healthcare facilities. *Am. J. Infect. Control.* 2019; **47**(6): Suppl. 54 doi.org/10.1016/j.ajic.2019.04.135.
10. Shneider G, Bim FL, Lopes-de-Sousa A, Watanabe E, De-Andrade D, Fronteira I.The use of antimicrobial impregnated fabrics in healthcare services: An integrative review. *Rev. Lat. Am. Enfermagem.*2021; **1**(29): e3416 doi.10.1590/1518-8345.4668.3416.
11. Vandegrift R, Bateman AC, Siemens KN, Nguven M, Wilson HE, Green JL, Van-Den-Wymelenberg KG, Hickley R.J. (Cleanliness in context: Reconciling hygiene with a modern microbial perspective. Microbiome, 2017; **5**(76): doi.org/10.1186/s40168-017-0294-2.
12. Bockmuhl DP, Schages J, Rehberg L. Laundry and textile hygiene in healthcare and beyond. *Microbial Cell*, 2019; **6**(7): 289-306.
13. Marcenac P, Kim SK, Mallinari NA, Person M, Frankson R, Berendes D, McDonald C, Yoder J, Hill V, Garcia-Williams A. Knowledge, attitudes and practices around hand drying in public bathrooms during the COVID-19 pandemic in the Unites States. *Am J. Infect Control*, 2021; **49**(9): 1186-188,
14. Sanders D, Grunden A, Dunn R. A review of clothing: The history of clothing and the role of microbes in textiles. *Biol. Lett.* 2020; **17**(1): 2020.0700 doi.1098/rsbl.2020.0700.
15. Hadi NS, Osuyi UG, Bashir SS, Yusuf AM, Shuaibu KA, Obiokpa SO. Bacteriological examination of of used towels from female and male hostel of Federal University of Lafia, Nigeria. *J. Adv. Microbiol.* 2021; **21**(8): doi.9734/jamb/2021/v21i8830374.
16. Gerba CP, Tanumi AH, Maxwell S, Sufuentes LY, Hoffman DR, Koenig DW. Bacterial occurrence in kitchen hand towel. *Food Protection Trends*, 2014; **34**(5): 312-317.
17. Moretro T, Almli VL, Asli AW, Kummen C, Galler M, Langsrud S.Kitchen clothes: Consumer practices, dropping properties and bacterial growth and survival. *Food Control*, 2022; **142**: 109195 doi.org/10..jfcont.2022.109195.
18. Tong SYC, Davis JS, Eichenberger E, Holland T, Fowler Jr. JV. *Staphylococcus aureus* infections: Epidemiology, pathophysiology, clinical manifestations and management. *Clin. Microbiol. Rev.*2015; **28**(3): 608-661.
19. Mores CR, Montelego C, Putoriti C, Wolfe AJ, Abonelfeltah A. Investigation of plasmid among clinical *Staphylococcus aureus* and *Staphylococcus haemolyticus* isolates from Egypt. *Front. Microbiol.* 2021; **4**(12): 659116 doi.10.3389/fmicb.2021.659116.
20. Perez-Montarelo D, Viedma E, Murcia M, Munoz-Gallego I, Larrosa N, Branas P, Fernandez-Hildago N, Gavalda J, Almirante B, Chaves F. Pathogenicity characteristics of *Staphylococcus aureus* endovascular infections: Isolates from different clonal complexes. *Front.*

Microbiol. 2021; **19**(8): 917 doi.10.3389/fmicb.2017.00917.

