Perspective Of Swimming Pools and Antibiotic Susceptibiltiy Profile of Bacteria Isolated from Selected Swimming Pools in Ibadan, Nigeria

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ABSTRACT

An ideal water for swimming must meet the required quality standards regarding odour, taste and clarity. This study was aimed at determining the microbiological quality and residual chlorine concentration in swimming pools of selected hotels and recreational centres in Ibadan, Oyo state, Nigeria. Swimming pools from two hotels and two recreational centres were purposively selected and stratified for the study, based on high patronage, accessibility to the public and swimming pool availability. Water samples were collected from each swimming pool in the morning (8-9am) and in the evening (5-6pm). Samples were collected during peak bathing periods at weekends. A total of 48 water samples were collected from the four swimming pools over a period of six weeks. The residual chlorine in the samples was determined using standard methods, while bacteriological analysis was carried out using the pour plate method. Susceptibility of the isolates to a panel of antibiotics was carried out using the disc diffusion method, and detection of ESBL production in the isolates was done using the double disc synergy test. Questionnaires were also administered to investigate swimmers' behavior that could serve as potential contaminants to the pool, while an in-depth interview was done with the pool operators to get information on swimming pool maintenance.

The level of education of the 107 respondents was primary (1), secondary (20) and tertiary (86). The religion was Christianity (65.5%), Islam (32.7) and others (1.9%). In terms of Ethnic group, Igbo (21.5%), Yoruba (71%), Hausa (4.7%) and others (2.8%), while 70.1% and 29.9% of the participants were males and females respectively. The 16-20 years age group had the largest number of respondents with 34. Only one of the respondents swam throughout the seven days of the week. Twenty-eight bacteria: P. aeruginosa (9), E. coli (7), Klebsiella spp. (9), Citrobacter spp., Enterobacter spp. (1) were obtained. Seven of the isolates obtained were positive for ESBL production. The resistance to antibiotics was: tetracycline (14%), cefpodoxime (57%), cefotaxime (32%), ceftazidime (18%), ciprofloxacin (14%), imipenem (18%), gentamicin (32%), chloramphenicol (43%), amoxicillin-clavulanate (46%) and trimethoprim-sulfamethoxazole (39%). There was a significant drop ($P \leq 0.05$) in the residual chlorine concentration, ranging from 59.2% to 72%, after bathers used the swimming pools.

The swimming pools did not comply with the CDC and WHO standard for recreational activities due to the presence of enteric bacteria and therefore constitute serious health risks to the bathers. The detection of ESBL-producing bacteria in the pools is another budding public health threat. The pool operators should follow recreational water guidelines for proper management of the swimming pools.

Keywords: Antibiotic resistance, Bacteriological analysis, Hotels, Recreational centres, Residual chlorine, Swimming pools.

INTRODUCTION

A swimming pool is a structure filled with water for intended swimming or water-based recreation. They are being used for swimming and other recreational based activities such as sports diving, underwater rugby, canoe polo, volleyball, etc. It may be domestic (private), semi-public such as found in hotel, school, health club, housing complex and cruise ship or public including municipal. As a result of increase in the numbers of swimming pools, there is need for effective maintenance to protect users from any form of infection. These include frequent changing of water and the use of disinfectant such as ozone, chlorine or bromine. An ideal water for swimming pool must meet potable water standards by being a clean, transparent, odourless, and tasteless liquid having the required freezing and boiling points (Cairncross *et al*., 2000). Temperature, pH and free chlorine are the major factors that control the quantity and quality of contamination in swimming pools (Saberianpour *et al*., 2015).

The standard temperature for swimming pools ranges from 27 to 29 °C, higher temperature provides excellent conditions for growing disease-causing microbes (Rasti *et al*., 2012), while optimal pH level ranges from 7.2 to 8, and chlorine should be 1 to 2 mg / l, free chlorine level of less than 0.4 mg/l causes an increase in the microbial contamination of pools (Saberianpour *et al*., 2015 and Rasti *et al*., 2012). Ezat *et al*. (2013) stated that chlorine concentration is one of the methods used to check the cleanliness of swimming pool water. The chlorine concentration in pool water might reduce due to the passage of urine, stool, sweat, and any discharge from the swimmers' bodies, thus affecting its disinfecting properties. Russel and Walling (2007) identified bacteria, protozoa and viruses as the major source of microbiological water contamination which are usually responsible for water-borne diseases.

