Research Article

Trend of Bacterial Uropathogens and Their Susceptibility Pattern: Study of Single Academic High-Volume Center in Italy (2015–2019)

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Urinary tract infections (UTIs) are a very widespread infection that can occur in disparate age range, in both sexes and in pregnancy/menopause state. Treatment of UTIs is difficult due to the emergence of antibiotic-resistant bacterial strains. The present study shows five years of data collected on patients admitted at the University Hospital "San Giovanni di Dio e Ruggi d’Aragona" in Salerno, Italy. The investigation exhibits the incidence of the infection, of the gender, and of the age group affected, identifying the most representative bacteria involved, drawing their profile of antimicrobial resistance. Bacterial identification and antibiotic susceptibility testing were performed using the VITEK 2 system. Among the 46382 studied patients, 9896 (21.34%) and 36486 (78.66%) were positive and negative for microorganism growth, respectively. Of 9896 positive patients, 6158 (62.23%) females and 3738 (37.77%) males were identified. The highest incidence of positive subjects (56.66%) was recorded in the elderly (>61 years). 8431 (85.20%) uropathogens were Gram-negative, 1367 (13.81%) were Gram-positive, and 98 (0.99%) were Candida species (Candida spp.). Escherichia coli (E. coli) and Enterococcus faecalis (E. faecalis) were the most representative Gram-negative and Gram-positive strains, respectively. The Gram-negative bacteria most representative were highly resistant to ampicillin, whereas among the Gram-positive bacteria, E. faecalis was highly resistant to gentamicin and streptomycin high level synergy, and Enterococcus faecium (E. faecium) to ampicillin, ampicillin/sublactam, and imipenem. This retrospective work investigates the local epidemiological trend in our university hospital in order to induce an increasingly targeted empirical therapeutic approach for the treatment of UTIs.

1. Introduction

Urinary tract infections (UTIs) represent widespread human microbial disorders involving any part of the urinary tract, such as the kidneys, bladder, urethra, and prostate [1]. UTIs are spread all over the world with a broad direct and indirect socioeconomic impact in the global population. Furthermore, these infections are associated with an important
2. Materials and Methods

2.1. Sample Collection. In the last five years (between January 2015 and December 2019) a total of 46382 urinary samples were collected from patients admitted to the University Hospital “San Giovanni di Dio e Ruggi d’Aragona.” In particular, midstream specimens of urine (MSU) were consigned to microbiological laboratory and processed as described below.

2.2. Inclusion and Exclusion Criteria. The samples tested met the following inclusion criteria: (i) patients aged 0 to 99; (ii) clinical evidence of one or more symptoms of UTI, such as dysuria, frequency, hesitation, urgency, and pain, was recorded in patients included in the analysis; and (iii) bacterial count value must be greater than equal to of 10^5 CFU/mL in the urine at mid flow to be deemed culture positive. Exclusion criteria were as follows: (i) patients with urinary catheter were excluded by the analysis; and (ii) bacterial count less than 10^5 CFU/mL was evaluated culture negative in medium flow urine.

2.3. Bacterial Culture. The samples were sown using the automated plating system ALFRED60 (Alifax) in accordance with the manufacturer’s recommendations on CHROMID® CPS® Elite plate (BioMerieux Corporation, France) and incubated for 24 hours at 37°C. If the growth of two or more bacterial species was observed, the samples were regarded as contaminated (exclusion criteria). Urinary cultures were negative if the number of colony forming units per mL (CFU/mL) was less than 10^4 (exclusion criteria). Bacteriuria was defined by the number greater than 10^5 CFU/mL and by a monomorphic growth (inclusion criteria). In this instance, bacterial identification and antimicrobial sensitivity test were executed.

