PREVALENCE OF EXTENDED SPECTRUM BETA LACTAMASE PRODUCING BACTERIAL SPECIES ISOLATED FROM HANDBAGS OF WOMEN IN ABEOKUTA, NIGERIA

ABSTRACT

BACKGROUND: Numerous studies have identified the presence of harmful microorganisms on inanimate objects. A woman's handbag, commonly used as a personal and portable accessory, often harbors various microbes, including bacteria. This study aims to assess the prevalence, antibiogram, and distribution of Extended Spectrum Beta Lactamase-producing isolates found in women's handbags. Additionally, it will examine the sensitivity and resistance patterns of these isolates to selected common antibiotics in Abeokuta, Nigeria.

Methods: This cross-sectional study analyzed 300 samples collected from various women's handbags. Antibiotic susceptibility testing was performed on all isolates using the Kirby-Bauer disc diffusion method, while the presence of Extended Spectrum Beta-Lactamase (ESBL) was determined using the double disc synergy test on isolates that showed resistance to standard antibiotics.

Results: Out of the 300 samples collected, 59% showed no bacterial growth, while 41% yielded bacteria growth. Among the ESBL-producing bacteria, *Klebsiella pneumoniae* demonstrated the highest prevalence (56.3%), followed by *Escherichia coli* (37.1%) and *Acinetobacter* spp (30%). In contrast, *Pseudomonas aeruginosa* had the lowest ESBL production at 16.7%. Ceftazidime was the most effective antimicrobial agent against ESBL-producing bacteria (19%), followed by Cefotaxime (13%) whereas Augmentin was the least effective (6%). Overall, Azithromycin was the most active antibiotic across all isolates (77.8%), while Ceftriaxone was the least effective (33.3%). All Bacillus spp. isolates were found to be sensitive to the first-line antibiotics.

Conclusion: Women's handbags are potential carriers of various multidrug-resistant bacteria, and can act as vectors for transmitting pathogenic bacteria to their users. It is essential to raise awareness and educate women about this potential route of disease transmission to help curb the spread of multi-drug-resistant organisms.

Keywords: Extended-Spectrum-Beta-Lactamase, Bacterial, Handbags, Cross Infections, Antibiotic Resistance, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, Women, Nigeria.

INTRODUCTION

Microorganisms are everywhere. Multiple studies have identified harmful microorganisms on inanimate objects, revealing that commonly used items such as doorknobs, cell phones, and money often become contaminated [(1)]. Research suggests that up to 80% of diseases spread through hand-to-hand contact or by touching contaminated objects [(2)]. An inanimate object that can transmit pathogens is known as a fomite [(3)]. Factors like moisture, frequency of use, and cleanliness can significantly influence the infection rates associated with these fomites. Studies have shown that *Staphylococcus aureus, Escherichia coli, and Klebsiella species* frequently

contaminate various surfaces like furniture, door hinges, and other high-contact areas [4]. These pose health risks and should be closely monitored.

Women's handbags, commonly used as personal and portable items, often harbor various microbes, including bacteria. Due to their frequent use, handbags create an ideal environment for bacterial growth. Commonly stored items such as mobile phones, cosmetics, partially consumed food, diapers, and milk bottles (in the case of nursing mothers), increase the risk of contamination [1]. Handbags are often placed on germ-infested surfaces such as restroom counters, fast food tables, and kitchen countertops, making them potential carriers of disease since they are highly susceptible to contamination. Research has also detected bacteria in the purses and handbags of healthcare workers, indicating a significant risk in clinical environments [5]. Although some people may try to clean their handbags by wiping them with a damp cloth, few women use natural sunlight for sterilization, which could help slow bacterial growth [6].

Extended-spectrum beta-lactamases (ESBLs) are enzymes that break down oxyimino-beta-lactam antibiotics, which are essential for treating serious infections in humans and animals. ESBLs are frequently produced by *E. coli* and *Klebsiella pneumoniae*, first identified in Enterobacteriaceae in 1983. Since then, ESBL-producing Enterobacteriaceae (E-ESBL) have been a growing concern, contributing to an estimated 1,700 deaths in the United States in 2013 due to therapeutic failure in severe infections [28,31]. The World Health Organization has classified ESBL-producing Enterobacteriaceae as one of the "Highest Priority" pathogens [32].

Escherichia coli, particularly ESBL-producing strains, has become a significant global pathogen, often associated with infections outside hospitals [29]. *E. coli* is a Gram-negative facultative anaerobe commonly found intestines of humans and animals, and is the leading cause of urinary tract infections and urosepsis. The emergence of antibiotic-resistant *E. coli* strains complicates treatment options. These strains resist many β-lactam antibiotics, such as penicillin, aztreonam, and cephalosporins [30]. Infections caused by ESBL-producing *E. coli* have higher mortality rates, often due to delays in effective treatment, as initial antibiotics may be ineffective [28]. This is because ESBLs degrade these antibiotics, although beta-lactamase inhibitors like clavulanic acid can counteract this effect for some antibiotics [7,8].

Previous studies have indicated that 79.4% of mobile phones carry Gram-negative bacteria, with women's phones showing higher contamination rates (82.3%) compared to men. Understanding the prevalence of ESBL-producing bacteria and their susceptibility to commonly used antibiotics is essential for addressing the risks associated with multidrug-resistant infections [8].This study sought to investigate the prevalence of ESBL-producing bacterial isolates recovered from women's handbags in Abeokuta, Nigeria, determine bacterial sensitivity and resistance to selected antibiotics, and raise awareness of microbial contamination, particularly those with potential for multidrug resistance.

