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Original Research

Sensitivity profile of pathogens identified in the diagnosis of urinary infection by uroculture carried out at the National Institute for Health Research, Luanda/Angola, during the pre-pandemic, intra-pandemic and post-pandemic of COVID-19

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Abstract: Urinary tract infection (UTI) is an infectious disease that affects any part of the urinary system, including the kidneys, ureters, bladder, and urethra. Antimicrobial resistance (AMR) is currently a public health problem. To understand the antibiotic susceptibility profile of microorganisms isolated in urine samples at the reference microbiology laboratory in Luanda/Angola from 2016-2022 (pre-pandemic, pandemic, and post-pandemic). Methodology: A descriptive, quantitative, documentary study was carried out using a survey of secondary data, based on the results of urocultures from patients with a suspected diagnosis of UTI. A total of 2,800 (50.99%) were studied (n=5,491) and confirmed as having a UTI. From 2016 to 2019, 2,060 were confirmed; in 2020, 51 cases were investigated and 24 (0.86%) were confirmed. In 2022, corresponding to the period after the COVID-19 pandemic, a total of 246 patients (8.78%) had a confirmed urinary tract infection. In general, in all periods, the most sensitive drugs were amikacin, fosfomycin, norfloxacin, nalidixic acid, tobramycin, akanamycin and cefotaxime. Females and the *E. coli* strain followed by proteus vulgaris and mirabilis and the 20-29 and 30-39 age groups were the most prevalent.

Keywords: UTI; Resistance; Antimicrobial; Sensitivity.

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1. Introduction

Urinary tract infection (UTI) is an infectious disease that affects any part of the urinary system, including the kidneys, ureters, bladder, and urethra. UTI is caused by the invasion and multiplication of microorganisms, mainly bacteria with a bacterial load of more than 100,000 CFU/mL, in the urinary tract, resulting in inflammation and irritation of the tissues involved [1]. UTI is one of the most common conditions worldwide, affecting around 150 million people every year, both in outpatient and inpatient settings. Although UTI can affect anyone, it is more common in women, with approximately 50 per cent of them being affected at some point in their lives and being six times more likely to develop the infection than men. Although most UTIs can be successfully treated, around 30 per cent of women will have a recurrence and more than 20 per cent will suffer from multiple recurrences [2, 3].

Antimicrobial resistance (AMR) has been increasingly reported in bacteria that cause urinary tract infections (UTIs) in recent decades and has become a major public health concern. A wide variety of bacteria can cause UTIs, but the most frequent include *E. coli*, *Klebsiella pneumoniae*, *Enterococcus sp.* and *Staphylococcus saprophyticus*. In Africa, there are few studies reporting epidemiological aspects of UTIs and ADRs as a public health problem. One example is the study by [3] which reported aspects of antibiotic resistance and virulence properties in strains of E. coli from cases of urinary tract infections in 137 cases of UTI in Nigeria [3].

Diagnosis takes an average of three days (urinalysis and uroculture); misdiagnosed infection can seriously increase the prevalence of antimicrobial resistance [1-3]. Urinary tract infections (UTIs) are among the most common bacterial infections in the community and in hospital settings. They can be uncomplicated, when they affect women and men in the absence of underlying abnormalities of the urinary tract or immunosuppression, affecting 10 to 12 per cent of adults at least once a year worldwide, and complicated when they affect women and men with anatomophysiological abnormalities or alterations in the urinary tract or with immunosuppression. Knowledge of the associated risk factors and the susceptibility profile of the microorganisms that cause them are indispensable tools for generating appropriate treatment guidelines [4-6].

The microbial aetiology of UTI is well characterised, with *Escherichia coli* being the most common uropathogen isolated in UTI [6]. Diagnosis can be obtained from a laboratory and/or clinical point of view. Diagnosis of UTI in the laboratory can be via the reagent strip method (qualitative) and urine sediment (quantitative) or by uroculture - the gold standard for diagnosing these infections - as it allows the infecting microorganism to be identified and therapy to be directed using the antimicrobial susceptibility test [8].

Antimicrobial resistance in bacteriuria, both symptomatic and asymptomatic, is increasing worldwide and some bacteria, such as some of the Enterobacteriaceae, are virulent and capable of acquiring multidrug resistance to the antimicrobials of choice for the treatment of UTI. Antimicrobial resistance rates vary according to geographical locations and are directly proportional to the use and abuse of antimicrobials, especially in empirical antibiotic therapy [9-10]. The negative consequences of the increase in bacterial resistance are expressed in terms of morbidity, mortality and health costs derived from medical care and threaten the sustainability of health systems around the world, which is why measures must be developed to rationalise and use antimicrobials, improving their indications and their use, thus reducing toxicity as much as possible and the cost they generate for institutions [11].

The aim of this study is to find out the antibiotic susceptibility profile of microorganisms isolated in urine samples at the reference microbiology laboratory in Luanda/Angola in the 2016-2022 period (pre-pandemic, intra-pandemic, and post-pandemic).

