ORIGINAL RESEARCH

Sensitivity and Resistance Pattern of Bacteria in Benin City, Nigeria

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ABSTRACT

Background: Sensitivity and resistance pattern of bacteria provides vital information for the development and implementation of an effective antibiotic policy. Proper identification of causative organisms enables informed decision making in rational use of antibiotics.
Objectives: To determine the most common site of bacterial infection, the prevalence of common bacteria based on their site of infection and to document the sensitivity of these microorganisms to two selected antibiotics.
Methods: A prospective cross-sectional study conducted in seven laboratories and a private hospital in Benin City, Nigeria. A validated structured questionnaire was administered to 420 respondents. Data obtained were analyzed using Microsoft Excel and GraphPad Instat. *P*-values < 0.05 at 95% confidence interval were interpreted as significant. Ethical considerations were observed.
Results: Response rate was 83.57%, 60% of the respondents were females while a majority were within the ages of 26-30 years (31.91%). Majority of the patients surveyed contracted *Staphylococcus aureus* (n=180, 51%) while *Escherichia coli* was the next most prevalent bacteria. *Staphylococcus aureus* was found to be resistant to cotrimoxazole and amoxicillin but sensitive to erythromycin and ciprofloxacin. Only 18 patients had more than one micro- organism isolated from their site of infection. Urinary tract was the most common site of infection. Isolates showed sensitivity and resistance to multiple antibiotics.
Conclusion: The urinary tract was the most common site of bacterial infection while the most prevalent microorganism was *Staphylococcus aureus* which is sensitive to erythromycin and ciprofloxacin but not to cotrimoxazole and amoxicillin.

Keywords: Antibiotics, Sensitivity, Resistance, Prescribing pattern, Micro-organisms

INTRODUCTION

Antibiotics are indispensable therapeutic agents in healthcare and should be used rationally to prevent the development of multi-resistant microorganisms. The World Health Organisation in 2014 declared that microbial resistance to antibiotics is no longer a prediction of the future but is happening right now in every region of the world and has the potential to affect everyone[1]. Resistance to antibiotics is a global concern and will have more devastating effects in developing countries where access to proper healthcare, clean water, balanced diet and hygiene are poor.

Irrational prescribing of antibiotics and delayed onset of treatment predispose an infected patient to the development of resistant strains of the pathogen[2]. These resistant strains complicate common infectious diseases leading to prolonged illness, co- morbidity, hospitalisation, increased cost of treatment, loss of school or working hours, disability and mortality[3].

Antibiotic sensitivity and resistance are measured by the Minimum Inhibitory Concentration (MIC), therapeutic outcome will be achieved when the minimum concentration of the antibiotic can inhibit bacteria growth[2]. Various factors affecting selection of antibiotics for an infectious disease include pharmacokinetic parameters, site of infection, host factors such as the status of the patient, route of administration, affordability of drug therapy etc. Therefore, Pharmacists are required to collaborate with Physicians to produce a workable antibiotic policy for their hospitals while bringing their professional expertise to bear in appropriate antibiotic selection for inclusion in their hospital drug formulary and Standard Treatment Guidelines[4].

Combination therapy involving two or more classes of antibiotics with different mechanisms of action which could be additive or synergistic has helped to combat resistant strains of pathogens.

Patients and care givers are also very important in the fight against antimicrobial resistance. Public health campaigns, patient education and counselling are necessary to improve awareness of the dangers of antibiotic misuse. Personal and environmental hygiene is imperative to reduce the incidence of infection[3].

Surveillance and research into the sensitivity and resistance pattern of micro-organisms in a community will provide valuable information for policy makers to optimize effective use of antibiotics. Therefore, the objectives of this study were to determine the most common site of bacterial infection, the prevalence of the most common microorganism based on site of infection and to document its sensitivity to two selected antibiotics.

METHODS

Study design

It was a prospective, cross-sectional study to determine the antibiotic sensitivity pattern of isolated pathogens from infected persons recruited in this study.