MATERIALS AND METHODS

The present cross-sectional study was conducted in June 2023 at the Federal Medical Centre, Abeokuta, Nigeria. Participants completed a detailed questionnaire on aspects such as the material composition, usage, and storage of their handbags; their home environments; common

items stored in their handbags; and the frequency with which they washed, cleaned, and aired their bags. The data obtained were analyzed using both descriptive and inferential statistical methods. A total of 300 samples were collected from various handbags using saline-soaked swabs. These were then sent to the Medical Microbiology Laboratory at the Federal Medical Center in Abeokuta for culturing and antibiotic susceptibility testing. Bacterial isolates were identified using standard microbiological techniques [(10)]. Identification methods included Colonial Morphology, wet preparation, Gram Stain, Indole Test, Simmons Citrate Test, Christensen's Urease Test, Oxidase Test, Catalase Test, Coagulase test, Methyl red, Voges-Proskauer test, Triple Sugar Iron test, and Motility Test. All isolates were preserved at -70°C in trypticase soy broth with 15% (v/v) glycerol for up to six months. The culture media used for culturing and identification included MacConkey agar, Blood agar, and Mueller-Hinton agar (from Oxoid, UK). Viable bacterial colonies were manually counted by examining the plates under suitable lighting conditions. Antibiotic susceptibility testing was performed using the Kirby-Bauer disc diffusion technique, following the guidelines set forth by the Clinical and Laboratory Standards Institute (CLSI, 2020). The antibiotics tested included Cefuroxime (30 µg), Ofloxacin (5 µg), Erythromycin (15 µg), Azithromycin (15 µg), Ceftriaxone (30ug), Cefixime (5 µg), Levofloxacin (5 µg), Ciprofloxacin (5 µg), Gentamicin (10 µg), and Amoxicillin-clavulanate (30 µg). The presence of ESBL in all isolates was detected using the double disc synergy test [(18)], utilizing 30 µg Augmentin and 30 µg Ceftazidime.

STATISTICAL ANALYSIS

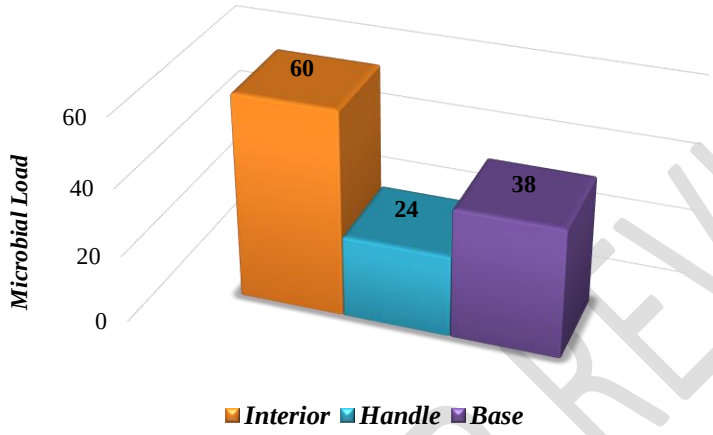
Data analysis was conducted using INSTAT (Graph pad Software Inc, La Jolla, CA, USA) employing chi-square and odd ratio analyses. Descriptive statistics are represented as relative frequencies. Continuous variables are expressed as mean ± SD, and categorical variables are represented by group percentages. A p-value of ≤ 0.05 was deemed statistically significant.

RESULTS

The study results are presented in figures and tables below. Of the total samples, 178 (59%) showed no bacterial growth, with the remaining 122 (41%) exhibiting bacterial presence. Figure 1 shows a statistically significant prevalence of bacteria microbes in women's handbags ($P<0.0001$). Figure 2 highlights *Escherichia coli* as the most prevalent bacterial species, followed by *Bacillus* species, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter* species, and *Pseudomonas aeruginosa*. Figure 3 compares bacterial prevalence across different handbag materials, revealing that leather bags had the highest contamination rates, while synthetic bags had the lowest rate. In Figure 4, the contamination rates in relation to handbag usage are displayed, with frequently used handbags exhibiting higher contamination than rarely used ones. Figure 5 indicates that handbags belonging to students, particularly those rarely emptied, had the highest contamination levels. Conversely, bags that were regularly emptied also showed contamination, though at reduced levels. Table 1 compares storage locations, showing that bags stored in lockers had the highest bacterial levels, followed by those stored on bunk beds, tables, and wall nails. Figure 6 displays the prevalence of ESBL-producing bacteria. The prevalence of ESBL-producing isolates did not significantly differ ($P = 0.3011$). Ceftazidime was the most effective antimicrobial agent against ESBL-producing bacteria, as shown in Figure 7, while Cefotaxime and Augmentin were the least effective. Figure 8 shows the antibiotic

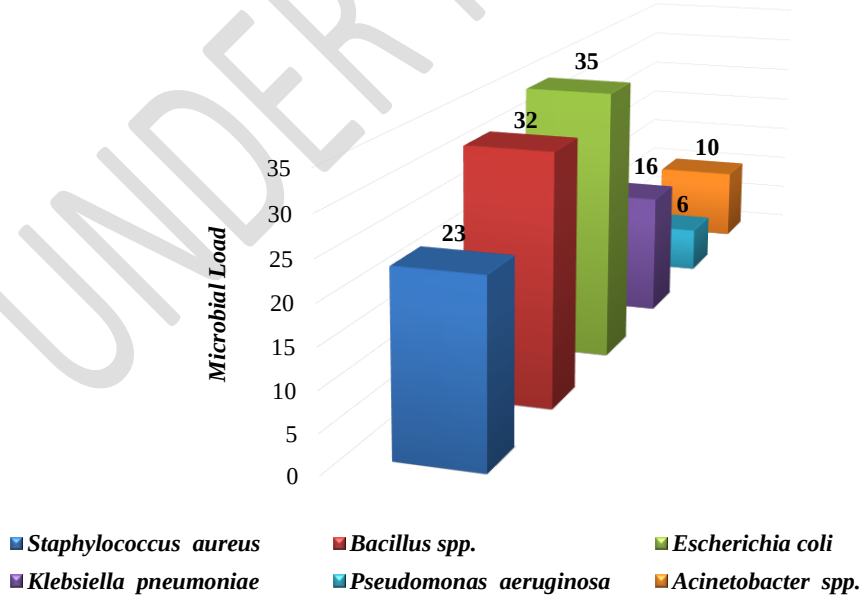
susceptibility profiles of bacterial isolates from female students' handbags. Azithromycin emerged as the most active antibiotic (77.8%), while Ceftriaxone proved ineffective (33.3%) against various isolates. These susceptibility tests were conducted in vitro using standard laboratory protocols.