2. Material and methods

This study is characterized as documentary, descriptive research with a quantitative approach using a survey of secondary data, based on the results of urocultures from patients with suspected UTI, included in the record book of the Microbiology Reference Laboratory of the National Institute for Health Research, located in the city of Luanda, Angola. Data collection was carried out in three distinct periods, described as follows: pre-pandemic period of COVID-19, corresponding to the years 2016 to 2019; intra-pandemic period of COVID-19, corresponding to the year 2020 and, finally, the post-pandemic period of COVID-19, corresponding to the year 2022.

The study population was made up of patients of both sexes, regardless of age, with a suspected diagnosis of UTI who had undergone clinical uroculture tests and had been assisted by the reference laboratory. The sampling technique used to select the sample was non-probabilistic intentional sampling.

Since the study was conducted in a leading health institution in Angola, the variables investigated form the infection and sensitivity profile of UTI patients in the country, with the following sociodemographic characteristics being investigated: age, gender, origin, type of pathogen diagnosed and type of antibiotic sensitive to the pathogen. It should be emphasised that this study complied with the ethical requirements for research with human beings, as defined by the Declaration of Helsinki. The project that gave rise to the study was approved by the Human Research Ethics Committee of the National Institute for Health Research in Luanda, Angola. The data obtained from the analysis of the variables contained in the clinical examinations was tabulated and analysed using analytical-descriptive statistics, with the aid of the SPSS (Statistical Package for Social Sciences) v 20.0 statistical package. The citations were written using the electronic programme Zotero 5.0 for Windows, complying with the Vancouver rules.

3. Results

3.1. General characterisation of patients by period assessed

In this study, we surveyed 5,491 laboratory records of urine tests from patients with suspected urinary tract infections seen at a reference clinical analysis laboratory in Luanda/Angola between 2016 and 2022. We understood that the years 2016 to 2019 referred to the pre-pandemic period, then 2020 was considered the intra-pandemic period and, finally, the year 2022 was considered the post-pandemic period of COVID-19. Of this amount (n=5,491), a total of 2,800 (50.99%) urinary tract infection diagnoses were confirmed (Table 1). Initially, in the pre-pandemic period (2016 to 2019), we identified records of a total of 5,029 cases of suspected urinary infection in this reference laboratory, stratified into 2,060 cases assessed in 2016, 885 cases in 2017, 597 cases in 2018 and 1,487 cases in 2019. With regard to confirmed cases of urinary infection, we found a total of 957 (34.18%) cases in 2016, 433 (15.46%) in 2017, 342 (12.21%) in 2018 and, finally, 798 (12.21%) cases in 2019.

With regard to the intra-pandemic period, we only had records for 2020, corresponding to 51 cases investigated and 24 (0.86%) cases with confirmed diagnoses of urinary infection, given that at the height of the COVID-19 pandemic (2021) all clinical analysis efforts were focused on diagnosing the disease. Finally, we found a total of 411 cases of suspected urinary infection in 2022, corresponding to the period after the COVID-19 pandemic, with confirmation of urinary infection in a total of 246 patients (8.78%) (Table 1).

3.2. Stratification of patients in relation to sociodemographic aspects

Patients with suspected and confirmed urinary tract infections were stratified by age, gender, and origin. For the pre-pandemic period, initially described in 2016, we found that patients with a suspected diagnosis of urinary infection had an average age of 33.44 years (±15 years), with a predominance of cases in the 20-29 age group (n= 596; 28.9%) and 30-39 age group (n= 585; 28.4%), were female (n=1454; 70.6%) and came from Luanda (n= 1668; 81.0%). With regard to the confirmed cases of urinary infection, we found that the parameters remained similar, as we observed similar average ages (33±16 years) and a predominance of cases in the same age groups [20-29 years (n= 285; 29.8%) and 30-39 years (n= 247; 25.8%)], gender [female (n=777; 81.2%)] and origin [Luanda (n= 783; 81.8%)] (Table 1).

For 2017, we found that the patients had a mean age of 33.82 (±15 years), with a predominance of cases in the 30-39 age group (n= 248; 28.0%) followed by the 20-29 age group (n= 245; 27.7%). Regarding gender, females had the highest number of cases with 616 (69.6%) and the highest number came from Luanda with 717 (81.0%) (Table 1). In relation to the patients diagnosed with urinary infection in 2017, we saw that the average age (35 ±16 years), with the predominance of the number of cases occurring in the 20-29 age group (n= 116; 26.08%) followed by the 30-39 age group (n= 114; 26.3%). In terms of gender, females accounted for the largest number of cases with 343 (79.3%) and the largest number came from Luanda with 351 (81.1%) (Table 1).

When we analyzed the year 2018, we saw that the patients had an average age of 36.36 (±16 years) and that the predominant number of cases was in the 20-29 age group (n=157; 26.3%) followed by the 30-39 age group with (n=153; 25.6%) cases. In terms of gender, females accounted for the largest number of cases with 371 (62.1%) and the largest number came from Luanda with 456 (76.4%) (Table 1). Regarding the positive cases for 2018, the patients had an average age of (37±16 years) in which the predominant number of cases was in the 20-29 age group (n=87; 25.4%) followed by the 30-39 age group with (n=84; 24.6%) cases. In terms of gender, 252 (73.3%) cases were female and 258 (75.4%) came from Luanda (Table 1).