2.4. Bacterial Identification and Antibiotic Susceptibility Test. After each plate examination, bacterial identification and antimicrobial susceptibility test were performed via technology Vitek 2 (BioMe’rieux, France), following the manufacturer’s recommendations. The results of antimicrobial susceptibility were interpreted as “susceptible,” “resistant,” or “intermediate” according to EUCAST guidelines and obtained after 16 h of incubation. In particular, the antimicrobial molecules examined in this study were amikacin, ampicillin, ampicillin/sulbactam, amoxicillin/clavulanic acid, cefepime, cefotaxime, ceftriaxone, ciprofloxacin, ertapenem, fosfomycin c/G6P, gentamicin and gentamicin high level synergy, imipenem, levofloxacin, linezolid, meropenem nitrofurantoin, norfloxacin, piperacillin/tazobactam, streptomycin high level synergy, ticarcycline, teicoplanin, trimethoprim/sulfamethoxazole, and vancomycin, in accordance with the typology of bacteria analysed. Antibiotics were selected in agreement with EUCAST guidelines.

2.5. Data Analysis. Data analysis was performed using IBM Statistical Package for Social Sciences Version 22.00 (IBM SPSS Inc., USA). The significance of the antibiotics resistance trend during the five years was analysed using the chi framework (http://www.spss.com). p values < 0.05 were considered statistically significant.
2.6. Ethical Consideration Statement. Ethics approval from the Human Research Ethics Committee was not required for this study. Our study exploited laboratory management data, collected from databases. This represents a retrospective study and is not directly associated with patients.

2.7. Limitations. Although our exposed data are very precious in a context where information on antimicrobial resistance of UTIs strains is limited, some limitations should be considered. First, our study was limited to a single clinical service. Prospective studies involving multiple hospitals are needed to establish criteria for treatment options to be extended beyond our hospitals. Second, although basic patients’ demographics and clinical signs are commonly available, other important information such as clinical details, hospitalization period, treatment received, and clinical outcomes is often unavailable.

3. Results

3.1. Incidence and Gender/Age Group Distribution of UTIs in Urinary Specimens. A total of 46382 urine samples were examined. Patients between the ages of 1 and 99 and of both genders were included in the study. UTI diagnosis was based on the patient’s clinical symptomatology, as well as on the presence of leukocytes and bacteria in the urine samples investigated. Of 46382 samples, 9896 (21.34%) were positive for growth of pathogenic strains, while 36486 (78.66%) were negative; the incidence of samples positive and/or negative for growth of pathogenic strains, while 36486 (78.66%) were negative; the incidence of samples positive and/or negative for every year and in the total five years of analysis is reported (Table 1).

Among the total positive pathogenic isolates, the Gram-positives were 1367 (13.81%), while the Gram-negatives were the most representative with 8431 (85.20%) isolated strains, and 98 (0.99%) were *Candida* species. Data were analysed in order to investigate the incidence of UTI for gender (Table 2). Female gender was more exposed to the infection with 6158 (62.23%) positive cultures, while 3738 (37.77%) were the male positive cultures (Table 2).

Analysis of age infection distribution showed that the major incidence was recorded in the elderly (>61 years) (56.6%), followed by late adulthood (46–60 years) (18.25%), young adults (19–45 years) (15.79%), infants (<1 year) (7.04%), early childhood (2–5 years) (0.91%), late childhood (6–12 years) (0.75%), and adolescents (13–18 years) (0.60%) (Table 3). The female to male ratio was higher in the age group 19–45 years (F/M = 3), while it was lower in the age group <1 year (F/M = 0.73).