Study site

This study was conducted in seven different laboratories and one private hospital laboratory situated in Benin City, Edo State in the South-South Geo-political zone of Nigeria between July and November 2018. The study sites were systematically selected to ensure adequate coverage of the city after the study protocol has been approved. The names of the laboratories are; Assurance medical laboratory, Union diagnostic laboratory, De Tees medical laboratory, Aduwa medical laboratory, Theonice medical laboratory, Lab corp diagnostic centre and Kings medical laboratory. The lab of Mount Gilead hospital, a secondary health facility performing various clinical and surgical activities was also included.

Study population

Consented patients residing in Benin City who visited the study sites for microbial culture and sensitivity test were included in this study.

Sample size

The population of Benin City according to the 2015 population and housing census was 1496000. The sample size was then calculated to be 384 using a well-documented sample size formula[5]. To account for attrition 420 participants were recruited for the study.

Sampling technique

A non-randomized sampling was done for the prospective study.

Research instrument

A validated structured questionnaire consisting of three sections (A, B and C) was administered to the respondents included in the study. Section

A was to collect data on patient demographic characteristics which included gender, marital status, level of education and occupation. Section B collected data on site of infection, period of stay in hospital, presence or absence of suture/prosthetics, comorbid conditions, and site of fluid/sample collection. Section C collected data on the isolated causative bacteria and their sensitivity and resistance pattern after incubation.

Data collection

Data was collected consecutively from consenting patients who visited the study sites with physician requested microbial identification and sensitivity screening laboratory tests using a self-administered questionnaire. If an approached patient decline to be a part of the study the next in line was recruited. They were only required to respond to sections A and B of the questionnaire. Those who could not read were assisted by a previously trained data collector that speaks the local language fluently. Section C of the data collection instrument was filled by the laboratory scientist after identification of the isolated pathogen and sensitivity and resistance screening results were available for a specific patient. This was done for a total of four hundred and twenty study participants that were recruited for this study.

Data analysis

Filled questionnaire were coded and entered into Microsoft Excel 2007 for sorting, calculation of frequencies and percentages based on the variables. Inferential statistics (Chi square test) was done using GraphPad Instat version 3.10 which reported exact p-values. P-values less than 0.05 at 95% confidence interval were interpreted as significant.

Ethical considerations

Ethical and administrative approval for the study was obtained from the Management of the study sites. Informed consent was obtained from the respondents. Confidentiality and anonymity of the patients' information were maintained during and after the study.

RESULTS

Three hundred and fifty-one (351) questionnaires were found usable for analysis giving a response rate of 83.57%. About 60% of the respondents were females, majority were within the ages of 26-30 years (31.91%). Details of the demographic characteristics of patients included in this study are shown in Table 1.

Prevalence of common bacteria based on location of infection

Majority of the patients surveyed had isolates of *Staphylococcus aureus* (n=180, 51%) while *Escherichia coli* was the next most prevalent microorganism isolated in this study. Figure 1 illustrates the prevalence of site of infection in this sample population. Urinary tract was the most common site of infection.

Details of the prevalent microorganisms and location of infection identified in this study are shown in Table 2. Only 18 patients had more than one microbial isolate from their site of infection.

Results of the association of isolated bacterial distribution with demographic characteristics of patients in this study are illustrated in Table 3. *Staphylococcus aureus* was the most common by gender, age and level of education.

Table 4 shows the two most probable antibiotics to which various bacteria were sensitive to according to the degree of sensitivity and resistance. It appears *Staphylococcus aureus* was most sensitive to erythromycin and ciprofloxacin while it was resistant to Septrin® and amoxicillin.

Table 1: Demographic characteristics of respondents, N = 351

Variable	Frequency, n	Percentage (%)
Age(years)		
<20	22	6.26
21-25	72	20.51
26-30	112	31.91
31-35	69	19.66
36-40	26	7.40
41-50	27	7.69
51-60	6	1.70
61-70	11	3.13
>70	6	1.71
Gender		
Female	214	60.97
Male	137	39.03
Marital status		
Married	172	49.00
Single	159	45.30
Others	20	5.70
Education		
No formal Education	17	4.84
Primary	9	2.56
Secondary	81	23.08
Tertiary	244	69.52
Occupation		
Student	64	18.23
Government employee	43	12.25
Private employee	69	3.70
Self employed	162	46.15
Retired	13	19.66

