Enterococcus Species in Urinary Tract Infections: A Comprehensive Review of Epidemiology, Pathogenicity, and Antimicrobial Resistance Trends in Clinical Practice

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ABSTRACT

Enterococcus species have emerged as significant pathogens in urinary tract infections (UTIs), particularly in hospitalized patients, elderly individuals, pregnant women, diabetics, and those with long-term catheterization. Over the last two decades, Enterococcus faecalis and Enterococcus faecium have demonstrated increasing antimicrobial resistance, including high-level aminoglycoside resistance (HLAR) and vancomycin-resistant Enterococci (VRE), posing major therapeutic challenges. This comprehensive review synthesizes global evidence on prevalence, virulence factors, risk groups, diagnostic methods, and antimicrobial susceptibility patterns of Enterococcus species associated with UTIs. Literature from 1995–2024 was analysed using PubMed, Scopus, Google Scholar, and Web of Science. Findings indicate that Enterococcus faecalis remains the predominant species, although E. faecium is increasingly isolated and exhibits higher drug resistance rates. Resistance to ampicillin, fluoroquinolones, and aminoglycosides is rising, while susceptibility to linezolid, teicoplanin, and daptomycin generally remains high. The review highlights the global burden, clinical relevance, and therapeutic challenges posed by multidrug-resistant Enterococcus species. Significant variation exists across regions due to differences in antimicrobial practices and hospital infection control policies. Strengthening diagnostic accuracy, antibiotic stewardship, and infection prevention strategies is essential to combat the increasing prevalence of drug-resistant Enterococcus-associated UTIs.

Keywords: Enterococcus faecalis; Enterococcus faecium; urinary tract infection, antimicrobial resistance; vancomycin-resistant Enterococci, HLAR, prevalence, antibiotic sensitivity, hospital-acquired infections.

INTRODUCTION

Urinary tract infection (UTI) is one of the most common bacterial infections encountered in hospital and community settings, affecting nearly 150–250 million individuals globally each year and contributing significantly to morbidity across all age groups [1]. Although Escherichia coli remains the predominant causative organism of UTIs worldwide,

Enterococcus species have emerged as important pathogens, particularly in complicated, recurrent, and healthcare-associated infections [2,3]. Enterococci, especially Enterococcus faecalis and Enterococcus faecium, account for 5–20% of all urinary isolates in many regions and are now recognized for their increasing antimicrobial resistance, which complicates clinical management [4,5].

Enterococci are Gram-positive, facultative anaerobic cocci that normally inhabit the gastrointestinal tract, but can colonize the genitourinary tract, wounds, and the bloodstream under favourable conditions [6]. Their ability to survive harsh environments—including high salt levels, low pH, detergents, and many disinfectants—gives them a unique advantage in causing healthcare-associated infections [7]. The increasing prevalence of Enterococcal UTIs has been attributed to the growing population of immunocompromised individuals, widespread use of broad-spectrum antibiotics, prolonged catheterization, and invasive urological procedures [8,9].

Enterococcus species possess a broad repertoire of virulence factors, including aggregation substances, cytolysin, biofilm-forming capability, pheromone-responsive plasmids, gelatinase, and surface adhesins that facilitate colonization, immune evasion, and persistent infection [10,11]. Their ability to form biofilms on urinary catheters allows chronic colonization and resistance to host immune mechanisms and antibiotics, which increases treatment failure and enhances the risk of recurrence [12,13].

A major concern in recent years has been the increasing antimicrobial resistance among Enterococcus species. Resistance to penicillin, ampicillin, aminoglycosides, fluoroquinolones, and even glycopeptides like vancomycin has been documented worldwide [14,15]. High-level aminoglycoside resistance (HLAR), mediated by aminoglycoside-modifying enzymes, results in loss of synergism between β-lactams and aminoglycosides, which were traditionally the cornerstone of therapy [16]. The emergence of vancomycin-resistant Enterococci (VRE) is an alarming global public health threat, as VRE infections are associated with prolonged hospitalization, limited therapeutic options, increased treatment costs, and high mortality [17–19].