These organisms which are often introduced from environmental sources (such as rain, wind etc.) and swimmers (through faeces, mucus, saliva, blood, urine, swimwear, skin tissue, sweat, and cosmetics such as deodorant, make-up, sunscreen etc.) have been reported as causes of infectious disease. It has been reported that the swimming pool water can be contaminated by pathogenic microorganisms which may be obtained via the swimmers, airborne contamination, or low sanitary status of the swimming pool itself (EPA, 2011). Recreational waters could be contaminated by direct excretion by the bathers (vomits, urine, etc.), transport on the body, or growth within the filter bed (Hoseinzadeh et al., 2013). Bello et al. (2012) reported bacteria such as Enterococcus faecalis, Clostridium perfringens, Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus epidermidis and Proteus vulgaris were isolated from swimming pools sampled in Lagos. Similarly, Amala and Aleru (2016) reported that 40% of the swimming pools sampled in Port-Harcourt metropolis, Nigeria, were contaminated with bacteria of the genera Bacillus, Micrococcus and Staphylococcus.

Bacteria can cause skin rashes, irritation of the body, eye problems, and diseases such as cholera, diarrhoea, Vibro illness, dysentery, typhoid fever, Ottis externa (infects swimmer's ear), Leptospiriosis, Legionellosis, Salmonellosis, Mycobacterium marinum infection, Escherichia coli infection, Campylobacteriosis, Botulism, etc. (Mustapha *et al*, 2020). The treatment of swimming pools using pumps, mechanical filters and disinfectants helps to control the transmission of infections, maintain the visual clarity of swimming pool waters and proper sanitation (Omotayo *et al*., 2016). Also, personal hygiene and health-related behaviors are essential in reducing the spread of microorganisms and minimizing the introduction of Disinfection-By-Products (DBP) chemical precursors into the water (Florentin *et al*., 2011).

It has been reported that the surviving disinfectant - tolerant pathogens might also be antibiotics resistant, a fact already documented for bacterial isolates from treated drinking water (Papadopoulou, 2008) and purified sewage effluents (Kummerer, 2000). The universal overuse and misuse of antibiotics has resulted in antibiotic resistance, an anthropogenic stressor that has become a worldwide public health problem according to Andrzejak *et al*. (2023).

Although it is known that swimming pool water should meet potable water standards by being a clean, transparent, odourless, and tasteless liquid having a freezing point of 0^0 C and boiling point of 100^0 C, such standards are not normally maintained in many countries. If no control is made over health standards for swimming pools, they can be a serious source of microbial contamination since the swimming pools are used by wide range of people with different levels of economic, social and health status (Hoseinzadeh *et al*., 2013). The aim of this study is to determine the bacterial loads of water in selected swimming pools at hotels and recreational areas in Ibadan City, Oyo state, Nigeria

MATERIALS AND METHODS

Study Area and Sampling

The study was carried out in Ibadan City, the capital of Oyo State and the largest city in West Africa, with an area of 3080km^2. The city is located on 7^{0}23'47" N3^{0}55'0" E with 230m (750 ft.) elevation above the sea level. This study was carried out in two Local Government areas of the city; Ibadan North and Ibadan Northwest. A combination of stratified and purposive sampling were employed in classifying the swimming pools into hotels and recreational pools, and also in the selection of the swimming pools in the local government to sample. Four swimming pools in four different recreational centres and hotels coded PHSW, AAASW, KKSW and LOOSW, were selected for this study.

Pilot Study and In-depth Interview with Pool Operators

Visual observations of the swimming pools and its environment were carried out before the commencement of the study, and interviews with the pool operators were also conducted, as a means of ascertaining the necessity for the study and to get approval for the sampling. The swimming pool operators were interviewed to get information on the average number of swimmers, swimming bathing loads, average age group of pool users, treatment methods of swimming pool water and disinfection and type of chlorine used. This was done in the form of in-depth interview.

Administration of Questionnaire

Questionnaires were administered purposively to frequent swimmers in each swimming pools to identify the swimmers habit that could serve as sources of contaminants to the pools e.g. urinating, defecating in the pool and types of infections swimmers contact when swimming in a contaminated pool. The responses were collated and recorded as they will be germane in determining the possible health implications of using the pools.

Determination of the residual chorine concentration in the water

The residual chlorine of the water samples obtained from the swimming pools was assayed using the Mohr's method for chloride ion determination using the methods of APHA (2005).

Sampling procedures

Water samples were collected from the swimming pools in sterile containers in the morning (8-9am) before use and in the evening (8-9pm) after use by the bathers, following standard methods (APHA, 2005; WHO, 2006). All samples were collected during the peak of bathing periods (weekends) by using sterile bottles with capacity of one liter (1 L). Water samples from the swimming pools were collected at three different points (deeper point, shallow point and intake point) and mixed together to form a composite representing each swimming pool. A total of 48 water samples were collected from four swimming pools weekly (two samples from each swimming pool) for a period of six weeks. The bottle was immersed to an elbow depth with its opening facing the water. Samples were labelled and transferred to the Microbiology laboratory on ice for analysis within two hours of collection.