The positive patients were admitted to the department of High-Risk Pregnancy and Prenatal Diagnosis, Urology, Paediatrics, Neonatology, Nephrology, Infectious Disease, Kidney Transplant Center, Obstetrician, Gynaecology, General Medicine Women, Neurology, Gastroenterology, Emergency Medicine, and others. Bacterial species were isolated and identified by 9896 positive cultures. Analysing the Gram-positive bacteria incidence (13.81%), our data reported that *Enterococcus faecalis* (*E. faecalis*) was the most representative isolated bacterium (9.68%). Lower percentages of incidence resulted for *Enterococcus faecium* (*E. faecium*) (1.97%), *Streptococcus agalactiae* (*S. agalactiae*) (0.71%), *Staphylococcus aureus* (*S. aureus*) (0.62%), *Staphylococcus coagulase negative* (CoNS) (0.58%), *Enterococcus spp.* (0.23%), and *Streptococcus spp.* (0.03%) (Figure 1(a)). The highest percentage of isolated bacteria belonged to Gram-negative bacteria (85.20%). In particular, *E. coli* resulted to be the most frequently isolated bacterium (48.89%), followed by *Klebsiella pneumoniae* (*K. pneumoniae*) (14.85%), *Proteus mirabilis* (*P. mirabilis*) (5.73%), *Enterobacter species* (*E. aerogenes*) (3.54%), *Pseudomonas aeruginosa* (*P. aeruginosa*) (2.99%), *Citrobacter spp.* (2.83%), *Acinetobacter spp.* (1.86%), *Klebsiella oxytoca* (*K. oxytoca*) (1.23%), *Morganella morganii* (*M. morganii*) (1.14%), and *Providencia spp.* (0.64%). Very low % was observed for *Serratia spp.* (0.30%), *Pseudomonas spp.* (0.25%), *Klebsiella spp.* (0.20%), and *Proteus spp.* (0.19%), and we called all other species that we identify in very low abundance “others” (*Achromobacter spp.*, *Aeromonas spp.*, *Burkholderia gladioli*, *Cedecea spp.*, *Edwardsiella tarda*, *Escherichia vulneris*, *Hafnia alvei*, *Kleuyvera intermedia*, *Moellerella wisconsinnsis*, *Moraxella spp.*, *Pasteurella pneumotropica*, *Raoultella spp.*, *Salmonella spp.*, *Shigella dysenteriae*, *Sphingomonas paucimobilis*, *Stenotrophomonas maltophilia*, and *Yersinia pseudotuberculosis*) with a % of 0.55 (Figure 1(b)).

On the other hand, Figure 2 shows the incidence variation of the most representative Gram-positive and Gram-negative uropathogens found during the analysed five years. The prevalence of each UTIs strain remained approximately constant through time. *E. coli* is the dominant effective agent in our hospital over the period studied. A significant trend in *E. coli* (p value = 0.039) and *P. mirabilis* (p value = 0.047) was detected.

3.2. Uropathogens’ Antimicrobial Resistance Profile. In addition to the main bacteria representative identification among the total positive urine samples, the present study

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**Table 1:** Number of urinary specimens analysed by the year.

<table>
<thead>
<tr>
<th>Years</th>
<th>Samples</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive (N.)</td>
<td>1417</td>
<td>1828</td>
<td>1918</td>
<td>2227</td>
<td>2506</td>
<td>9896</td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>16.27</td>
<td>21.32</td>
<td>22.20</td>
<td>21.77</td>
<td>24.50</td>
<td>21.34</td>
<td></td>
</tr>
<tr>
<td>Negative (N.)</td>
<td>7293</td>
<td>6745</td>
<td>6722</td>
<td>8005</td>
<td>7721</td>
<td>36486</td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>83.73</td>
<td>78.68</td>
<td>77.80</td>
<td>78.23</td>
<td>75.50</td>
<td>78.66</td>
<td></td>
</tr>
<tr>
<td>Total (N.)</td>
<td>8710</td>
<td>8573</td>
<td>8640</td>
<td>10232</td>
<td>10227</td>
<td>46382</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2:** Percentage of Gram-positive and Gram-negative bacteria and *Candida* spp. isolated in urine specimens collected in the period 2015–2019.