Figure 1: Bacterial Load Per Site



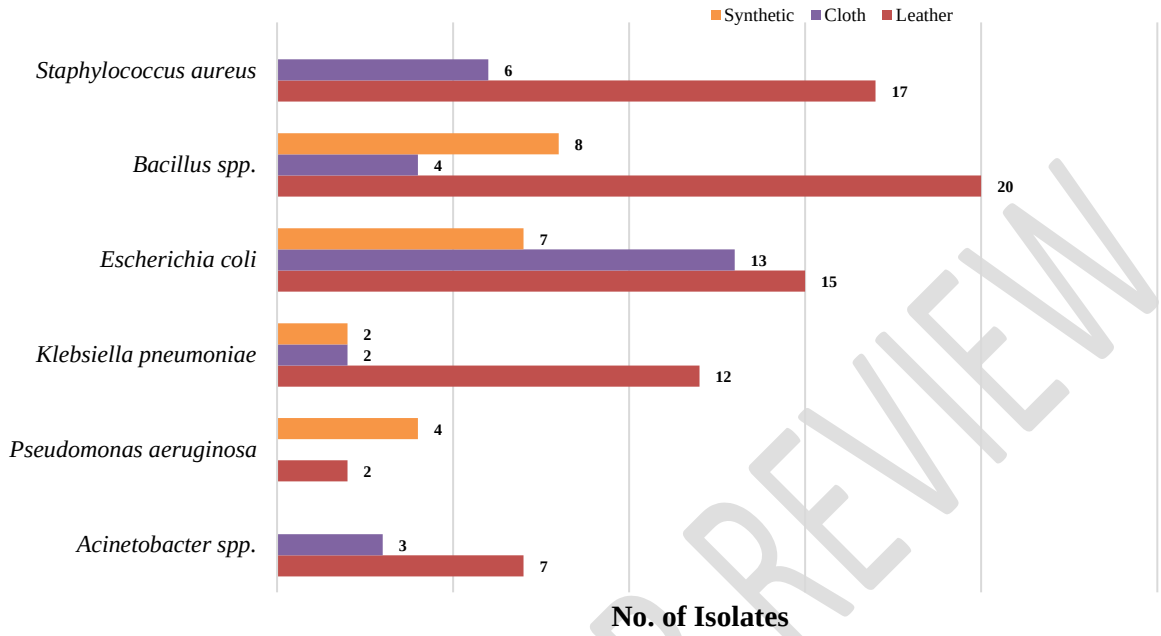
* All units are in CFU (colony-forming units); Significance Level (α) = 0.05; $p < 0.0001$.

Figure 2: Distribution of Bacterial Isolates



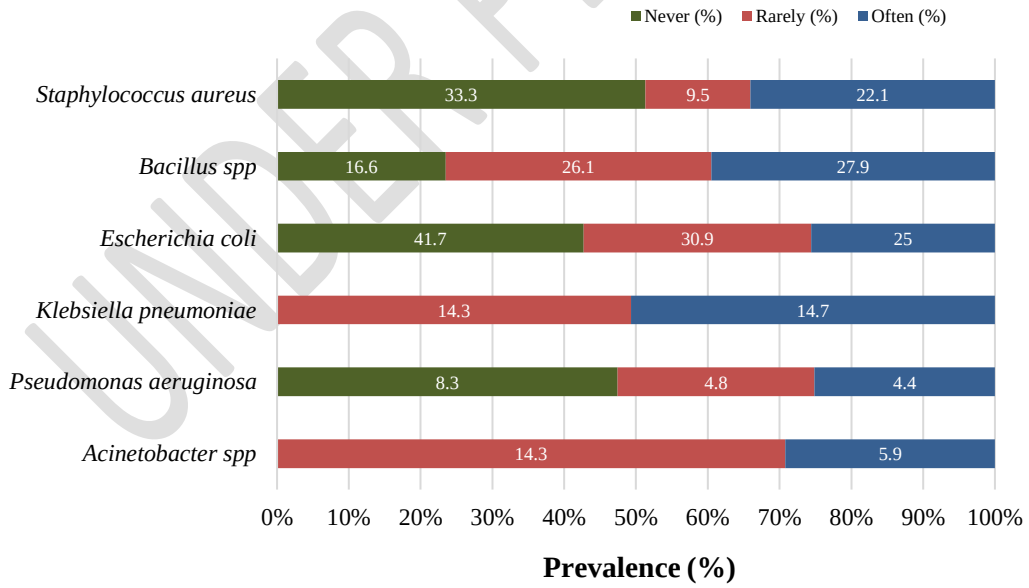
* All units are in CFU (colony-forming units); Significance Level (α) = 0.05; $p < 0.0001$.