Isolation and characterisation of bacteria

The pour plate method was used in the isolation of bacteria from the water samples obtained from the swimming pools. Isolation was carried out on Nutrient agar (Total Heterotrophic count), MacConkey agar (Total Coliform count), Eosin Methylene Blue (EMB) agar (Escherichia coli), Slanetz and Bartley medium (Enterococci), Pseudomonas Centrimide agar (Pseudomonas spp.). All the culture media were purchased from Oxoid, United Kingdom, and were sterilized at 121^{o}C for 15 minutes in an autoclave, except where otherwise stated. The Most Probable Number (MPN) technique was used in determining the MPN index/100mL of each water sample, and the presence of faecal coliforms at 44.5^{o}C incubation. The water samples were serially diluted and aliquots of the selected factor were appropriately cultured on each medium. The plates were incubated for 24 hours at 35±2ºC, while the MPN set-up for the coliform and faecal coliforms were incubated for 48 hours at 35±2ºC and 44.ºC, respectively. Morphologically distinct colonies presumptive of the target organisms on each medium were selected and repeatedly subcultured on Nutrient agar to obtain pure cultures, which were stored on Nutrient agar slant for further studies. The isolates obtained were characterised using a combination of standard morphological, biochemical and sugar fermentation tests.

Antibiotic Susceptibility Test of Bacterial Isolates

The disc diffusion method of Bauer *et al*. (1996) was used to determine the susceptibility of the isolated bacteria to a panel of antibiotics, which were selected using the CLSI (2024) guidelines. The antibiotics used which were all purchased from Oxoid, United Kingdom were: TE: tetracycline (30µg), CPD: cefpodoxime (10µg), CTX: cefotaxime (30µg), CAZ: ceftazidime (30µg), CIP: ciprofloxacin (10µg), IPM: imipenem (10µg), GEN: gentamicin (30µg), C: chloramphenicol (C10µg), AMC: amoxicillin-clavulanate (30µg), SXT: trimethoprim-sulfamethoxazole (1.25µg/28.75) (Oxoid, UK). Each isolate was subcultured on nutrient agar for 18–24 hours, after which one or two colonies were suspended in sterile normal saline to achieve a turbidity equivalent to 0.5 McFarland standard. The standardized inoculum was spread uniformly on already-prepared Mueller-Hinton agar plates using sterile swab sticks. Antibiotic discs were aseptically placed on the agar surface using a pair of sterile forceps. The plates were incubated at 35 ± 2 °C for 18–24 hours. Following incubation, the diameters of the zones of inhibition were measured in millimeters and interpreted according to CLSI criteria (CLSI, 2024)

The production of Extended spectrum β-lactamase (ESBL) by the isolates was screened phenotypically using the double-disc synergy test (DDST), following CLSI (2024) guidelines. Isolates exhibiting resistance to three or more classes of antibiotics were categorized as multidrug-resistant (MDR) based on the criteria established by Magiorakos *et al*. (2012).

RESULTS

A total of 107 respondents who are frequent users of the swimming pools were sampled. The distribution of the sexes showed that seventy-five (70.1%) of the respondents were males, with the remaining 32 (29.9%) being females. The ages of the respondents ranged from ≤ 20 years to 40 years, with 51.4% (55) belonging to 21-30 age group which constituted the predominant age group. The other respondents belonged to the ≤ 20 years group and 31-40 age group with values of 44 (41.1%) and 8 (7.5%) respectively. The level of education of the respondents showed that 80.4% (86) had tertiary education, with 18.7% (20) having only secondary school education, one respondent (0.9%) had primary school education. Majority of the swimmers (52.3%) swim at least once a week, while few (0.9%) swim 6 days in a week. Also, 58.9% of the respondents swim 1-3 times in a month, 4-6 times (24.3%) and 16.8% swam more than 10 times in a month.

Level of perception of the respondents' opinion of the swimming pools

The data obtained from the respondents showed that 83.2% (89) of the total number of respondents had a favourable perception of the swimming pools, while 16.8% (18) of the respondents perceived that the operating conditions of the swimming pools are unfavourable and need a lot of improvements (Table 2 and Table 3).

Table 2: Swimmers' Opinion of the Swimming pools

Swimmers Opinion	SD	D	U	A	SA
Pool water is odourless	4.7	6.5	5.6	34.6	48.6
Pool water is clean and clear	0	5.6	3.7	35.5	55.1
Pool environment is clean	0	1.9	5.6	43.0	49.5
Pool water is tasteless	0	4.7	10.3	41.1	43.9
The swimming pool is spacious	0.9	5.6	4.7	39.3	49.5
Pool walls are clean and clear	1.9	5.6	5.6	37.4	49.5
The swimming pool maintains hygiene standard	0	4.7	9.3	42.1	43.9