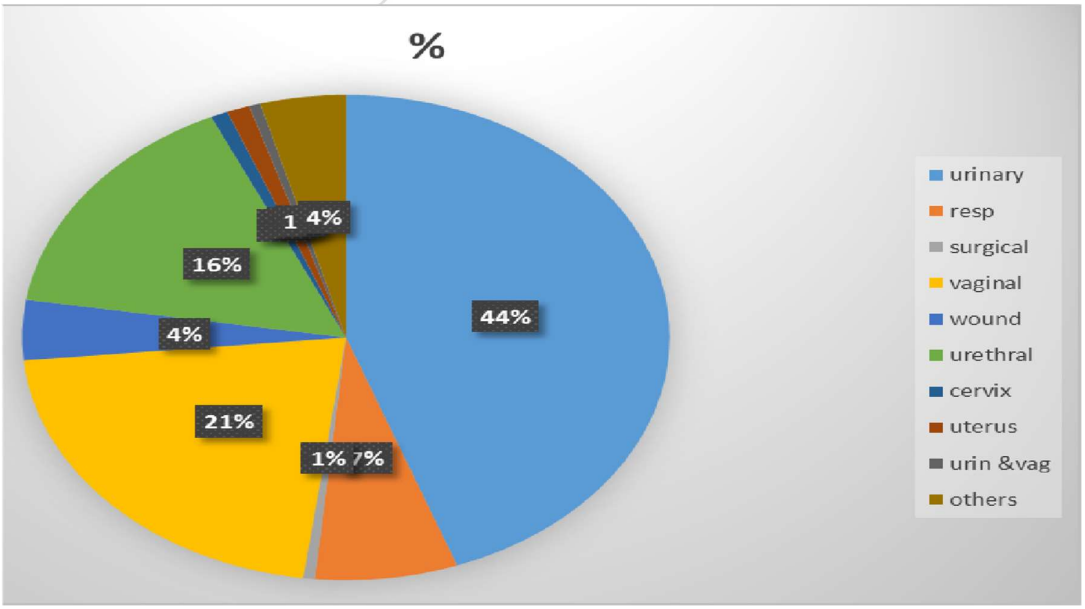

Figure 1: Prevalence of site of infection in a sample population of residents in Benin City

Table 2: Prevalence of respondents with location of bacterial infection

Bacteria	Frequency	Location of infection (n, %)
Coliform and *Staph.*	8	Urinary tract (4, 50.00)
Coliforms	45	Urinary tract (20, 44.44)
Enterococcus	1	Vaginal tract (1, 100.00)
Escherichia coli	47	Urinary tract (39, 76.60)
Klebsiella	12	Urinary tract (6, 50.00)
Shigella	2	Others (2, 100.00)
Staph and *E. coli*	7	Urinary tract (7, 100.00)
Staph and *Proteus mirabilis*	3	Vaginal tract (3, 100.00)
Staph. aureus	180	Urinary tract (74, 41.11)
Strep. agalactae	4	Uterus (4, 100.00)
Morexalla catarrhalis	3	Respiratory tract (3, 100.00)
Neisseria gonorrhea	8	Urethra (8, 100.00)
Proteus mirabilis	9	Urinary tract (5, 55.00)
Pseudomonas aeruginosa	2	Urinary tract (2, 100.00)
Pseudomonas species	1	Others (1, 100.00)
Strep. pneumonia	6	Respiratory tract (6, 100.00)
Strep. pyogenes	4	Respiratory tract (4, 100.00)
Strep. species	6	Respiratory tract (6, 100.00)

Table 3: The distribution of isolated bacteria with demographic characteristics

Variable	Frequency, n	Micro- organism (n, %)	
Gender			
Female	214	Staph (114,53.27)	$p = 0.2868$
Male	137	Staph (65,47.44)	
Age (years)			
< 20	22	Staph (10,45.46)	$p = 0.3784$
21- 25	72	Staph (34,47.22)	
26- 30	112	Staph (60,53.57)	
31- 35	69	Staph (40,57.00)	
36- 40	26	Staph (17,65.00)	
41- 50	27	Staph (11,40.74)	
51- 60	6	Staph (4,66.67)	
61- 70	11	Strep. spp and Coliform (3,27.27)	
>70	6	Proteus mirabilis (3,500.00)	
Education			
No formal education	17	Staph (8,47.06)	$p = 0.7898$
Primary	9	Staph (6,66.67)	
Secondary	81	Staph (42,51.85)	
Tertiary	244	Staph (123,50.41)	