21. Onemu SO, Ademulegun F, Onemu-Metitiri MO, Obeagu EI, Hassan OA. The contribution of curable plasmid-mediated resistance in isolates of *Staphylococcus aureus* at the University of Benin Teaching Hospital, Benin City, Nigeria. *Asian J Dent Health Sci.* 2023; **3**(3): doi.org/10.22270/ajdhs.v3i3.50.
22. Ledwaba S, Costa DVS, Bolick DT, Giallourou N, Medeiros PHOS, Swan JR, Traore AN, Potgieter N, Nataro JP, Gurrant RL. Enteropathogenic *Escherichia coli* infection induces diarrhea, intestinal damage metabolic alterations and increased intestinal permeability in a murine model. *Front. Cell Infect. Microbiol.* 2020; **10:** doi.org/10.3389/fcimb.2020.595266
23. Kour P, Dudeja P. Pathophysiology of enteropathogenic *Escherichia coli*-induced diarrhea. *Newborn*, 2023; **2**(1): 102-113 doi.5005/jp.journals-11002-0056
24. Ngwai YB, Iliyasu H, Young E, Owuna G. Bacteriuria and antimicrobial susceptibility of *Escherichia coli* isolated from urine of asymptomatic university students in Keffi, Nigeria. *Jundishapur J. Microbiol.* 2012; **5**(1): 32-327.
25. Onemu SO, Ige FR, Onemu-Metitiri MO, Uyigue PO, Obeagu EI. The prevalence of asymptomatic bacteriuria in pregnant women in Akure, Ondo State, Nigeria. *DYSONA-Life Science*, 2023; **5**: 1-8 doi.10.30493/DLS.2023.151009.
26. Perveen K, Sial SA, Kunari S, Ali A, Akound I, Akound AA. Isolation and susceptibility of microorganisms responsible for asymptomatic antenatal bacteriuria. *J. Adv. Microbiol.* 2023; **23**(11): 23-29.
27. Podschun R, Pietsch S, Holler C, Ullmarin U. Incidence of *Klebsiella* species in surface waters and their expression of virulence factors. *Appl. Environ. Microbio*l.2001; 67(7): 3325-3327.
28. Nygren E, Stromberg LG, Longenius J, Husmark U, Lofstrom U, Bergstrom B. Potential sources of contamination and hard surfaces identifies as high risk sites near the patient environment. *PLoS ONE*, 2023; **18**(7): e0287855.
29. Navon-Veneza S, Kondratyeva K, Carattoli A. *Klebsiella pneumoniae*: A major worldwide source and shuttle for antibiotics resistance. *FEMS Microbiol. Rev.* 2017; **41**(3): 552-275.
30. Caneira C, Lito L, Melo-Cristino, Duarte A. Community and hospital acquired *Klebsiella pneumoniae* urinary tract infections in Portugal: Virulence and antibiotic resistance. *Microorganisms*, 2019; **7**(5):138doi.3390/microorgansims.7050138.
31. Chang D, Sharma L, Dela-Cruz CS, Zheng D. Clinical epidemiology, risks factors and control strategies of *Klebsiella pneumoniae* infection. *Front. Microbiol.*2021;12: doi.org/10.103389/fmicb.2021.750662.
32. Wareth G, Neubauer H. The animal food environment interface of *Klebsiella pneumoniae* in Germany: An observational study on pathogenicity, resistance development and the current situation. *Vet Res.* 2021; **52**(16): doi.org/1186/s13567-020.00875-w.
33. Gorrie CL, Mircela M, Wick RR, Judd LM, Lam MMC, Gomi R, Abbot IJ, Thomson NR, Srtugnell RA, Pratt NF, Garlic JS, Watson KL, Hunter PC, Picher DV, McGloughlin SA, Spelman DW, Wyres KL, Jenny AWJ, Holt KE. Genomic dissection of *Klebsiella pneumoniae* infections in hospital patients reveals insights into an opportunistic pathogen. *Nat. Commun.* 2022; **13**(1): 3017 doi.10.1038/s41467-022-30717-6.
34. Langendonk RF, Neill DR, Fothergill JI. Building blocks of antibacterial resistance in *Pseudomonas aeruginosa*: Implications for current resistance: Breaking therapies. *Front. Cell Microbiol.* 2021; **16**(1): 665759 doi.3389/fcimb.2021.665759.
35. Bakht M, Alizadeh SA, Rahimi S, Anari RK, Rostamani M, Javadi A, Peyamani A, Marshi MA, Nikkhahi F. Phenotype and genetic determination of resistance to common disinfectants among biofilm producing *Pseudomonas aeruginosa* strain from clinical specimens in Iran. *BMC Microbiol.* 2022; **22**: 124 doi.org/10.1086/s12866.022.02524-y.
36. Onemu SO, Odeyemi, Adu ME, Obeagu EI. Efficacy assessment of some commonly used disinfectants against multidrug resistant bacterial isolates from a tertiary healthcare facility in Benin City, Nigeria, *Newport Int. J. Scientific Exp. Sci.* 2023; **4**(1) doi.org/10.59289/NIJSES/2023/10.7.1000.
37. Onyeze, R., Udeh, S. M., Akachi, B. and Ugwu, O. P. Isolation and characterization of fungi Associated with the Spoilage of Corn (Zea Mays). *International Journal Pharma Medicine and Biological Science*, 2013; *2*(3), 86-91.

38. Ilozue, N. M., Ikezu, U. P. and Okechukwu, P. U. Antimicrobial and phytochemical screening of the seed extracts of Persea americana (avocado pear). *IOSR Journal of Pharmacy and Biological Sciences*, 2014; *9*(2), 23-25.
39. Amalu, P. C., Chukwuezi, F. O. and Ugwu, O. P. C. Antimicrobial effects of bitter kola (Garcinia kola) nut on Staphylococcus aureus, Escherichia coli and Candida albicans. *Journal of Dental and Medical Sciences (IOSR-JDMS)*, 2014:*13*(4), 29-32.
40. Adonu, C. C., Esimone, C. O., Ugwu Okechukwu, P. C., Bawa, A. and Ossai, E. C. In vitro evaluation of the antibacterial potential of extracts of the aerial parts of Cassytha filiformis against urogenital clinical Gram positive organisms. *International Journal of Pharmaceutical Biological and Chemical Sciences*, 2013: *2*(1), 01-09.
41. Chukwuezi Fabian, O. and Ugwu Okechukwu, P. Antimicrobial effects of bitter kola (Garcinia kola) nut on Staphylococcus aureus, Escherrichia coli and Candida alibicans. *Journal of Dental and Medical Sciences*, 2014:*13*(4), 29-32.

CITE AS: Onemu S. O.; Odeyemi O.; Ademulegun F. G.; Awogbemila H O. and Emmanuel Ifeanyi Obeagu (2024). Bacterial Colonization of Students' Bath Towels in a Tertiary Educational Centre in Owo, Nigeria. IDOSR JOURNAL OF SCIENTIFIC RESEARCH 9(1) 37-42. https://doi.org/10.59298/IDOSRJSR/2024/1.1.3742.100