In the analysis of the last year of the pre-pandemic period, 2019, it was possible to analyze that the average age was 35.05 (±15 years) with a predominance of cases in the 30-39 age group with (n=400; 26.9%) cases followed by the 20-29 age group with (n=399; 26.8%) years. In terms of gender, females accounted for the largest number of cases with 1,032 (69.4%) and the largest number came from Luanda with 1,274 (85.7%) (Table 1). In 2019, it was possible to analyze the positive cases for urinary infection, the average age was (36±16 years) with a predominance of cases in the 30-39 age group with (n=219; 27.4%) cases followed by the 20-29 age group with (n=195; 24.4%) years. With regard to gender, 651 (81.6%) cases were female and 687 (86.1%) came from Luanda (Table 1).

In relation to the intra-pandemic period (2020), we found that the average age of the patients was 33.05 (±18 years), with the highest number of cases in the 30-39 age group (n=12; 23.5%) followed by the 40-49 age group with (n=10; 19.6%) cases. In terms of gender, females accounted for the largest number of cases with 33 (64.7%), and the largest number came from Luanda with 27 (52.9%) (Table 1). For the year 2020 we saw that the average age for positive cases of urinary infection was (35±20 years) with a predominance in the number of cases in the 30-39 age group with (n=6; 25%) cases followed by the 20-29 age group with (n=5; 20.8%) years. About gender, 19 (79.2%) cases were female and 12 (50%) came from Luanda (Table 1).

Finally, in relation to the post-pandemic period (2022), we found that the average age of users was 31.31 (±19 years), with the greatest predominance of cases in the ≥60 age group (n=43; 10.5%), followed by the 30-39 age group (n= 87; 21.2%). When gender was analyzed, we saw that females accounted for the largest number of cases with 33 (64.7%). The largest number of cases came from Luanda, with 27 (52.9%) (Table 1). Also, for the same post-pandemic period (year 2022), we saw that the average age for positive cases of urinary infection was (32±19 years) with a predominance in the number of cases in the 30-39 age group with (n=55; 22.4%) cases followed by the 20-29 age group with (n=47; 19.1%) years. Regarding gender, females accounted for the largest number of cases with 185 (75.2%) and the largest number came from Luanda with 232 (94.3%) (Table 1).

Table 1. Sociodemographic characterization of patients with suspected diagnosis (A / n=5.491) and confirmed diagnosis (B / n=2.800) of urinary infection at a reference laboratory in Luanda, Angola, from 2016 to 2022.

Variables	2016		2017		2018		2019		2020		2022	
	A (n=2060)	B (n=957)	A (n=885)	B (n=433)	A (n=597)	B (n=342)	A (n=1487)	B (n=798)	A (n=51)	B (n=24)	A (n=411)	B (n=246)
Age (years), mean±dp	33.44±15	33±16	33.82±15	35±16	36.36±16	37±16	35.05±15	36±16	33.05±18	35±20	31.31±19	32±19
Age categorised (n/%)												
1-10 years	118 (5.7)	56 (5.9)	62 (7.0)	27 (6.2)	24 (4.0)	12 (3.5)	81 (5.4)	42 (5.3)	7 (13.7)	3 (12.5)	82 (20.0)	46 (18.7)
11-19 years	173 (8.4)	91 (9.5)	59 (6.7)	31 (7.2)	42 (7.0)	28 (8.2)	98 (6.6)	60 (7.5)	5 (9.8)	2 (8.3)	29 (7.1)	17 (6.9)
20-29 years	596 (28.9)	285 (29.8)	245 (27.7)	116 (26.8)	157 (26.3)	87 (25.4)	399 (26.8)	195 (24.4)	8 (15.7)	5 (20.8)	84 (20.4)	47 (19.1)
30-39 years	585 (28.4)	247 (25.8)	248 (28.0)	114 (26.3)	153 (25.6)	84 (24.6)	400 (26.9)	219 (27.4)	12 (23.5)	6 (25.0)	87 (21.2)	55 (22.4)
40-49 years	261 (12.7)	118 (12.3)	126 (14.2)	60 (13.9)	95 (15.9)	58 (17.0)	253 (17.0)	127 (15.9)	10 (19.6)	1 (4.2)	60 (14.6)	38 (15.4)
50-59 years	211 (10.2)	97 (10.1)	95 (10.7)	52 (12.0)	73 (12.2)	33 (9.6)	148 (10.0)	86 (10.8)	5 (9.8)	4 (16.7)	26 (6.3)	17 (6.9)