Figure 3: Prevalence Based on Handbag Material



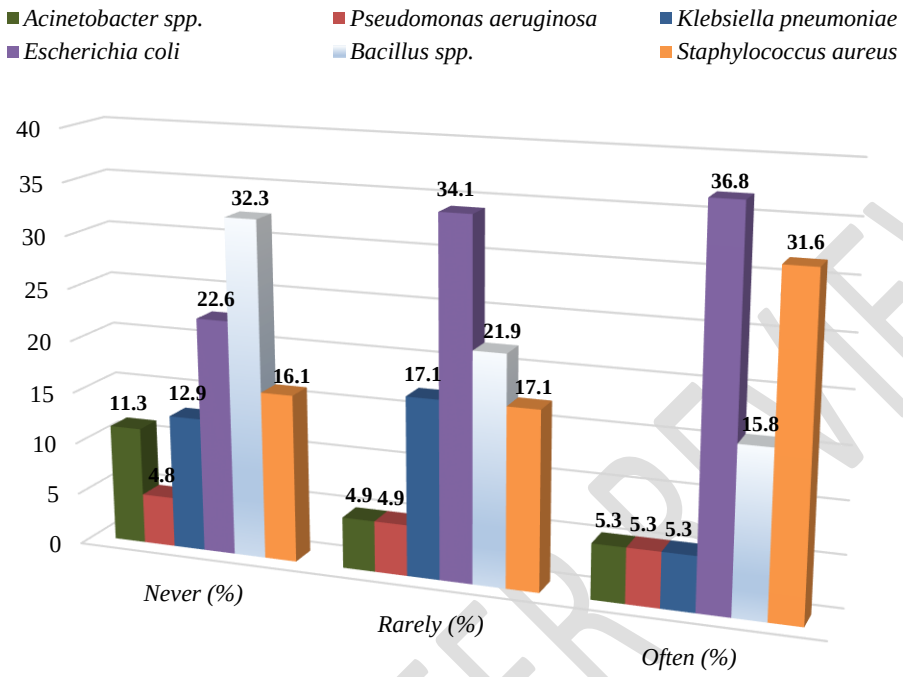
* All units are in CFU (colony-forming units); Significance Level (α) = 0.05; $p < 0.035$.

Figure 4: Prevalence Based on Usage Duration



* *Significance Level (α) = 0.05; p < 0.001*.

Figure 5: Prevalence Based on Emptying Habits



* All units are in CFU (colony-forming units); Significance Level (α) = 0.05; $p < 0.01$.

Table 1: Prevalence Based on Storage Conditions

Organisms	Lockers (%)	Tables (%)	Bunk beds (%)	Wall Nails (%)
Staphylococcus aureus	11 (19.3)	4 (25)	7 (18.4)	1 (9.1)
Bacillus spp.	17 (29.8)	1 (6.3)	5 (13.2)	9 (81.8)
Escherichia coli	14 (24.6)	4 (25)	16 (42.1)	1 (9.1)
Klebsiella pneumoniae	10 (17.5)	2 (12.5)	4 (10.5)	-
Pseudomonas aeruginosa	-	3 (18.8)	3 (7.9)	-
Acinetobacter spp.	5 (8.8)	2 (12.5)	3 (7.9)	-
Total	**57**	**16**	**38**	**11**

* Units are in CFU (colony-forming units); Significance Level (α) = 0.05; $p < 0.045$

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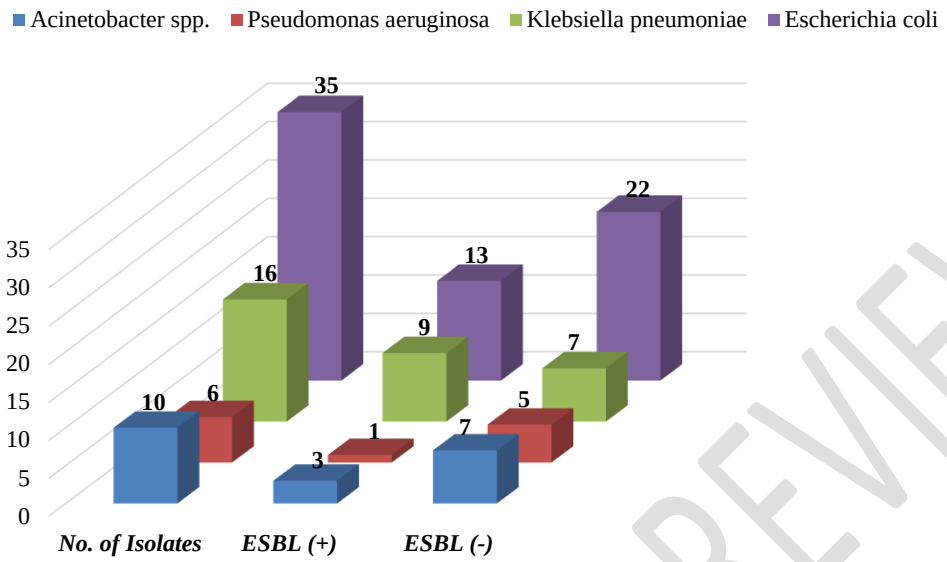
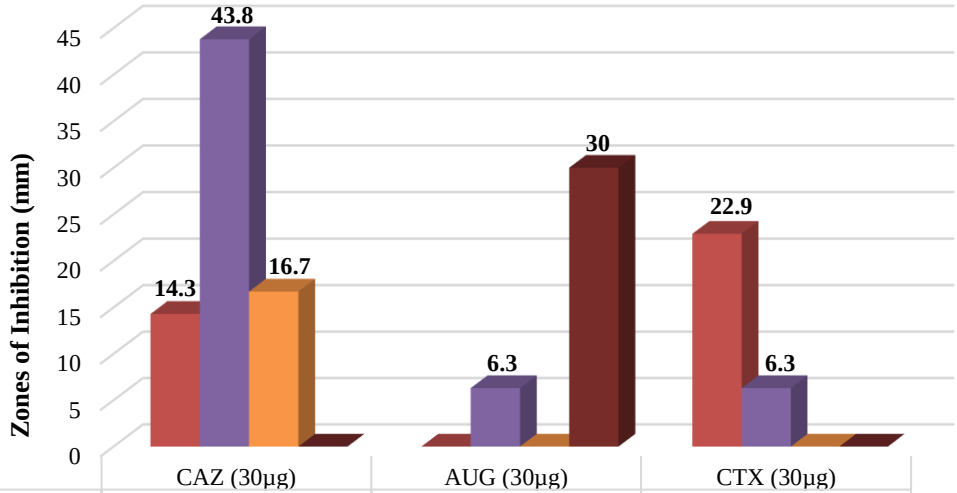
Figure 6: Prevalence of ESBL-Producing Bacterial Isolates