DISCUSSION

This study has shown that bacterial infections occur in both gender and across all age groups. Different microorganisms were successfully isolated in this study with *Staphylococcus aureus* having the highest prevalence in the urinary tract. This study recorded comparable results with the study done in Ethiopia on bacterial profile and antibiotic susceptibility where Staphylococcus *spp.* was the most common causative organism and majority of respondents were within the age of 26-30 years. *Staphylococcus aureus* is a successful commensal and serious pathogen which can

Table 4: Sensitivity and resistance pattern of isolated bacteria to two most probable antibiotics.

Microorganism	Sensitivity +	Sensitivity + +	Sensitivity + + +	Resistance 0
Staph. Aureus	Amoxiclav, Streptomycin	Pefloxacin, Gentamycin	Erythromycin, Ciprofloxacin	Septrin®, Amoxicillin
E. coli	Amoxicillin, Sparfloxacin	Streptomycin, Pefloxacin	Gentamycin, Ciprofloxacin	Amoxiclav, Septrin®
Coliform	Pefloxacin, Streptomycin	Ampiclox, Cefuroxime	Ciprofloxacin, Gentamycin	Amoxicillin, Chloramphenicol
Klebsiella	Streptomycin, Amoxicillin	Chloramphenicol, Gentamycin	Pefloxacin, Ciprofloxacin	Amoxiclav, Septrin®
Staph and E. coli	Gentamycin, Amoxicillin	Streptomycin, Amoxiclav	Ofloxacin, Pefloxacin	Septrin®
Strep. agalactae	-------	Ciprofloxacin, Azithromycin	Penicillin, Levofloxacin	Gentamycin, Septrin®
Proteus mirabilis	Streptomycin, Amoxiclav	Cefuroxime, Levofloxacin	Ceftriaxone, Moxifloxacin	Gentamycin, Ofloxacin
Strep. Pneumonia	Streptomycin, Ciprofloxacin	Ampiclox, Gentamycin	Erythromycin, Azithromycin	Amoxicillin
N. gonorrhea	Ofloxacin	Pefloxacin, Ciprofloxacin	Gentamycin, Ceftriaxone	Erythromycin, Streptomycin
Strep. spp	Gentamycin, Amoxicillin	Cefuroxime, Chloramphenicol	Erythromycin, Pefloxacin	Amoxiclav
Coliform and Staph.	Amoxicillin	Ciprofloxacin, Chloramphenicol	Levofloxacin, Ceftriaxone	Gentamycin, Tetracycline
Strep. faecalis	Erythromycin, Pefloxacin	Ciprofloxacin, Gentamycin	Ceftriaxone, Chloramphenicol	Amoxicillin, Amoxiclav
Shigella spp	-------	----------	Amoxicillin, Levofloxacin	Sparfloxacin, Ofloxacin
Mox. Catarrhalis	Streptomycin, Septrin®	Chloramphenicol, Sparfloxacin	Ciprofloxacin, Ofloxacin	Amoxicillin, Amoxiclav
Staph and Proteus	Amoxiclav, Amoxicillin	Gentamicin, Chloramphenicol	Erythromycin, Cefuroxime	Septrin®, Pefloxacin
P. aeruginosa	--------	Septrin®	Ofloxacin + Ornidazole	Amoxiclav

cause life threatening diseases such as sepsis, pneumonia, endocarditis etc. However, our study reported more female patients (60.97%) contrary to the prevalence of male patients (58%) in another study reported by Abebaw *et al.* (2018)[6]. There was no significant association between gender and the most common microorganisms (p = 0.2868), this result is at variance with the work done by Magliano et.al, (2012)[7]. Most of the Patients had tertiary education (69.52%), this may be attributed to their knowledge of the importance of a culture and sensitivity test to confirm a diagnosis of infection hence their compliance with physician ordered laboratory test. However, there was no significant association between distribution of most common microorganisms and level of education (p = 0.7898) which is comparable with a study carried out by Shayo *et al.* (2012)[8]. This study had a high frequency of married people coming for proper laboratory tests which may be due to their responsibility to family and community.