	≥60 years	116 (5.6)	63 (6.6)	50 (5.6)	33 (7.6)	53 (8.9)	40 (11.7)	108 (7.3)	69 (8.6)	4 (7.8)	3 (12.5)	43 (10.5)	26 (10.6)
Sex (n/%)													
	Male	606 (29.4)	180 (18.8)	269 (30.4)	90 (20.8)	226 (37.9)	90 (26.3)	455 (30.6)	147 (18.4)	18 (35.3)	5 (20.8)	103 (25.1)	61 (24.8)
	Female	1454 (70.6)	777 (81.2)	616 (69.6)	343 (79.2)	371 (62.1)	252 (73.7)	1032 (69.4)	651 (81.6)	33 (64.7)	19 (79.2)	308 (74.9)	185 (75.2)
Origin	Luanda	1668 (81.0)	783 (81.8)	717 (81.0)	351 (81.1)	456 (76.4)	258 (75.4)	1274 (85.7)	687 (86.1)	27 (52.9)	12 (50.0)	385 (93.7)	232 (94.3)
	Belas	2 (0.1)	1 (0.1)	2 (0.2)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	10 (19.6)	3 (12.5)	3 (0.7)	0 (0.0)
	Viana	202 (9.8)	100 (10.4)	100 (11.3)	49 (11.3)	90 (15.1)	48 (14.0)	139 (9.3)	75 (9.4)	2 (3.9)	1 (4.2)	18 (4.4)	12 (4.9)
	Cacuaco	61 (3.0)	25 (2.6)	25 (2.8)	11 (2.5)	20 (3.4)	11 (3.2)	31 (2.1)	17 (2.1)	5 (9.8)	2 (8.3)	3 (0.7)	2 (0.8)
	Icolo e Bengo	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Cazenga	84 (4.1)	36 (3.8)	37 (4.2)	19 (4.4)	29 (4.9)	23 (6.7)	33 (2.2)	15 (1.9)	1 (2.0)	1 (4.2)	1 (0.2)	0 (0.0)
	Quiçama	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Talatona	2 (.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	6 (11.8)	5 (20.8)	0 (0.0)	0 (0.0)
	Kilamba	41 (2.0)	12 (1.3)	4 (0.5)	2 (0.5)	2 (0.3)	2 (0.6)	10 (0.7)	4 (0.5)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)
	Kiaxe												

Legend. A. Suspected diagnosis of Urinary Tract Infection (n= 5.491). B. Confirmed diagnosis of urinary infection (n=2.800).

3.3 Characterization of the types of infectious agents identified in patients with confirmed urinary infection (n=2.800)

Regardless of the period assessed, the urinary infections diagnosed were predominantly associated with E. coli infection (2016, n=933 / 97.49%; 2017, n=432 / 99.77%; 2018, n=342 / 100.0%; 2019, n=794 / 99.49%; 2020, n=15 / 62.5% and 2022, n=195 / 79.26%). For the year 2016, table 2 shows a similarity in the involvement of patients by type of pathogen, covering approximately 1.3% of cases by type of infection. For the year 2017, the same table shows that there were approximately 0.3% of cases by type of infection; the same cannot be said for the years 2018 and 2019, which did not show similarity by type of infection. The year 2020 showed similarities by type of infection of approximately 2 and 3.9 per cent respectively. The year 2022, which marked the post-pandemic period, showed similarity by type of infection of approximately 0.5%.

Table 2. Description of the types of pathogens identified in the diagnosis of urinary infections diagnosed in Luanda/Angola between 2016 and 2022.

Variables		2016 (n=957)		2017 (n=433)		2018 (n=342)		2019 (n=798)		2020 (n=24)		2022 (n=246)	
		N	%	N	%	N	%	N	%	N	%	N	%
Escherichia coli	Yes	933	45.3	432	48.8	342	57.3	794	53.4	15	29.4	195	47.4
	No	1127	54.7	453	51.2	255	42.7	693	46.6	36	70.6	216	52.6
Proteus vulgaris	Yes	26	1.3	3	0.3	0	0.0	0	0.0	0	0.0	17	4.1
	No	2034	98.7	882	99.7	597	100.0	1487	100.0	51	100.0	394	95.9
Proteus mirabilis	Yes	27	1.3	0	0.0	0	0.0	0	0.0	1	2.0	47	11.4
	No	2033	98.7	885	100.0	597	100.0	1487	100.0	50	98.0	364	88.6
Klebsiela sp.	Yes	27	1.3	0	0.0	0	0.0	0	0.0	1	2.0	13	3.2
	No	2033	98.7	885	100.0	597	100.0	1487	100.0	50	98.0	398	96.8
Enterobacter sp.	Yes	26	1.3	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	No	2034	98.7	885	100.0	597	100.0	1487	100.0	51	100.0	410	99.8
Pseudomona Aeruginosa	Yes	27	1.3	0	0.0	0	0.0	0	0.0	2	3.9	2	0.5
	No	2033	98.7	885	100.0	597	100.0	1487	100.0	49	96.1	409	99.5

Estafilococus aureus	Yes	27	1.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	No	2033	98.7	885	100.0	597	100.0	1487	100.0	51	100.0	411	100.0
Proteus sp.	Yes	26	1.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	No	2034	98.7	885	100.0	597	100.0	1487	100.0	51	100.0	411	100.0
Shigela sp.	Yes	26	1.3	0	0.0	0	0.0	0	0.0	2	3.9	3	0.7
	No	2034	98.7	885	100.0	597	100.0	1487	100.0	49	96.1	408	99.3
Rhizobium radiobacter	Yes	10	.5	3	0.3	2	0.3	5	.3	2	3.9	10	2.4
	No	2050	99.5	882	99.7	595	99.7	1482	99.7	49	96.1	401	97.6
Klebsiella pneumoniae	Yes	27	1.3	0	0.0	8	1.3	0	0.0	1	2.0	2	0.5
	No	2033	98.7	885	100.0	589	98.7	1487	100.0	50	98.0	409	99.5

3.4 Distribution of infectious agents identified in patients with confirmed urinary infection by age group and sex in the periods evaluated

Next, we evaluated the incidence of cases of infection stratified by sex and age established by evaluation period. We found that the most common infectious agents in the population evaluated were *E. coli*, followed by *P. vulgaris* and *P. mirabilis*. Figure 1 shows the high distribution of *E. coli* infections in female patients and in the 20-39 age group in all the periods evaluated here, except for 2022 (post-pandemic). In 2022, there was also a high incidence of cases of *E. coli* infection in patients aged between 1 and 10 years (n=39; 20%), similar to that identified for the 20 to 29 age group (n=39; 20%) and the 30 to 39 age group (n=43; 22.1%) (Supplementary material 1).