The epidemiology of Enterococcal UTIs varies by geographical region. Several studies from Asia, Africa, and Europe have reported increasing isolation rates of Enterococcus species in UTIs, particularly among elderly patients, diabetics, pregnant women, ICU patients, and those with urinary catheters [20–23]. In India, Enterococcus isolation rates from UTIs range between 6–18%, with E. faecalis being the dominant species, followed by E. faecium, which shows significantly higher drug resistance [24–26].

Accurate species identification and antimicrobial susceptibility testing are crucial for effective management, especially

in regions with rising multidrug-resistant Enterococci. Automated diagnostic platforms (VITEK-2, MALDI-TOF MS), molecular detection systems (PCR), and updated CLSI/EUCAST guidelines have significantly improved detection rates and reduced diagnostic delays [27–29].

Given the therapeutic challenges posed by resistant Enterococcal strains, understanding their epidemiology, antimicrobial resistance trends, risk factors, and virulence properties is essential. This review compiles global data on Enterococcal UTIs, summarizes antimicrobial sensitivity profiles, and discusses the clinical implications of emerging resistance patterns.

MATERIAL AND METHODS

This is a narrative review, not an original study.

Search Strategy

A comprehensive literature search was conducted using:

1. PubMed
2. Scopus
3. Google Scholar
4. Web of Science

Keywords: “Enterococcus”, “urinary tract infection”, “E. faecalis”, “E. faecium”, “antimicrobial resistance”, “VRE”, “HLAR”, “biofilm-forming Enterococcus”.

Inclusion

1. Studies from 1995–2025
2. English language
3. Studies describing epidemiology, risk factors, virulence factors, antibiotic sensitivity, and resistance patterns of Enterococcus in UTIs.

Exclusion

1. Case reports
2. Non-urinary Enterococcal infections
3. Animal studies unless mechanistic relevance was present.

Data Extraction

Data were extracted on:

- Prevalence patterns
- Species distribution
- Antibiotic susceptibility
- Resistance mechanisms
- Global comparisons

RESULTS

1. Species Distribution

- E. faecalis: 60–80% globally
- E. faecium: 15–35% but increasingly isolated
- Rare species: E. durans, E. gallinarum, E. casseliflavus

2. Risk Groups

- Elderly
- Diabetic patients
- Pregnant females
- ICU patients
- Catheterized patients
- Post-urologic procedures

3. Antibiotic Resistance Trends

- High resistance to ciprofloxacin: 35–90%
- High resistance to ampicillin: 30–70%
- HLAR prevalence: 20–55%
- VRE prevalence: 5–30% depending on region
- Good susceptibility to:
- linezolid
- daptomycin
- teicoplanin

4. Biofilm Formation

- Present in 40–80% of isolates
- Strongly associated with catheter-associated UTIs

DISCUSSION

Enterococcus Species Causing Urinary Tract Infections: Comparative Analysis With Global Evidence

Enterococcus species have gained enormous clinical importance as causative agents of UTIs over the past three decades, primarily because of their increasing prevalence, multidrug resistance, and ability to cause persistent and recurrent infections. Although traditionally considered low-virulence organisms, their epidemiology has changed drastically due to selective antibiotic pressure, widespread device usage, and rising comorbidities in the population [31].

1. GLOBAL EPIDEMIOLOGY AND CHANGING PREVALENCE TRENDS

Many studies worldwide have documented a noticeable increase in Enterococcal UTIs, particularly in healthcare-associated settings. In the United States, Hidron et al. reported that Enterococcus species constitute the third most common cause of nosocomial UTIs, accounting for nearly 15% of all catheter-associated infections [32]. Similarly, in Europe, Wagenlehner et al. demonstrated that Enterococci were isolated in over 10% of complicated UTIs, with E. faecalis being the predominant species [33].

Studies from Asian countries reveal even higher prevalence. In a large Indian study by Kothari & Sagar, Enterococcus accounted for 6–8% of urinary isolates, and rates were significantly higher in ICU and catheterized patients [24]. Another multi-centre study from South India by Praharaj et al. reported 9.8% prevalence, emphasizing the rise of E. faecium in tertiary-care hospitals [34].

African studies also show rising trends—Masika et al. found that Enterococci represented 11% of UTI isolates in Kenya, with substantial drug resistance levels [35].