<table>
<thead>
<tr>
<th>Microorganisms isolated</th>
<th>n. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram-positive bacteria</td>
<td>1367 (13.81)</td>
</tr>
<tr>
<td>Gram-negative bacteria</td>
<td>8431 (85.20)</td>
</tr>
<tr>
<td><em>Candida</em> spp.</td>
<td>98 (0.99)</td>
</tr>
<tr>
<td>Gender</td>
<td>n. (%)</td>
</tr>
<tr>
<td>Female</td>
<td>6158 (62.23)</td>
</tr>
<tr>
<td>Male</td>
<td>3738 (37.7)</td>
</tr>
</tbody>
</table>
exhibits their relative antimicrobial resistance profile too. In particular, the most representative Gram-positive (E. faecium and E. faecalis) and Gram-negative (K. pneumoniae, E. coli, and P. mirabilis) antimicrobial resistance profile is reported in Figures 3 and 4, respectively. The data commented in the text below refer to the percentages of the total five years, indicated as 2015–2019 in the Supplementary Tables (S1–S5). Among the Gram-positive identified bacteria in urine samples, E. faecium turned out to be the most resistant strain against several antibiotics, such as ampicillin, ampicillin/sulbactam, imipenem, and levofloxacin (86.08%, 83.60%, 86.15%, and 83.16%, respectively). Very low % of resistance was found against linezolid (0.52%), tigecycline (0.55%), and vancomycin (2.58%). Total resistance to ampicillin was steadily high, ranging between 71.43% and 93.33% throughout the study period (p value = 0.03). Resistance to gentamicin decreased from 66.67% to 48.57% between 2015 and 2016, increased up to 80% in 2018, and finally decreased to 33.33% in 2019 (p value = 0.03). The levels of resistance to streptomycin were almost constant over the study period (64.83%), and a decrease of up to 53.45% in 2017 was observed (p value = 0.045) (Figure 3(a)).

E. faecalis, the first Gram-positive in order of abundance, seems to be very responsive to several antibiotics such as ampicillin/sulbactam, with a 0.22% of resistance, linezolid and tigecycline (1.16%), imipenem (1.68%), teicoplanin (1.88%), ampicillin (1.99%), and vancomycin (2.73%). E. faecalis resistance for the antibiotics gentamicin high level synergy, levofloxacin, and streptomycin high level synergy showed a middle value (51.10%, 40.24%, and 37.37%, respectively). An increase in ampicillin (p value = 0.03), tigecycline (p value = 0.02), and imipenem (p value = 0.04) resistance of up to 5.14%, 3.32%, and 3.29% was observed over the years, respectively. Resistance levels to ampicillin/sulbactam were constant over the years investigated (p value = 0.0005). Resistance to streptomycin showed a significant decrease from 40.52% in 2015 to 25.53% in 2019. Levofloxacin resistance level increased from 35.26% to 52.41% between 2015 and 2016 and decreased up to 29.47% in 2019 (p value = 0.003). Resistance to gentamicin showed an increase from 54.25% to 59.04% between 2015 and 2016, a decrease up to 43.09% in 2018, and an increase to 52.17% in 2019 (p value = 0.004) (Figure 3(b)).