When evaluating the incidence of cases of infection stratified by sex and age in the period 2016-2022, we saw that the infectious agent *P. vulgaris*, after *E. coli*, shows a high distribution of infections in female patients, in the years 2016, 2017 and 2022, in the age groups 20-29 years, in the year 2016 and 2022 respectively, 50-59 years in the year 2017, and there were no records of these pathogens in the years 2018 and 2019, as illustrated in figure 2.

In relation to the incidence of infection cases stratified by sex and age in the 2016-2022 period, we saw that the infectious agent *P. mirabilis*, in figure 3, after *E. coli* and *P. vulgaris* and in the same proportion as *Klebsiella sp*, *Enterobacter sp*, *Pseudomona aeruginosas*, *Staphylococcus aureus* and *Shigella sp*, show a proportionality in the distribution of infections in female and male patients, in the year 2016, in the 20-29 age groups. In the year 2022, the predominance of urinary infection for the strain in question was in females and in the 60+ age group, with no records in the years 2017, 2018 and 2019, as shown in figure 3.

3.5 Characterization of sensitive antibiotics identified in patients with confirmed urinary infections (n=2.800)

Based on the number of urinary system infections identified, we obtained the total number of sensitivity cases analyzed by antibiogram (Table 3). Looking at the whole period, we found that the main cases of antibiotic sensitivity were related to Amikacin, followed by Fosfomycin and Norfloxacin. Specifically in 2016, we observed an incidence of cases of sensitivity to Amikacin (n=379; 39.60 per cent), followed by Fosfomycin (n=328; 34.27 per cent) and Norfloxacin (n=277; 28.94 per cent) and Nalidixic Acid (n=258; 26.96 per cent). In 2017, the main cases of antibiotic sensitivity were Tobramycin (n=198; 45.73%), Fosfomycin (n=156; 36.03) and Ciprofloxacin (n=131; 30.25%). In 2018, the main cases of antibiotic sensitivity were related to Ciprofloxacin (n=110; 32.16%), followed by Kanamycin (n=98; 28.65%) and Norfloxacin (n=95; 27.78%). In 2019, the main cases of antibiotic sensitivity were Amikacin (n=286; 35.84%) followed by Cefotaxime (n= 279; 34.96) and Furantoin (226; 28.32%). In 2020, despite having the smallest sample, cases of antibiotic sensitivity were related to Ciprofloxacin (n=10; 41.67%), followed by Norfloxacin (n=9; 37.5%) and Kanamycin and Tobramycin with (n=8; 33.33%) respectively. When we analyzed the year 2022, we saw that the most sensitive cases were related to Norfloxacin (n=94; 98.21%), Amikacin (n=82;33.33%) and Gentamicin (n=80;32.52%), as illustrated in table 3.

Table 3. Description of antibiotic sensitivity profiles in patients diagnosed with urinary infection in Luanda, Angola, 2016 to 2022.