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Highly patronized due to hygiene standard	0	2.8	12.1	40.2	44.9
Swimmers maintain health and hygiene standard	2.8	4.7	8.4	29.9	54.2
Washroom is clean and close to the pool	0.9	7.5	4.7	33.6	53.3
Food and drinks not allowed around pool	0.9	3.7	5.6	28.0	61.7
Sick people are not allowed to swim	0	0.9	9.3	26.2	63.6
Children strictly monitored to prevent littering	0.9	0	3.7	28.0	67.3
Pets are not allowed around the pool	2.8	2.8	8.4	26.2	59.8
Individuals with wounds not allowed to swim	0	0.9	7.5	23.4	60.1
Total (%)	**100**	**100**	**100**	**100**	**100**

KEY: SD: Strongly Disagree, D: Disagree, U: Undecided, A: Agree, SA: Strongly Agree

Table 3: Level of perception of the respondents' opinion on the swimming pools

Perception Category	**F**	**%**	**Range of scores**	**SD**	**Minimum**	**Maximum**
Unfavourable	18	16.8	15 - 31.9	7.69	15.0	68.0
Favourable	89	83.2	32.0 - 68.0			

It is noteworthy from Figure 1 that 86% of the respondents have never urinated in pools, 98.1% have never defecated in the pool and 64.5% never spit in the pool. Furthermore, 96.3% have never vomited in the pools, 88.8% have never entered the pool with any type of wounds. Most of the swimmers ranked swimming with clean swim wears highest, while "maintenance of hygienic practices" ranked second, with taking pre-swim showers ranking third.

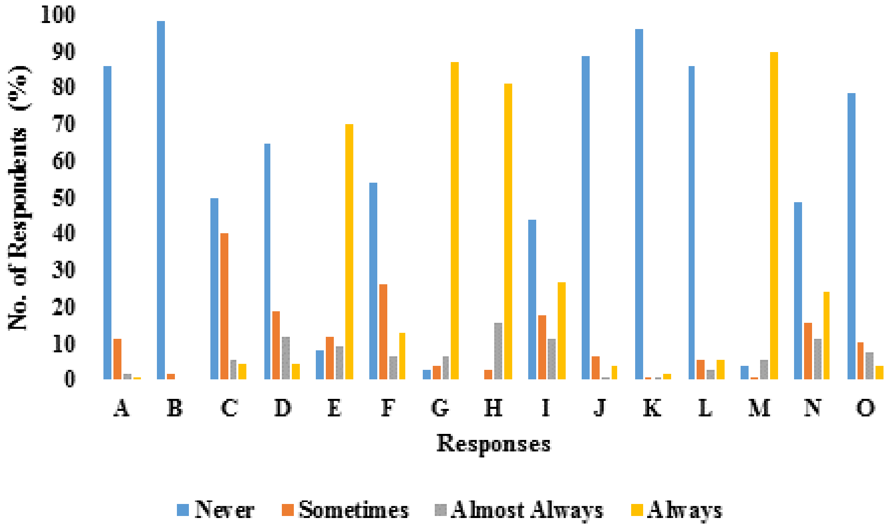

Figure 1: Swimmers' responses to habits around the pool

Key: A= Urinate in the pool, B= Defecate in the pool, C= Ingest swimming pool water, D= Spit in the pool, E= Take footbath before entering pool area, F= Use antimicrobial agent, G= Take pre-swim shower, H= Maintain hygiene practices, I= Use swimming cap, J= Enter the pool when you have wounds, K= Vomit in the pool, L= Use tampon(menstrual cup), M= Swim with clean swim wears, N= Use swimming googles, O= Use nose clip,

As shown in Figure 2, 76.6% of respondents have never experienced headache, 93.5% have never experienced diarrhea, 86% have never experienced skin rashes, and 77.6% never experienced eye irritation. In addition to the aforementioned, 98.1% responded to have never had dysentery, 86.9% have never experienced skin irritation, 86% have not experienced eye infection, 90.7% never had cough, 91.6% never experienced ear pain, and 99.1% never had urinary tract infection (UIT) after using the pools. Even though majority of these swimmers have never experienced these ailments after swimming, they ranked eye irritation, headache and sore throat, respectively as the possible health risks after swimming.