With regard to Gram-negative, K. pneumoniae showed a profile of high resistance for several antibiotics. In particular, the highest percentage (98.99%) resulted for ampicillin, followed by a percentage of about 50% for amoxicillin/clavulanic acid, cefotaxime, ceftazidime, ciprofloxacin, norfloxacin, and trimethoprim/sulfamethoxazole (51.5%, 53.96%, 49.79%, 52.95%, 54.40%, and 50.83 %, respectively). Lower strength rates were found for use of cefepime, ertapenem, fosfomycin c/C6P, gentamicin, imipenem, meropenem, and piperacillin/tazobactam (36.74%, 30.47%, 34.82%, 15.39%, 21.39%, and 40.45%, respectively). The lowest percentage of resistance was recorded for amikacin, with a resistance of 10.35%. Resistance level to amikacin was almost constant over the time (12.7%), and a decrease of up to 3.24% in 2018 was observed (p value = 0.02). The resistance rates to ampicillin (98.83%) and imipenem (15.64%) were constant throughout the study period (p value = 0.02). Resistance to amoxicillin increased from 46.07% to 66.76% between 2015 and 2018 and decreased up to 35.26% in 2019 (p value = 0.01). An increase in ampicillin resistance from 33.15% to 39.75% between 2015 and 2016, a decrease up to 32.23% in 2018, and an increase up to 46.36% were observed (p value = 0.03). The resistance to piperacillin was constant over time, ranging between 35.92% and 47.7% (p value = 0.002) (Figure 4(a)). E. coli showed high resistance for ampicillin (69.00%). Furthermore, this strain showed a 21% higher resistance rate to norfloxacin, ciprofloxacin, trimethoprim/sulfamethoxazole, amoxicillin/clavulanic acid, ceftaxime, and ceftazidime. For cefepime and gentamicin, lower percentages than the above were found (19.28% and 19.33%). E. coli showed the lowest % of resistance for amikacin (0.36%), ertapenem (4.69%), fosfomycin c/C6P (5.62%), nitrofurantoin (3.66%), meropenem (1.36%), and piperacillin/tazobactam (10.22%). The rates of resistance to amikacin (p value = 0.03), norfloxacin (p value = 0.003), gentamicin (p value = 0.047), ciprofloxacin (p value = 0.03), ceftazidime (p value = 0.04), cefotaxime (p value = 0.04), cefepime (p value = 0.005), and ampicillin (p value = 0.0005) were constant over time (Figure 4(b)). P. mirabilis, the third strain for percentage of incidence, resulted very sensitive for meropenem, amikacin, piperacillin/tazobactam, ertapenem, and cefepime with a resistance of 1.06%, 2.22%, 4.99%, 5.14%, and 5.29% respectively. An intermediate value of resistance about 20% to 60% was observed for amoxicillin/clavulanic acid, ampicillin, cefotaxime, ceftazidime, ciprofloxacin, fosfomycin c/C6P, gentamicin, norfloxacin, and trimethoprim/sulfamethoxazole (18.94%, 62.12%, 40.46%, 37.68%, 51.06%, 41.87%, 24.51%, 50.73%, and 54.58%, respectively). A significant decline in fosfomycin resistance from 52.94% to 33.6% was detected over the study period (p value = 0.02). The levels of resistance to meropenem (p value = 0.04), ciprofloxacin (p value = 0.05), and cefepime (p value = 0.02) were stable over time. A significant reduction in resistance rates to cefotaxime from 47.06% to 33.6% (p value = 0.05) and ceftazidime from 44.7% to 27.8% (p value = 0.05) was detected. In contrast, a significant increase in amoxicillin resistance from 0% to 21.8% was observed (p value = 0.03). Ampicillin resistance ranged from 48.39% to 68.61% throughout the study period (p value = 0.05) (Figure 4(c)).
**Figure 1:** Prevalence of Gram-positive (a) and Gram-negative (b) on the total microorganisms isolated from urine culture samples. "Others" represent genera or species less representative, thus they were merged.

**Figure 2:** Trend incidence of the most representative Gram-positive and Gram-negative uropathogens isolated from urine samples during the analysed five years.
4. Discussion

The present paper shows data collected about patients of all ages and both sexes admitted at the University Hospital “San Giovanni di Dio e Ruggi d’Aragona” in Salerno, Italy, from January 2015 to December 2019. Analysis of our findings showed that 21.34% resulted positive for microorganism’s growth. Opposite results were found in Bushenyi District in Uganda (32.2%) and at National Hospital Abuja in Nigeria (13.1%) [15, 22]. The largest number of positive patients belonged to the female gender (62.23%). Their high predisposition to contract infection is due to their genital anatomy [10]. As regards age groups, highest prevalence was found in the elderly group (56.6%), due to several factor,