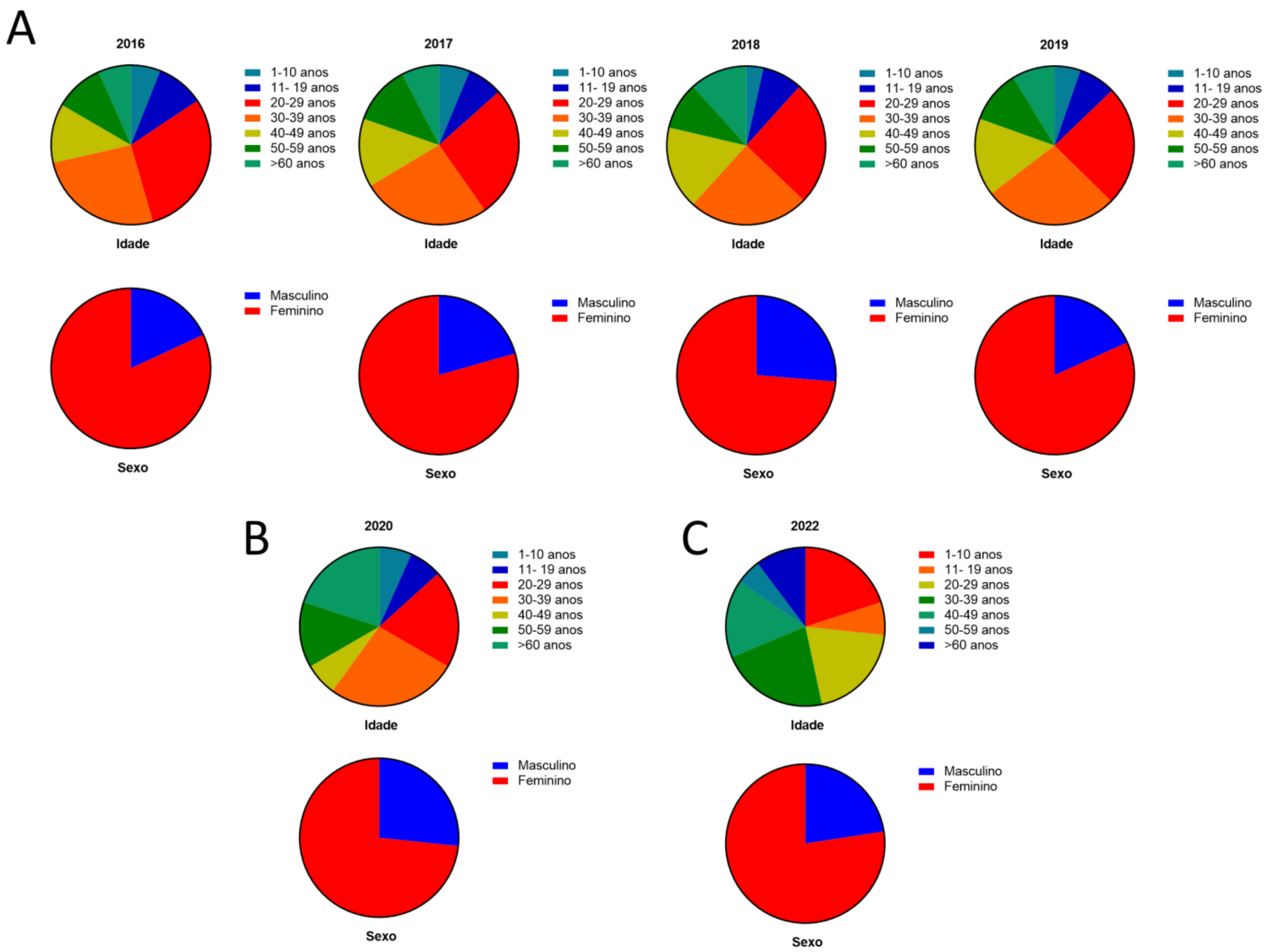
Antibiotics	2016 (n=957)		2017 (n=433)		2018 (n=342)		2019 (n=798)		2020 (n=24)		2022 (n=246)	
	N	%	N	%	N	%	N	%	N	%	N	%
Canamicina	2	0.21	1	0.23	0	0.00	5	0.63	2	8.33	12	4.88
Nitrofurantoina	112	11.70	0	0.00	72	21.05	84	10.53	2	8.33	76	30.89
Norfloxacina	277	28.94	71	16.40	95	27.78	223	27.94	9	37.50	94	38.21
Tetraciclina	133	13.90	72	16.63	46	13.45	149	18.67	0	0.00	34	13.82
Ácido nalidixico	258	26.96	113	26.10	71	20.76	180	22.56	0	0.00	58	23.58
Metronidazol	14	1.46	2	0.46	9	2.63	23	2.88	0	0.00	20	8.13
Ampicilina	95	9.93	31	7.16	68	19.88	87	10.90	0	0.00	32	13.01
Amikacina	379	39.60	123	28.41	98	28.65	286	35.84	8	33.33	82	33.33
Gentamicina	95	9.93	36	8.31	51	14.91	113	14.16	5	20.83	80	32.52
Cefotaxima	97	10.14	71	16.40	65	19.01	279	34.96	4	16.67	76	30.89
Tobramicina	85	8.88	198	45.73	34	9.94	78	9.77	8	33.33	57	23.17
Ciprofloxacina	170	17.76	131	30.25	110	32.16	212	26.57	10	41.67	87	35.37
Amoxacilina	116	12.12	25	5.77	42	12.28	97	12.16	2	8.33	45	18.29
Fosfomicina	328	34.27	156	36.03	77	22.51	226	28.32	1	4.17	71	28.86
Vancomicina	2	0.21	0	0.00	0	0.00	6	0.75	1	4.17	15	6.10
Penincilina	3	0.31	0	0.00	0	0.00	5	0.63	1	4.17	32	13.01

4. Discussion

Urinary tract infections are diagnosed both clinically and in the laboratory. Clinically, the infection is diagnosed by anamnesis and physical examination by the doctor. From a laboratory point of view, the infection can be diagnosed by urinalysis, urine sediment and uroculture by a trained professional. Antimicrobial resistance is now a public health problem, as stated in various national and international studies.

There are few studies on uroculture in Africa, which was a limitation of our study. On the other hand, in Angola, studies carried out [27], show a high number of patients with urinary infections resistant to the different drugs used to treat urinary tract infections. The same study reveals that the high rate of resistance to antimicrobials is closely linked to impiric antibiotic therapy and self-medication on the part of users, since pharmacies often sell users medicines without a medical prescription [27]. Uroculture studies carried out in Europe, Portugal and Spain, in the pre-pandemic phase, the most isolated strain was *E. coli*, the gender was female, and the most sensitive antimicrobials were fosfomycin and nitrofurantoin, with a sensitivity rate above 95%, and ciprofloxacin and cotrimoxazole with a sensitivity rate of 80%, in a study where male individuals had greater resistance to the other drugs [12]; and a 95% resistance rate to meropenem and ceftriaxone in pediatric patients [13]. In most uroculture studies, in the intra-pandemic phase, the highest gender prevalence belongs to females and the most isolated strain is *E. coli* [14].