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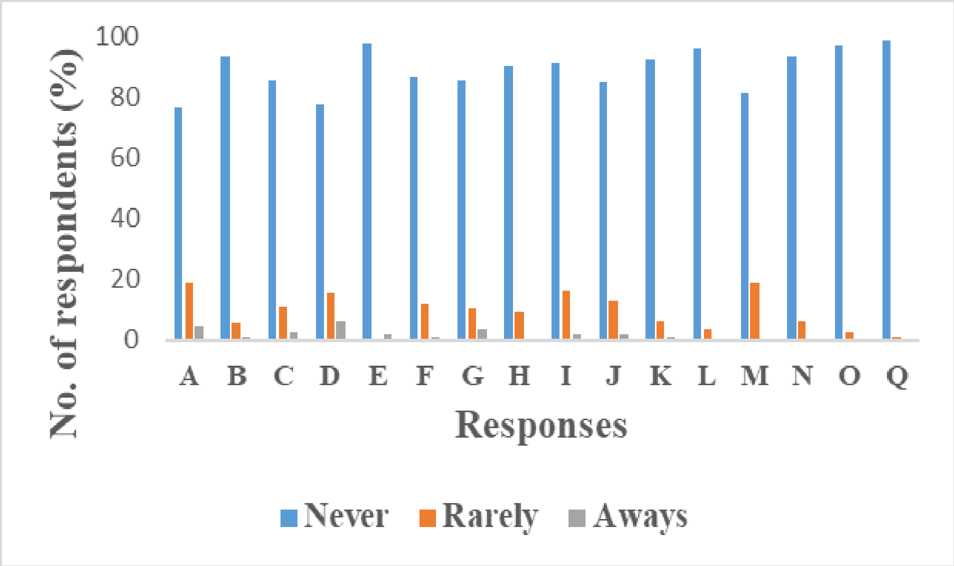

Figure 2: Swimmers' responses to possible health risks after swimming in the pools

Key: A= Headache, B= Diarrhea, C= Skin rashes, D= Eye irritation, E= Dysentery, F= Skin irritation, G= Eye pain or infection, H= Cough/ congestion, I= Ear pain, J= Stomach ache, K= Bloating, L= Constipation, M= Fever, N= Loss of appetite, O= Vomiting, P= Sore throat, Q= Urinary Tract Infection

Table 4: Chlorine concentration in swimming pool water samples before and after usage (mg/l)

Samples	**Residual**	**Chlorine(mg/l)**
	After treatment before use	After use before treatment
1	27.48	7.58
2	11.31	5.92
3	19.61	7.47
4	27.66	9.78
CDC Standard for swimming pools	1-3 mg/l	

Figures 3 shows the frequency of bacterial isolates obtained from the swimming pool water samples. A total of twenty-eight bacteria were obtained including: P. aeruginosa (9), E. coli (7), Klebsiella spp. (9), Citrobacter sp. (1), Enterobacter sp. (1) and Flavobacterium sp. (1) were obtained. Seven of the isolates obtained were positive for Extended Spectrum B-Lactamase (ESBL) production.

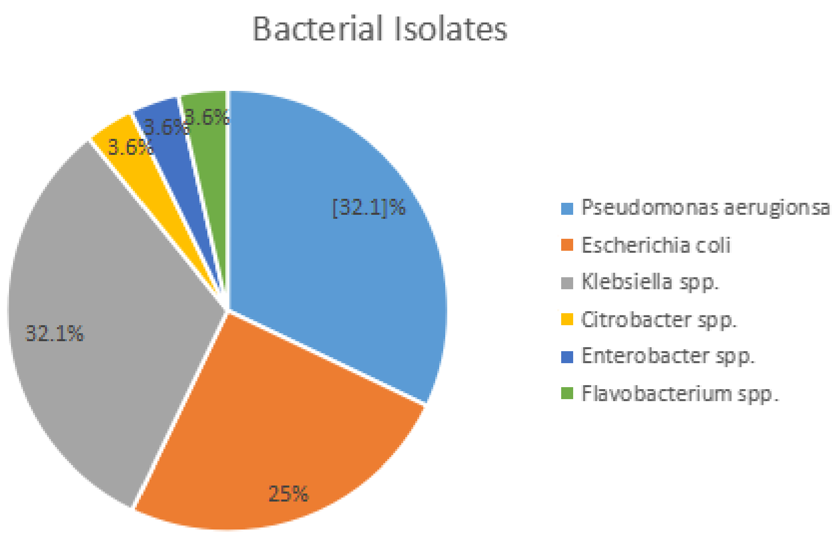

Figure 3: Frequency of bacteria isolated from the swimming pool water samples

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Table 5: Antibiotypes of bacterial obtained from the swimming pool water samples