* All units are in CFU (colony-forming units); Significance Level (α) = 0.05; $p < 0.3011$.

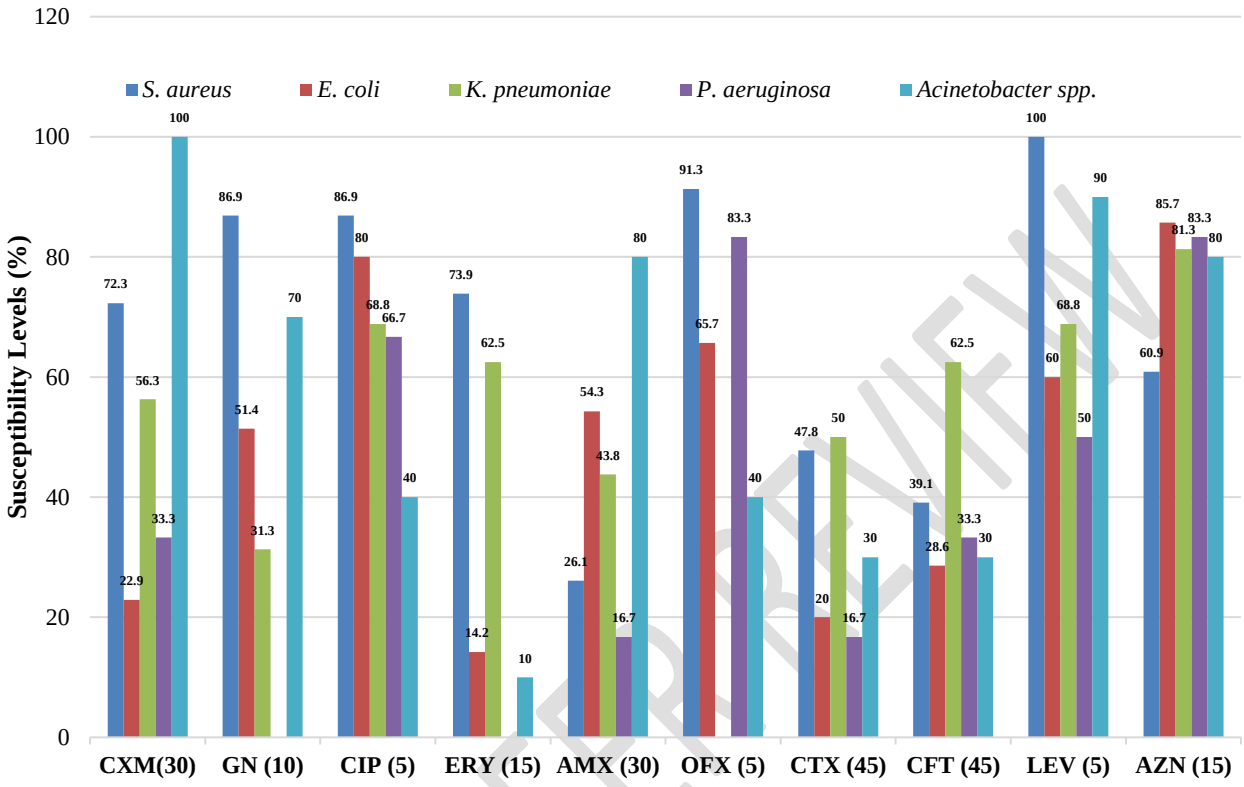
Figure 7: Susceptibility Profile of ESBL-Producing Isolates



	CAZ (30µg)	AUG (30µg)	CTX (30µg)
Escherichia coli	14.3	0	22.9
Klebsiella pneumoniae	43.8	6.3	6.3
Pseudomonas aeruginosa	16.7	0	0
Acinetobacter spp.	0	30	0

* Significance Level (α) = 0.05; $p < 0.025$.

Figure 8: Antibiotic Susceptibility Profile of Bacterial Isolates



* CXM: Cefuroxime; GN: Gentamicin; CIP: Ciprofloxacin; ERY: Erythromycin; AMX: Amoxicillin – clavulanate; OFX: Ofloxacin; CTX: Ceftriaxone; CFT: Cefixime; LEV: Levofloxacin; AZN: Azithromycin. Significance Level (α) = 0.05; $p < 0.001$.