<table>
<thead>
<tr>
<th>Year</th>
<th>Ampicillin</th>
<th>Ampicillin/sulbactam</th>
<th>Gentamicin</th>
<th>Imipenem</th>
<th>Levofloxacin</th>
<th>Linezolid</th>
<th>Streptomycin</th>
<th>Teicoplanin</th>
<th>Tigecycline</th>
<th>Vancomycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>93.33%</td>
<td>93.33%</td>
<td>66.67%</td>
<td>93.33%</td>
<td>81.25%</td>
<td>0.00%</td>
<td>66.67%</td>
<td>12.50%</td>
<td>0.00%</td>
<td>12.50%</td>
</tr>
<tr>
<td>2016</td>
<td>71.43%</td>
<td>71.43%</td>
<td>48.57%</td>
<td>75.00%</td>
<td>74.29%</td>
<td>0.00%</td>
<td>65.71%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2017</td>
<td>91.80%</td>
<td>89.66%</td>
<td>63.79%</td>
<td>93.44%</td>
<td>91.38%</td>
<td>0.00%</td>
<td>53.45%</td>
<td>3.28%</td>
<td>0.00%</td>
<td>3.33%</td>
</tr>
<tr>
<td>2018</td>
<td>92.73%</td>
<td>88.89%</td>
<td>80.00%</td>
<td>89.09%</td>
<td>81.48%</td>
<td>1.82%</td>
<td>62.96%</td>
<td>3.64%</td>
<td>1.85%</td>
<td>1.85%</td>
</tr>
<tr>
<td>2019</td>
<td>75.00%</td>
<td>70.37%</td>
<td>33.33%</td>
<td>75.00%</td>
<td>81.48%</td>
<td>0.00%</td>
<td>64.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Ampicillin</th>
<th>Ampicillin/sulbactam</th>
<th>Gentamicin</th>
<th>Imipenem</th>
<th>Levofloxacin</th>
<th>Linezolid</th>
<th>Streptomycin</th>
<th>Teicoplanin</th>
<th>Tigecycline</th>
<th>Vancomycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>0.00%</td>
<td>0.00%</td>
<td>54.25%</td>
<td>0.65%</td>
<td>35.26%</td>
<td>0.00%</td>
<td>40.52%</td>
<td>1.28%</td>
<td>0.00%</td>
<td>3.87%</td>
</tr>
<tr>
<td>2016</td>
<td>0.00%</td>
<td>0.00%</td>
<td>59.04%</td>
<td>0.59%</td>
<td>52.41%</td>
<td>0.61%</td>
<td>46.39%</td>
<td>1.78%</td>
<td>0.00%</td>
<td>2.96%</td>
</tr>
<tr>
<td>2017</td>
<td>0.92%</td>
<td>0.49%</td>
<td>49.25%</td>
<td>0.92%</td>
<td>46.31%</td>
<td>1.38%</td>
<td>40.59%</td>
<td>1.39%</td>
<td>0.47%</td>
<td>1.85%</td>
</tr>
<tr>
<td>2018</td>
<td>2.97%</td>
<td>0.00%</td>
<td>43.09%</td>
<td>2.48%</td>
<td>38.02%</td>
<td>1.98%</td>
<td>35.26%</td>
<td>1.48%</td>
<td>1.48%</td>
<td>1.49%</td>
</tr>
<tr>
<td>2019</td>
<td>5.14%</td>
<td>0.53%</td>
<td>52.17%</td>
<td>3.29%</td>
<td>29.47%</td>
<td>1.40%</td>
<td>25.53%</td>
<td>3.32%</td>
<td>3.32%</td>
<td>3.79%</td>
</tr>
</tbody>
</table>