Isolate Code	Organism identity	tet	cpd	ctx	caz	cip	Ipm	gen	chl	amc	sxt	Phenotype of resistance	ESBL Status
1g	Pseudomonas auruginosa	S	R	R	R	S	S	S	S	R	S	cpd-ctx-caz-amc	+
1h	Escherichia coli	R	R	R	R	R	R	R	R	R	R	te-cpd-ctx-caz-cip-ipm-gen-chl-amc-sxt	-
1c	Pseudomonas aeruginosa	S	S	S	S	S	R	S	S	S	S	Ipm	-
1j	Escherichia coli	S	S	S	S	R	S	R	S	R	S	cip-gen-amc	-
1k	Klebsiella spp.	S	S	S	S	S	S	I	S	R	S	Amc	-
1i	Enterobacter spp.	S	S	S	S	S	S	S	S	S	S	-	-
1q	Pseudomonas aeruginosa	I	R	R	S	R	S	R	R	R	R	cpd-ctx-cip-gen-chl-amc-sxt	-
4e	Klebsiella spp.	S	S	S	S	S	S	S	R	S	S	Chl	-
4f	Pseudomonas aeruginosa	S	R	I	S	S	S	R	R	R	S	cpd-gen-chl-amc	-
2mp	Pseudomonas aeruginosa	I	R	R	S	S	S	R	R	R	R	cpd-ctx-gen-chl-amc-sxt	+
2np	Pseudomonas aeruginosa	I	R	I	S	S	S	R	R	R	R	cpd-gen-chl-amc-sxt	-
1u	Klebsiella spp.	S	S	S	S	S	S	S	S	I	S	-	-
4g	Pseudomonas aeruginosa	R	R	S	S	S	S	R	R	R	R	te-cpd-gen-chl-amc-sxt	-
3c	Pseudomonas aeruginosa	S	R	S	R	S	S	S	R	S	R	cpd-caz-chl-sxt	+
2a	Klebsiella spp.	R	S	S	S	S	S	S	S	S	R	te-sxt	-
2b	Klebsiella spp.	S	S	S	S	S	S	S	S	S	R	Sxt	-
1a	Escherichia coli	S	R	S	S	S	S	S	S	R	S	cpd-amc	-
2bp	Citrobacter spp.	S	R	R	R	S	R	S	S	S	R	cpd-ctx-caz-ipm-sxt	+
3e	Klebsiella spp.	S	R	R	I	S	I	I	R	R	S	cpd-ctx-chl-amc	-
1e	Escherichia coli	S	S	S	S	R	S	S	R	S	S	cip-chl	-
4b	Escherichia coli	R	R	R	S	S	S	R	S	I	R	te-cpd-ctx-cn-sxt	+
3d	Pseudomonas aeruginosa	S	R	S	R	S	S	S	R	S	S	cpd-caz-chl	+
4h	Escherichia coli	S	R	R	S	S	S	R	S	R	S	cpd-ctx-cn-amc	-
2e	Klebsiella spp.	S	R	S	S	S	S	S	S	R	S	cpd-amc	-
2g	Klebsiella spp.	S	I	S	S	S	R	S	S	S	S	Ipm	-
4c	Flavobacterium spp.	S	S	S	S	S	S	S	S	S	S	-	-
1t	Escherichia coli	S	S	S	S	S	S	S	S	S	R	Sxt	+

Key: Tet: Tetracycline (30µg), Cpd: Cefpodoxime (10µg), Ctx: Cefotaxime (30µg), Caz: Ceftazidime (30µg), Cip: Ciprofloxacin (30µg), Ipm: Imipenem (10µg), Gen: Gentamicin (30µg), Chl: Chloramphenicol (10µg), Amc: Amoxicilin clavunate (30µg), Sxt: Trimethroprim sulfamethoxazole (1.25µg), S: Sensitive, R: Resistant.

Figure 4 shows that of the 28 isolates tested with the panel of 10 antibiotics, 14.3% resistant to tetracycline, 57.1% were resistant to cefpodoxime, 32.1% showed resistance to cefotaxime, 17.9% resistant, resisted ceftazidime, 14.3% resisted ciprofloxacin, 17.8% were resistant to imipenem, 32.1% resisted gentamicin, 42.9% resisted chloramphenicol, 46.4% resisted amoxicillin-clavulanate and 39.3% showed resistance to trimethoprim-sulfamethoxazole.