Figure 1. Graphical representation of the distribution of cases of *E. coli* infection stratified by age group, sex and evaluation period. Caption. A. Pre-pandemic period. B. Intra-pandemic period. C. Post-pandemic period.



It should be noted that the last survey carried out in Angola showed that there were more women than men, and in this study, it was also evident that the largest number of sample members were women. Published studies show that women in Angola are the most resistant to antimicrobials in uroculture studies [27]. Studies show that *Proteus mirabilis* is more isolated in catheterized men [15]. This information does not match ours, as we found prevalence in non-catheterized patients. According to [16], in the pre-pandemic phase, in a study of hospitalized patients, the most isolated gram-positive strain was S. epidermitis and it was resistant to most of the drugs, followed by *E. coli* with a resistance rate of 76% to ampicillin, amoxicillin, and sulfamethoxazole/trimethoprim, while being sensitive to the other drugs. Although betalactams and sulphonamines are widely used to treat urinary tract infections, this study advises against the use of these drugs in the pre-, intra- or post-pandemic context, especially as long as they show these resistance rates.

Figure 2. Graphical representation of the distribution of *P. vulgaris* infection cases stratified by age group, sex and evaluation period. Caption. A. Pre-pandemic period. B. Intra-pandemic period. C. Post-pandemic period.

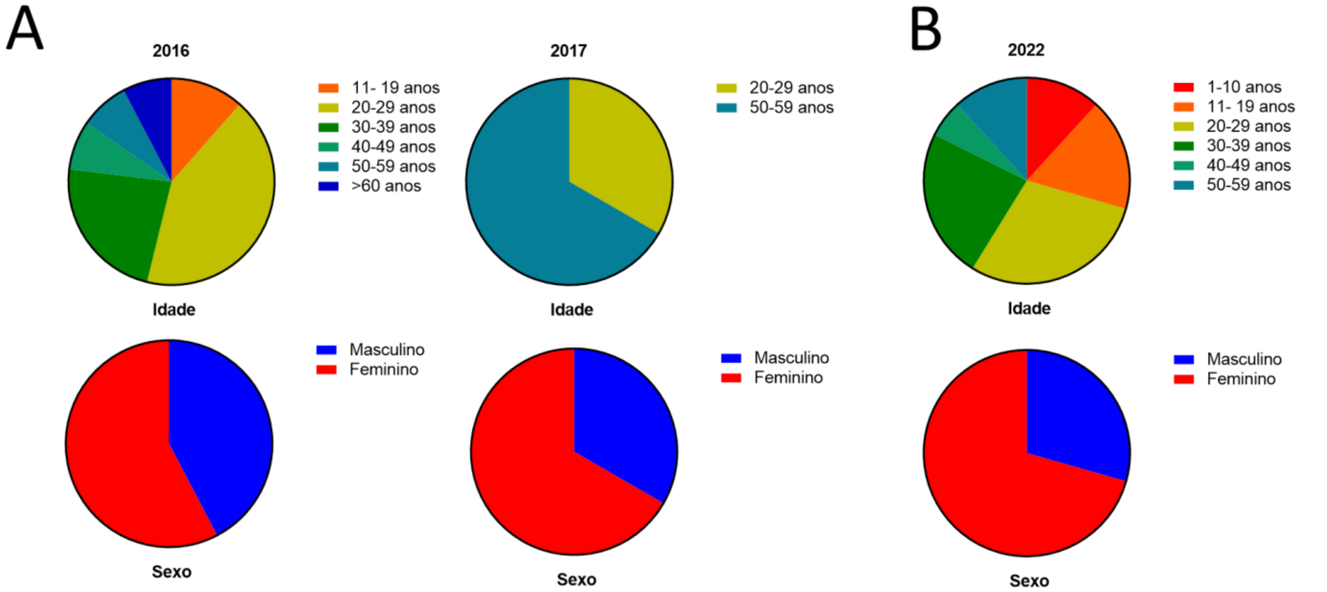
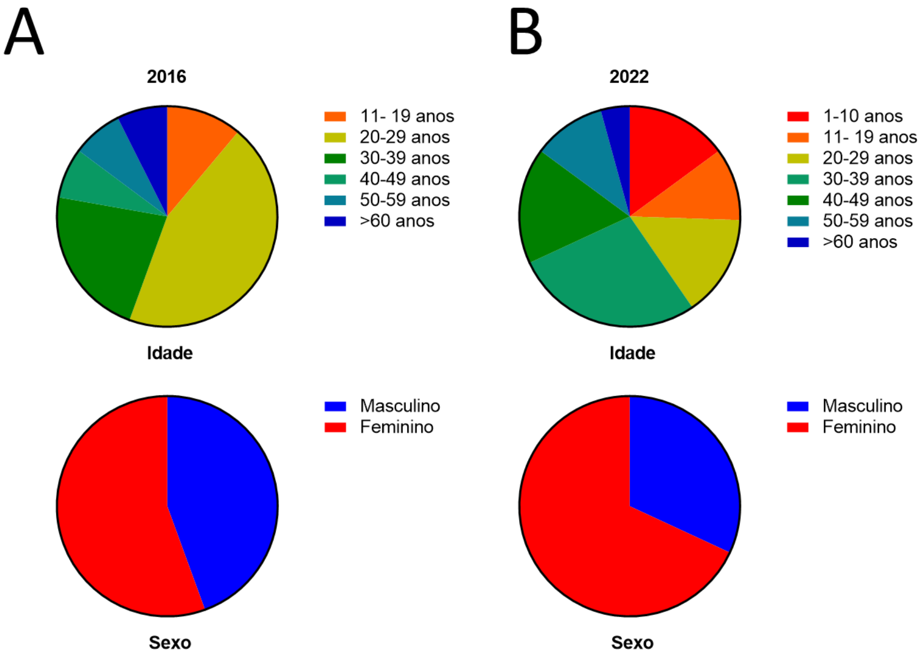