DISCUSSION

The findings revealed that the interiors of the handbags contained more bacterial contaminants compared to the handles and base, a result consistent with prior research suggesting that the interior surface of handbags offers conducive environments for microbial growth due to frequent use [1]. The handbags examined contained high concentrations of Gram-positive and Gram-negative bacteria. Gram-positive bacteria like *Staphylococcus aureus* were primarily body flora, which explains their presence. This aligns with Itah et al.'s findings [4] that *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella* spp. are commonly found on frequently touched surfaces. The isolation of *Bacillus* spp. from handbags also highlights its resilience in various environments. Additionally, *E. coli*, *Klebsiella* spp., and *Acinetobacter* spp. were detected, signaling potential contamination due to poor hygiene, as these microbes are commonly present in feces, soil, and water. Their presence poses an infection risk if hand and handbag hygiene are neglected [13].

Pseudomonas aeruginosa was also identified, likely due to its ability to survive on both living and non-living surfaces, making it a common contaminant [14]. Notably, leather handbags showed higher contamination rates compared to cloth or synthetic bags. This could be attributed to leather's permeable and coarse texture [15], which can trap dirt, moisture, and bacteria. This facilitates microbial proliferation, as bacteria thrive in warm, moist conditions [16]. Furthermore, residual proteins and fats from the tanning process may provide nutrients that promote bacterial proliferation [17]. The study also revealed a correlation between handbag cleaning habits and bacterial contamination. Among female students, those who frequently emptied their handbags (15.6%) had lower bacterial contamination compared to those who rarely (33.6%) or never (50.8%) cleaned out their bags. Items such as cosmetics, money, and phones, often placed on contaminated surfaces, likely contributed to this contamination, especially when left in handbags for extended periods, and could have provided an ideal environment for bacterial proliferation [18].

Of the 122 samples tested, 26 (38.8%) were identified as ESBL producers, with *Klebsiella pneumoniae* being the most prevalent (56.3%), followed by *E. coli* (37.1%), *Acinetobacter* spp. (30%), and *Pseudomonas aeruginosa* (16.7%). These findings are consistent with a study conducted in Ethiopia [19], which also identified *E. coli* and *Klebsiella pneumoniae* as the leading ESBL producers. Similarly, research conducted in the United States of America found widespread contamination in handbags, particularly by S*taphylococcus aureus* and *E. coli* [5], with leather bags showing significantly higher contamination levels. This current study mirrors those results, as leather bags were again linked to higher bacterial loads. Furthermore, recent studies indicate that 85% of handbags tested were contaminated with *E. coli* and *Klebsiella* spp. [21], with some recording contamination rates of close to 90% for leather bags [22]. These suggest a consistent trend of leather materials being particularly prone to bacterial contamination across various regions.

The study also examined the antibiotic susceptibility of the ESBL-producing isolates, revealing that Ceftazidime was the most effective antimicrobial agent, while Cefotaxime and Augmentin were the least effective against these ESBL-producing bacteria. Additionally, azithromycin (77.8%) was found to be most active antibacterial agent, while ceftriaxone (33.3%) was largely ineffective. The dominance of Gram-negative bacteria in this study is consistent with research by Jorg and Thomas [20], which identified Gram-negative organisms as primary pathogens frequently found in normal flora.

Interestingly, 59% of the samples yielded no growth. This high proportion of samples with no bacterial growth suggests that many women practice good hygiene with their handbags, which effectively reduces microbial contamination and its associated health risks [4]. This finding highlights the importance of hygiene awareness in reducing bacterial contamination [21]. The absence of bacterial growth in a substantial number of samples may reflect variability in microbial presence due to factors such as the handbag's material, usage patterns, and environmental conditions. This emphasizes the importance of material choice for minimizing

contamination risks [2], as this variability indicates that not all handbags are equally prone to contamination. Thus, further research could provide unique insights for developing more effective hygiene guidelines by exploring how factors like handbag material and usage patterns influence bacterial growth [22,23].

This study underscores the need for infection control practices beyond healthcare settings, as handbags could serve as vectors for resistant bacteria transmission. Public health campaigns should emphasize the importance of regular cleaning of personal belongings and proper hand hygiene to curb this risk. The Center for Disease Control (CDC) has already stressed the importance of maintaining clean, frequently touched surfaces to prevent the spread of infections, particularly in light of rising antibiotic resistance [24].

ESBLs can inactivate a wide range of beta-lactam antibiotics, making infections caused by these organisms particularly challenging to treat. The presence of ESBL-producing bacteria in community settings indicates a potential reservoir for these pathogens. The implication of this is important for understanding the clinical implications of bacterial infections. This prevalence underscores the clinical significance of bacterial contamination, particularly the presence of ESBL-producing bacteria like *E. coli and K. pneumoniae,* which present significant public health concerns due to their resistance to a broad spectrum of beta-lactam antibiotics [1,3]. These resistance patterns suggest potential complications like prolonged illness, increased healthcare costs, and a higher risk of treatment failure. Clinicians must be aware of local resistance patterns to make informed decisions regarding empirical therapy [4]. The Infectious Diseases Society of America (IDSA) recommends that healthcare providers utilize local antibiograms to guide antibiotic selection [25].
A notable finding in the study was the high prevalence of antibiotic-resistant bacteria, particularly *Escherichia coli* and *Klebsiella pneumoniae,* isolated from female handbags. These organisms are known to cause a range of infections, including urinary tract infections and bloodstream infections. The presence of such resistant strains in everyday items suggests a potential for transmission to individuals, leading to infections that are increasingly difficult to treat. The emergence of antibiotic-resistant bacteria is a major public health concern. According to the Centers for Disease Control and Prevention (CDC), at least 2.8 million antibiotic-resistant infections occur in the United States each year, leading to more than 35,000 deaths [26]. Thus, infections caused by resistant strains often require more complex treatment regimens, which could significantly increase healthcare costs, patient morbidity and mortality [27].