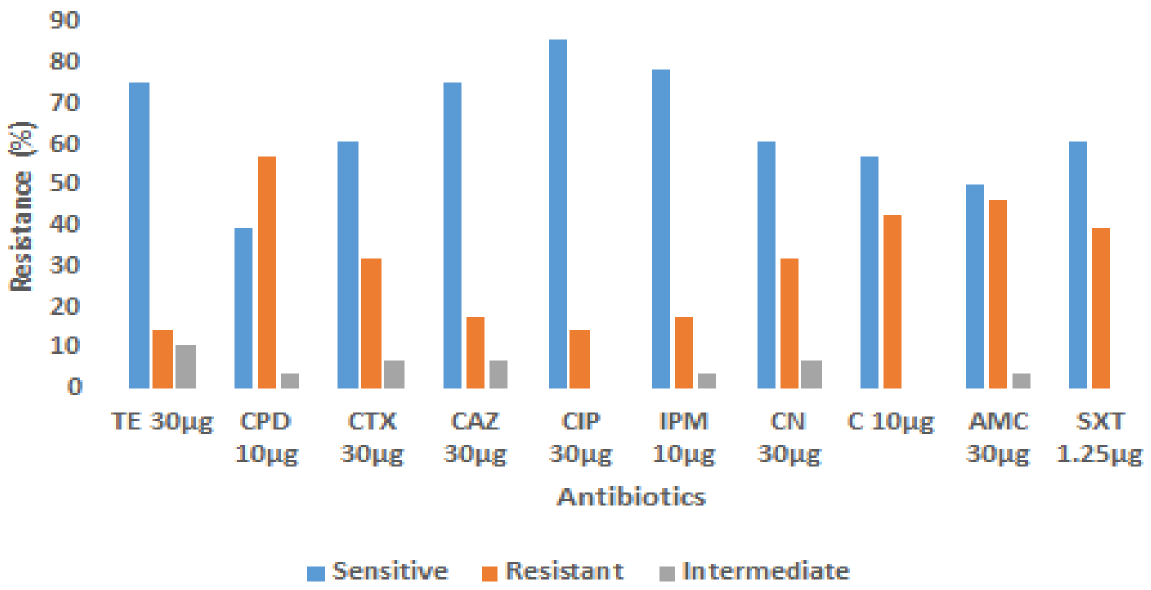

Figure 4: Resistance of the bacterial isolates to a panel of antibiotics

Key: TE: Tetracycline, CPD: Cefpodoxime, CTX: Cefotaxime, CAZ: Ceftazidime, CIP: Ciprofloxacin, IPM: Imipenem, CN: Gentamicin, C: Chloramphenicol, AMC: Amoxicillin-Clavulanate, SXT: Trimethoprim-sulfamethoxazole

DISCUSSION

Swimming pools serve as vital recreational facilities in urban areas, promoting physical fitness, encouraging social interaction, and supporting mental well-being. The safety of the swimming pool is very important because it is a public recreation centre. From this study, the percentage of males who visited the pools was over 70 % while the female population was less than 30%. The age group that visited the pools was in the range of ≤20-30, closely with 80% of those visiting the pools being tertiary education students. The opinions of the swimmers in terms of the purity of the water and the cleanliness of the pools varied across the different swimming pools as shown in Table 2. 83% of pool users have a favourable level of perception of the swimming pool. The basic hygiene required by most swimming pools was followed by the pool users, with very few swimmers deviating from the expectations.

After swimming, rare cases of common possible health risks such as headache, vomiting, and skin irritations were reported, which might be due to the chlorination of the pools, as reviewed by Couto *et al*. (2021), who reported on the implications of both acute and chronic exposures to chlorine in different populations. The initial chlorine and residual chlorine concentrations in the four selected pools were all higher than the values recommended by WHO for swimming pools, posing a potential health risk to the pool users. Over the years, chlorine has been the most widely-used disinfectant in maintaining the hygiene level of swimming pools. However, it must reach a certain concentration to be effective as a disinfectant, with the accepted concentration ranging from 1 -1.5 ppm of residual chlorine, although this varies slightly from country to country. WHO (2006) reported that the free chlorine in recreational waters should be 1mg/l and not exceed 1.2mg/l. The results obtained from this study is similar to those reported in Alexandria, where 80%-88.4% of the pools had unacceptable levels of chlorine (Abdou, 2005; Abd El-Salam, 2012). The overdosing of chlorine may not be dissociated from the ignorance of the pool managers.

Chlorine is widely used in swimming pools to disinfect water and control microbial growth. The ideal free chlorine concentration recommended by the CDC is 1–3 mg/L (ppm) for pools, and 3–5 ppm for hot tubs, with a pH between 7.2–7.8 to maximize effectiveness. However, some bacteria such as *Pseudomonas aeruginosa*, *Legionella*, and biofilm-forming microbes exhibit chlorine tolerance, surviving even within recommended chlorine ranges. Factors like organic matter, UV exposure, and poor water circulation reduce chlorine efficacy. Maintaining proper chlorine levels and regular monitoring is essential to minimize the risk of waterborne infections in recreational swimming environments. In this study, the chlorine concentration before and after bathing far exceeded the permissible limit, and this could portend a health risk to the bathers (WHO, 2006; CDC, 2020).