Figure 3: Antimicrobial susceptibility pattern of the most representative Gram-positive bacteria. The percentage of antibiotic resistance of (a) Enterococcus faecium and (b) Enterococcus faecalis is reported for each year investigated in the study. Gentamicin and streptomycin are both used as “high level synergy.”
Figure 4: Continued.
such as urinary tract abnormalities, disability, decreased immune response, and prostate disorders in men and hormonal changes in women [10, 23, 24]. Among detected UTI strains, 13.81% were Gram-positive, 85.20% were Gram-negative and 0.99% were Gram-positive Gram-negative strains were resistant to ampicillin [27]. Lower resistance from 52.94% to 33.60% was found in study period. A percentage of resistance from 40.52% to 25.53%. Similar data were obtained from a study conducted at University of Campania “Luigi Vanvitelli” in Italy [10]. Comparable results were observed from a study conducted in India by Bharti et al. They reported a 92% higher sensitivity rate to linezolid, vancomycin, and teicoplanin [26]. Concerning Gram-negative bacterial strains, K. pneumonia was identified as the most resistant uropathogen. This strain reported a 96% higher resistance rate to ampicillin. Its inappropriate use represents a plausible cause of the high ampicillin resistance rate over time. A percentage of resistance of less than 30% was found for amikacin, imipenem, ertapenem, and meropenem. Strains of E. coli also showed low resistance to carbapenems and amikacin. The prevalence of ESBL (extended spectrum beta lactamase) for E. coli and K. pneumonia strains was monitored. During the studied period, a total of 3206 E. coli were detected, including 30.75% which showed the ESBL phenotype. Comparable data were obtained for K. pneumonia, where 35.43% were ESBLs (data not shown). The 3rd most frequently isolated Gram-negative bacteria were P. mirabilis. This strain showed a high resistance versus ampicillin, ciprofloxacin, norfloxacin, and trimethoprim/sulfamethoxazole. The lowest resistance resulted for the antibiotics amikacin cefepime, ertapenem, meropenem, and piperacillin/tazobactam. An important reduction of fosfomycin resistance from 52.94% to 33.6% was found in study period. The most represented Gram-negative bacteria exhibited a high rate of resistance to ampicillin, according to the Campania region antibiotic-resistant report. Comparable results were reported in Ethiopia, where 78% of Gram-negative strains were resistant to ampicillin [27].

![Figure 4: Antimicrobial susceptibility pattern of the most representative Gram-positive bacteria. The percentage of antibiotic resistance of (a) Klebsiella pneumoniae, (b) Escherichia coli, and (c) Proteus mirabilis is reported for each year investigated in the study. Abbreviations: c/G6P = clavulanic acid; Cefo = cefotaxime; Cefta = ceftazidime; Cipro = ciprofloxacin; Erta = ertapenem; Genta = gentamicin; Norf = norfloxacin; Pip./Taz. = piperacillin/tazobactam; Trim./Sulf. = trimetoprim/sulfamethoxazole.](image-url)
ampicillin resistance rates were observed in India (R > 35%) [28]. Our data demonstrated that carbapenems could be used for the treatment of infections caused by Gram-negative strains. Studies conducted in our region reported that resistance to carbapenem drugs was the lowest compared to other antibiotics. Otherwise, linezolid and glycopeptides may be the appropriate treatments for Gram-positive strains, in accordance with our regional reports [29]. Aware of the problem of antimicrobial resistance in hospital settings, our study will influence the choice of empirical therapy for UTIs.

5. Conclusions

The antimicrobial susceptibility profiles of the strains most represented in the cases of UTIs have focused attention on the poor control and management of UTIs. We suggest that the choice of empirical antibiotic therapy should be based on knowledge of the localized epidemiological trend. This study reports information on the current situation in our university hospital, in order to establish guidelines for the correct use of antibiotics.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Enrica Serretiello and Veronica Folliero contributed equally to this work.

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Supplementary Materials

Supplementary Table 1: antimicrobial susceptibility pattern of Escherichia faecium. Supplementary Table 2: antimicrobial susceptibility pattern of Escherichia faecalis. Supplementary Table 3: antimicrobial susceptibility pattern of Klebsiella pneumoniae. Supplementary Table 4: antimicrobial susceptibility pattern of Proteus mirabilis. (Supplementary Materials)

References