LIMITATIONS OF THE STUDY

This study provides valuable insights into the prevalence of Extended Spectrum Beta-Lactamase (ESBL)-producing bacteria in women's handbags. However, several limitations should be considered to clarify potential bias and constraints that could have influenced the findings:

1. Sample Size and Selection: With 300 handbag samples from a specific geographic area (Abeokuta, Nigeria), the sample may not fully represent the broader population. This localized sample may not reflect the prevalence of ESBL-producing bacteria

across other regions or diverse demographic groups. A larger, more varied sample could offer a more comprehensive understanding of this issue.

2. The study's cross-sectional nature limits the ability to establish causal inferences between bacterial contamination and handbag usage or hygiene practices. While associations can be identified, it does not determine if specific behaviors directly contribute to bacterial contamination.
3. Self-Reported Data: Questionnaires were used to collect information on participants' handbag usage, cleaning habits, and environmental factors. Since self-reported data can be subject to recall bias or inaccuracies, there may be underestimations or overestimations of actual practices that impact bacterial contamination.
4. Microbiological Techniques: While widely accepted, the standard microbiological methods used in this study to identify bacterial isolates and assess antibiotic susceptibility have inherent limitations. Misidentification of specific bacterial species or variations in susceptibility testing is possible. Furthermore, the study did not investigate the presence of other potentially pathogenic microorganisms, such as viruses or fungi, which may also pose health risks.
5. Temporal Factors: The data collection occurred within a specific time frame, which may not account for seasonal variations in bacterial prevalence or changes in public health practices that impact contamination levels. A longitudinal approach would provide insights into trends over time and help capture potential fluctuations.

Future research addressing these limitations could provide a more nuanced understanding of the risks associated with microbial contamination in everyday items like handbags. This knowledge could inform public health strategies aimed at reducing the spread of multidrug-resistant infections and improving community health.

CONCLUSION

This study identified a significant prevalence of ESBL-producing Gram-negative bacteria in female students' handbags in Abeokuta, Nigeria, with *Pseudomonas aeruginosa* being the most frequent EBSL producer. The findings showed that most isolates were susceptible to azithromycin, while resistance was highest to ceftriaxone. Handbags were found to harbor a variety of multidrug-resistant bacteria, potentially acting as vectors for pathogenic transmission. Thus, raising awareness about this potential route of disease transmission among women could help mitigate the spread of multidrug-resistant organisms and improve public health.

RECOMMENDATIONS

To effectively raise awareness and promote better hygiene practices, consider the following practical recommendations and interventions:

1. Educational Initiatives: Public health organizations and educational institutions should launch campaigns to educate people about the risks of handbag contamination. These initiatives can leverage social media, workshops, and

informational brochures to spread awareness about proper handbag hygiene practices.

2. Guidelines for Handbag Maintenance: Create and distribute clear guidelines for cleaning and maintaining handbags. Regular cleaning with disinfectant wipes, avoiding placing handbags on potentially contaminated surfaces (such as public restrooms or kitchen counters), and using protective pouches for cosmetics and food items are all possible recommendations.
3. Incorporating Hygiene into Fashion: Collaborate with handbag manufacturers and retailers to promote hygiene-conscious designs. This could involve the use of easy-to-clean materials or antimicrobial coatings, with marketing campaigns emphasizing the importance of hygiene in handbag selection.
4. Workshops and Demonstrations: Host community workshops to demonstrate effective cleaning techniques for handbags and their contents. These interactive sessions will provide participants with practical skills to maintain hygiene.
5. Digital Reminders: Use digital platforms to issue regular reminders about handbag hygiene, especially during peak usage times like back-to-school or holiday shopping. These notifications can reinforce the habit of regular cleaning.
6. Continuous Research and Feedback: Promote continuous research into the impact of handbag hygiene on public health. Gathering feedback from participants in educational programs could refine strategies and improve outreach efforts.

Disclaimer (Artificial intelligence)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript. The article is an original research article.

REFERENCES

1. Oluduro, A. O., Ubani, A. O., & Ofoezie, I. E. (2012). Bacterial assessment of electronic hardware user interfaces in Ile-Ife, Nigeria. Revista de Ciências Farmacêuticas Básica e Aplicada, 32(3), 323–334.
2. Al-Ghamdi, A. K., Ashshi, S. A. A., Faidah, H., Shukri, H., & Jiman-Fatani, A. A. (2011). Bacterial contamination of computer keyboards and mice, elevator buttons, and shopping carts. African Journal of Microbiology Research, 5(23), 3998–4003.
3. Ngonda, F. (2017). Assessment of bacterial contamination of toilets and bathroom door handles/knobs at Daeyang Luke Hospital. Pharmaceutical and Biological Evaluations, 54(4), 193–197.
4. Itah, A. Y., & Ben, A. A. (2004). Incidence of enteric bacteria and Staphylococcus aureus in daycare centers in Akwa Ibom State, Nigeria. Southeast Asian Journal of Tropical Medicine and Public Health, 35, 202–209.
5. Feldman, J., & Feldman, M. (2012). Women doctors' purses as an unrecognized fomite. Delhi Medical Journal, 84, 277–280.