Swimming pools may be contaminated with microorganisms that are associated with swimmers like faecal contamination of the water, accidental faecal release, or residual faecal material on bodies, and non-faecal shedding like vomit, mucus, saliva, skin, mouth, and upper respiratory tract contamination. These organisms could cause a variety of infections ranging from dermal, central nervous system and respiratory infections (Papadopoulou et al., 2008; WHO, 2009). A total of 28 bacteria belonging to six genera were identified in this study: Pseudomonas aeruginosa (32.1%), Escherichia coli (25%), Klebsiella spp. (32.1%), Citrobacter spp. (3.6%), Enterobacter spp. (3.6%), and Staphylococcus spp. (3.6%). The isolation of this group of organisms has been reported in several studies. Okafor and Obudu (2020) reported the isolation of Bacillus spp., Enterobacter spp., Staphylococcus spp., Klebsiella spp., Citrobacter spp., Salmonella spp., Proteus spp.., Pseudomonas spp. and Escherichia coli from swimming pools in Awka, Anambra State, Nigeria, while Amala and Aleru (2016) isolated Staphylococcus epidermidis, Bacillus cereus, Micrococcus and Staphylococcus aureus from swimming pools in Port Harcourt also in Nigeria, same as Sule et al. (2010), who reported the isolation of similar organisms in pools at Ilorin, Nigeria. Outside of Nigeria, George et al. (2014) isolated E. coli, Enterobacter faecalis, Klebsiella pneumoniae, Staphylococcus aureus and Staphylococcus epidermidis in their study on selected swimming pools in Accra Ghana. Microbiological analysis showed that all the swimming pools tested contained potential bacterial pathogens, a result attributed to poor maintenance, insufficient water treatment, and unhygienic conditions (Onuorah et al., 2017).

Numerous studies show that bacteria cultured from swimming pools exhibit phenotypic resistance in antibiotic sensitivity testing. In northern Greece, ~16.6% of pool water samples harbored *P. aeruginosa*, and about 20% of those isolates proved resistant to antibiotics in phenotypic assays. A Mediterranean hydrotherapy pool surveillance reported 35.5% of isolates from 107 bacteria were antibiotic-resistant. In Al-Ahsa (Saudi Arabia), Klebsiella and *P. aeruginosa* isolates showed variable MIC profiles with multidrug resistance patterns. These findings underscore the prevalence of phenotypically resistant pool-associated bacteria, stressing the need for routine antimicrobial susceptibility testing and stringent water-quality controls in recreational aquatic facilities.

The relatively high percentage of resistance to the tested antibiotics is a another major wake up call, with 14.3% of the isolates being resistant to tetracycline, 57.1% were resistant to cefpodoxime, 32.1% showed resistance to cefotaxime, 17.9% resistant, resisted ceftazidime, 14.3% resisted ciprofloxacin, 17.8% were resistant to imipenem, 32.1% resisted gentamicin, 42.9% resisted chloramphenicol, 46.4% resisted amoxicillin-clavulanate and 39.3% showed resistance to trimethoprim-sulfamethoxazole. This aligns partly with the work of Fakorede *et al.* (2024), which who reported resistance to most commonly-used antibiotics in their study on bacterial isolates from selected swimming pools in Ile-Ife, Nigeria.

The detection of ESBL-producing bacteria in the swimming pools is another budding public health threat as seven (25%) of the isolates from the pools in this study were ESBL producers. Extended-spectrum β-lactamase (ESBL)-producing bacteria—particularly Escherichia coli and Klebsiella pneumoniae harboring ESBL genes have been detected in various recreational water sources, posing a potential risk to swimmers. In a Nigerian study (Zaria), phenotypic ESBL production was confirmed in about 27% of isolates, with 5 isolates coming from recreational water, highlighting that even treated surface waters may contain ESBL-producers (Atta et al., 2022). A Norwegian–Danish multi-compartment study found ESBL-producing E. coli in 40% of recreational water sampling events, with ratios up to 3.8% of total E. coli, and genetic overlap between clinical, wastewater, and recreational isolates—suggesting aquatic exposure can result in colonization (Jorgensen et al., 2017).

In the U.S. mid-Atlantic region, a large evaluation of surface and reclaimed waters found ESBL activity in only 0.8% (4 of 488) of isolates, reflecting low prevalence in well-regulated settings (Solaiman *et al.*, 2022). A 2023 study in Ireland assessing recreational water users vs. controls found 7.1% carriage of ESBL-producing Enterobacterales among participants, but intriguingly swimmers had significantly lower prevalence than non-swimmers (risk ratio = 0.34), suggesting complex interaction between exposure and colonization risk (Farrell *et al.*, 2023). Taken together, these data indicate that while ESBL producers can be present in recreational waters, prevalence is generally low in properly-managed systems. Maintaining adequate chlorination, monitoring pH, and routine microbial surveillance remain critical to minimizing transmission risk via swimming pool water.

CONCLUSION

The results obtained in this study showed that most of the pools did not comply with the WHO standard for recreational activities due to the presence of microorganisms and therefore constitute a serious problems to the bathers. The operators should follow recreational water guidelines for proper management of swimming pools. Users should adhere to good sanitary practices, and the various health authorities should monitor swimming pool facilities and ensure strict compliance to guidelines for sanitation and proper pool management in order to reduce the incidence of recreational diseases. Routine AMR monitoring in recreational waters is recommended. It was observed that faecal coliform (Escherichia coli) and Enterococci were absent from some of the swimming pools. The absence of these organisms, however, does not guarantee safety, as some pathogens are more resistant to treatment than the indicators, and there is no perfect indicator organism.

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