Based on location of infection, the urinary tract had the highest prevalence (44.44%) which is comparable with a study done by Tan *et al.* (2016)[9]. The urinary tract removes waste and excess water from the body, this may explain the high infection rate which could be at the urethra, prostrate, bladder or kidneys. The vaginal tract was next with a percentage frequency of 21.39%, common vaginal infections were bacterial vaginosis which if not treated can spread to the

cervix and the uterus causing pelvic inflammatory disease[10]. Surgical sites had a low frequency (0.57%) which suggests an improvement in sterilization of surgical equipment, surgical procedures, and post-operative management.

The study revealed that the prevalence of most common microorganisms based on location of infection showed comorbid conditions by coliform and *Staphylococcus*; *Staphylococcus* and *E. coli*; *Staphylococcus* and *Proteus mirabillis.* Other bactericaemia identified from these respondents were single isolates from the various sites of infection. A significant association exists between most common microorganism and site of infection (p= 0.0032) similar to a study done by Bankole *et al.* (2011)[11]. The study showed no significant association between age and most common microorganisms isolated (p= 0.3784) which agrees with a study done by Algowhary (2021)[12] but is different from the study reported by Abebaw *et al.* (2018)[6]. They attributed the high incidence of bacterial infection in age group < 5 years to lack of hygiene, ingestion of contaminated food and low immunity. The high prevalence of *Staphylococcus aureus* and Coliform infection observed in respondents between the ages of 61-70 years may be due to their sedentary lifestyle and reduced personal hygiene.

Antimicrobial sensitivity to most common micro- organisms isolated in this study will provide baseline information for rational use of antibiotics and prompt therapeutic interventions for patients with microbial infections. The results showed that *Staphylococcus aureus* was highly sensitive (+3) to erythromycin and ciprofloxacin which is similar to reports by Gashaw *et al.* (2014)[13] and Sakpota *et al.* (2020)[14].

E. coli was highly sensitive to gentamycin and ciprofloxacin, but moderately sensitive to streptomycin and pefloxacin, slightly sensitive to sparfloxacin but resistant to amoxicillin-clavulanic and cotrimoxazole. Another study on susceptibility pattern of *E. coli* to antibiotics reported ertapenem, imipenem and nitrofurantoin to be the most effective antibiotics while it showed high resistance to ampicillin, ceftriaxone and cefepime[15].

Klebsiella spp. was highly sensitive to pefloxacin and ciprofloxacin but had the same resistant pattern to amoxicillin-clavulanic as reported by Saha (2019)[16] in a study done with Urinary samples. Proteus mirabilis was highly sensitive to ceftriaxone and moxifloxacin, moderately sensitive to cefuroxime and levofloxacin but resistant to gentamycin and ofloxacin. Other studies reported sensitivity to penicillin and amoxicillin[17] but resistance to cotrimoxazole, fluroquinolones and amoxicillin- clavulanic acid[18].

Neisseria gonorrhea was highly sensitive to gentamycin and ceftriaxone but resistant to erythromycin and streptomycin, this finding is comparable to previous studies[19,20]. Streptococcus isolates were sensitive to erythromycin, azithromycin, gentamycin and ampiclox but resistant to amoxicillin. The resistance pattern is similar to the study reported by Assegu *et al.* (2020)[21]. Shigella was highly sensitive to amoxicillin-clavulanate and levofloxacin. Moraxella catarrhalis was highly sensitive to fluoroquinolones but resistant to amoxicillin- clavulanate. Pseudomonas aeruginosa which accounts for about 10% of nosocomial infections was found to be sensitive to ofloxacin and ciprofloxacin in this study.

Sensitivity and resistance pattern of microorganisms provides vital information for formation and implementation of effective antibiotic policy. Patients will receive the right medication at the least cost and development of microbial resistant strains due to inappropriate use of antibiotics will be avoided.

CONCLUSION

The urinary tract is the most common site of infection in the sample of patients studied. *Staphylococcus aureus* is the most prevalent pathogenic microorganism followed by *E.*

coli. In Benin City, *Staphylococcus aureus* appears to be sensitive to erythromycin and ciprofloxacin while it is resistant to amoxicillin and cotrimoxazole. This information may guide prescribers in antibiotic selection in a timely manner in the empirical management of patients while they await laboratory microbial screening results for confirmation or the need to change medications for better patient care.

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