6. Jaya, C. T., Aswini, S. J., Sirisha, I., & Sharma, Y. V. (2014). How safe ladies' handbags are: A microbiological view. Biology and Medicine, 104(172), 0974–8369.
7. Philippon, L. N., Naas, T., Bouthors, A.-T., Barakett, V., & Nordmann, P. (1997). OXA-18, a class D clavulanic acid-inhibited extended-spectrum β-lactamase from Pseudomonas aeruginosa. Antimicrobial Agents and Chemotherapy, 41, 2188–2195.
8. Paterson, D. L., & Bonomo, R. A. (2005). Extended-spectrum beta-lactamases: A clinical update. Clinical Microbiology Reviews, 18(4), 657–686.
9. Araya, S., Kassu, D., & Yimtubezinash, W. (2020). Extended-spectrum beta-lactamase-producing gram-negative bacteria on healthcare workers' mobile phones: Evidence from Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. Risk Management and Healthcare Policy, 14(3), 283–291.
10. Aflakian, F., Rad, M., Salimizand, H., Nemati, A., & Zomorodi, A. R. (2022). Detection of virulence genes and determination of the antimicrobial susceptibility of Escherichia coli isolates with mastitis in Mashhad, Iran: A short communication. Veterinarski Arhiv, 92(4), 525–530.
11. Clinical and Laboratory Standards Institute. (2020). Performance standards for antimicrobial susceptibility testing (30th ed., CLSI supplement M100). Wayne, PA: Clinical and Laboratory Standards Institute.
12. Livermore, D. M. (1995). β-Lactamases in laboratory and clinical resistance. Clinical Microbiology Reviews, 8, 557–584.
13. Bright, K. R., Boone, S. A., & Gerba, C. P. (2010). Occurrence of bacteria and viruses on elementary classroom surfaces and the potential role of classroom hygiene in the spread of infectious diseases. The Journal of School Nursing, 26(1), 33–41.
14. Xu, R., Polk, R. E., & Stencel, L. (2012). Antibiogram compliance in University Health System Consortium participating hospitals with Clinical and Laboratory Standards Institute guidelines. American Journal of Health-System Pharmacy, 69, 598–606.
15. Elżbieta, B., & Sygula-Cholewińska, J. (2017). Antimicrobial effect of lining leather fatliquored with the addition of essential oils. Biotechnology and Food Science, 81(9), 149–157.
16. Kumar, S., & Singh, R. (2018). Microbial contamination of handbags: A review. International Journal of Current Microbiology and Applied Sciences, 7(5), 1234–1240.
17. Bennett, J. E., Dolin, R., & Blaser, M. J. (2019). Principles and practice of infectious diseases. Elsevier.
18. Afzal-Shah, M., Woodford, N., & Livermore, D. M. (2001). Characterization of OXA-25, OXA-26, and OXA-27, molecular class D β-lactamases associated with carbapenem resistance in clinical isolates of Acinetobacter baumannii. Antimicrobial Agents and Chemotherapy, 45, 583–588.
19. Mulisa, G., Selassie, L. G., Jarso, W. T., Shiferaw, G. T., & Zewdu, A. (2016). Prevalence of extended-spectrum beta-lactamase-producing Enterobacteriaceae: A cross-sectional study at Adama Hospital, Adama, Ethiopia. Journal of the Emergence of Infectious Disease, 1(1), 1–6.
20. Jörg, M., Thomas, M., & Donnelly, T. M. (2013). Clinical veterinary advisor: Birds and exotic pets. Elsevier Health Sciences.
21. Kaur, R., & Singh, S. (2018). Bacterial contamination of handbags: A study. International Journal of Current Microbiology and Applied Sciences, 7(5), 1234–1240.

22. Mavhandu, L., & Mavhandu, M. (2019). Bacterial contamination of handbags in South Africa. African Journal of Microbiology Research, 13(1), 1–7.
23. Bennett, J. W., & Kauffman, H. (2019). Microbial contamination of personal items: A review. Journal of Environmental Health.
24. Centers for Disease Control and Prevention. (2020). Antibiotic resistance: A global threat. Retrieved from https://www.cdc.gov/drugresistance/index.html
25. Infectious Diseases Society of America. (2019). The 10 x ’20 Initiative: Pursuing a global commitment to develop 10 new antibiotics by 2020. Retrieved from https://www.idsociety.org
26. Centers for Disease Control and Prevention. (2019). Antibiotic resistance threats in the United States, 2019. Retrieved from https://www.cdc.gov/drugresistance/biggest-threats.html
27. Ventola, C. L. (2015). The antibiotic resistance crisis: Part 1: Causes and threats. P&T, 40(4), 277–283. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4378521/
28. Ramos, S., Silva, V., Dapkevicius, M. de L. E., Caniça, M., Tejedor-Junco, M. T., Igrejas, G., & Poeta, P. (2020). Escherichia coli as commensal and pathogenic bacteria among food-producing animals: Health implications of extended spectrum β-lactamase (ESBL) production. Animals, 10(12), 2239. https://doi.org/10.3390/ani10122239
29. Laupland, K. B., Church, D. L., Vidakovich, J., Mucenski, M., & Pitout, J. D. D. (2008). Community-onset extended-spectrum β-lactamase (ESBL) producing Escherichia coli: Importance of international travel. Journal of Infection, 56(6), 441–448. https://doi.org/10.1016/j.jinf.2008.09.034
30. Bezabih, Y. M., Sabiiti, W., Alamneh, E., Bezabih, A., Peterson, G. M., Bezabhe, W. M., & Roujeinikova, A. (2021). The global prevalence and trend of human intestinal carriage of ESBL-producing Escherichia coli in the community. Journal of Antimicrobial Chemotherapy, 76, 22–29. https://doi.org/10.1093/jac/dkaa399
31. Dantas Palmeira, J., & Ferreira, H. M. (2020). Extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae in cattle production - a threat around the world. https://doi.org/10.1016/j.heliyon.2020.e03206
32. World Health Organization. (2017). Global priority list of antibiotic-resistant bacteria to guide research, discovery, and development of new antibiotics. Available online: https://remed.org/wp-content/uploads/2017/03/global-priority-list-of-antibiotic-resistant-bacteria-2017.pdf (accessed on February 3, 2024)