Figure 3. Graphical representation of the distribution of *P. mirabilis* infection cases stratified by age group, sex and evaluation period. Caption. A. Pre-pandemic period. B. Intra-pandemic period. C. Post-pandemic period.



Other uroculture studies carried out in the Middle East, in Saudi Arabia, during the intra-pandemic period, have shown that Klebsiella pneumoniae is highly resistant to aminoglycosides. Tobramycin, which in our study was highly sensitive in the intra-pandemic phase, and all the other data presented in the study carried out in Saudi

Arabia agree with the study we carried out, as far as resistance is concerned. In South America, particularly in Brazil, studies carried out on pregnant women showed that the E. coli strain was highly resistant to cephalothin, ampicillin and ampicillin/sulbactam (56%) on average. This drug has shown great resistance, most likely due to indiscriminate use in the community or hospital environment. On average, they were resistant in our study (75%) [18-20].

Although many studies point to penicillin and tobramycin as being very resistant, in fact studies carried out by [21], in the post-pandemic phase, have shown great sensitivity to these drugs and high rates of resistance to gentamicin and quinolones. In other studies, carried out in South America, the most frequent microorganisms were *Escherichia coli*, followed by *Klebsiella pneumoniae*. *E. coli* showed high sensitivity to betalactams (carbapenems) and aminoglycosides and high resistance to ceftriaxone, ampicillin/sulbactam [22-23]. However, studies carried out by us did not use carbapenems, but aminoglycosides in the study phase showed high resistance, probably due to the indiscriminate use of this class of drugs in COVID-19. On the other hand, despite ceftriaxone being a third-generation drug, *Klebsiella pneumoniae* showed high resistance rates, in agreement with this study and with studies by [22].

Antimicrobial resistance profiles have in some cases converged with regard to betalactams, with high sensitivities to cephalosporins and second and third generation quinolones. According to [24], in Colombia, uroculture studies were carried out before and during the COVID-19 pandemic, using different types of drugs such as ceftriaxone, cefepime, piperacillin/tazobactam, meropenem, ciprofloxacin and vancomycin [25]. It was found that during the pandemic phase, resistance to the drugs under study decreased (*Klebsiella pneumoniae*, producer of extended-spectrum beta-lactamase [ESBL], 32% pre-pandemic to 24% post-pandemic; *K. pneumoniae*, resistant to carbapenems, from 4% to a differential of 2%; *Pseudomonas aeruginosa*, resistant to carbapenems, from 12% to 8%; *Acinetobacter baumann*, resistant to carbapenems, from 12% to 8%); *Pneumoniae*, resistant to carbapenems, from 4% to a differential of 2%; *Pseudomonas aeruginosa*, resistant to carbapenems, from 12% to 8%; *Acinetobacter baumannii*, resistant to carbapenems, 23% to 9%), while *Enteroccus faecium* increased its resistance to vancomycin from (42% to 57%). When *S. aureus* was analyzed, there were no changes in the methicillin resistance rate, [24]. Studies carried out in Peru have shown high rates of resistance to ampicillin, cephalothin and nitrofurantoin at a rate of 72.6%, 82.3% and 88.7%, respectively.

4. Conclusion

After carrying out the study and analysing the different study periods, we concluded that in all study periods the female sex was the most prevalent and the most frequently isolated strain was E. coli followed by proteus vulgaris and mirabilis and the age groups were 20-29 and 30-39 years respectively. In the pre-pandemic period, the most sensitive drugs recommended for the treatment of urinary infections were amikacin, fosfomycin, norfloxacin, nalidixic acid, tobramycin, akanamycin and cefotaxime. In the intra-pandemic period, the most sensitive antimicrobials were ciprofloxacin, norfloxacin, kanamycin and tobramycin. In the post-pandemic period, in addition to norfloxacin and kanamycin, gentamicin was also very sensitive.

In the African context, and particularly in Angola, in order to reduce the high rates of resistance to antimicrobials, it is necessary to create therapeutic protocols, to advise users against self-medication and to take stricter measures against pharmacies that sell drugs to users without a prescription. In addition, basic sanitation associated with the storage, treatment and quality of drinking water, especially in the most vulnerable populations, could be an important element in mitigating this situation, since this social group is capable of self-medicating in situations of physiological distress.

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