These variations clearly indicate that Enterococcal UTIs are increasingly being recognized as major contributors to morbidity, particularly among vulnerable populations.

2. SPECIES DISTRIBUTION AND CLINICAL SIGNIFICANCE

Virtually all published studies agree that E. faecalis remains the dominant species, although E. faecium is rapidly increasing, especially in hospital settings. For instance, Fisher & Phillips observed E. faecalis in 75% of Enterococcal UTIs, with E. faecium contributing to 22% [36]. In India, Desai et al. found E. faecalis in 68% of isolates and E. faecium in 30% [37].

Importantly, E. faecium exhibits markedly higher drug resistance, especially to β-lactams and glycopeptides. Arias and Murray have highlighted that E. faecium has undergone significant adaptive evolution in hospital environments, making it a "perfect nosocomial pathogen" [38].

This difference in resistance pattern has substantial therapeutic implications since infections caused by E. faecium often require advanced antimicrobials such as linezolid or daptomycin.

3. RISK FACTORS COMPARISON WITH OTHER STUDIES

Most authors agree that Enterococcal UTIs occur predominantly in individuals with predisposing factors. Several studies, including those by Fisher et al. and Klein et al., have identified the following consistent risk factors:

- Advanced age
- Diabetes mellitus
- Indwelling urinary catheter
- Structural abnormalities
- Previous antibiotic exposure
- Hospitalization or ICU stay
- Pregnancy [39,40]

A study from Chandigarh, India (Biswas et al.) found Enterococcal infections to be significantly associated with long-term catheterization (>72 hours) and prior fluoroquinolone therapy, both of which promote colonization and biofilm formation [41].

In diabetic patients, high urinary glucose levels facilitate pathogen growth. Shrestha et al. demonstrated that Enterococcal UTI incidence was 2.8-fold higher in diabetics than non-diabetics [42].

Pregnancy is also a notable risk group. A study found Enterococcus species in 11% of antenatal urine samples, highlighting obstetric relevance [43].

4. VIRULENCE FACTORS & BIOFILM FORMATION: COMPARISON WITH OTHER AUTHORS

Biofilm formation is central to the pathogenicity of Enterococci in UTIs. Mohamed & Abd El-Malek found that 72% of Enterococcus isolates from catheterized patients were strong biofilm producers [44]. Biofilm formation enhances antimicrobial resistance and results in chronic or recurrent infections.

Other studies have reported:

Gelatinase production (34–50%)

Cytolysin activity (10–30%)

Aggregation substances contributing to adhesion to uroepithelium

Esp (Enterococcal surface protein) gene associated with persistence

Shankar et al. demonstrated that the Esp gene is significantly more common in UTI isolates (54%) compared to non-UTI isolates (22%), reinforcing its virulence role [45].

Studies from India (Sood & Malhotra) confirm similar findings, indicating strong

biofilm production in catheter-associated cases [46].

5. ANTIMICROBIAL RESISTANCE PATTERNS: GLOBAL COMPARISON

5.1 Penicillin & Ampicillin Resistance

Resistance to β-lactams is widely reported.

Karmarkar et al. documented ampicillin resistance in 48% of E. faecium isolates [47].

In China, Sun et al. reported 55% resistance to ampicillin among Enterococcal isolates causing UTIs [48].

5.2 Fluoroquinolone Resistance

Fluoroquinolone resistance is extremely high in Asia.
Mehta et al. found 78% resistance to ciprofloxacin in India [49].
An Iranian study (Sharifi et al.) reported 82% resistance to levofloxacin [50].

5.3 High-Level Aminoglycoside Resistance (HLAR)

HLAR is among the most concerning trends:

Praharaj et al. (India): 42% HLAR [34]

Karmarkar et al.: 55% HLAR [47]

Babapour et al. (Iran): 49% HLAR [51]

HLAR eliminates synergistic therapy, significantly complicating management.

5.4 Vancomycin-Resistant Enterococci (VRE)

The emergence of VRE is a major global health threat.

CDC reports VRE prevalence in US hospitals at 15–20% [52].

Europe: 10–12% (Werner et al.) [53].

India: 2–12% depending on region (Rao et al.) [54].

VRE strains carry vanA or vanB genes, leading to high-level resistance.

5.5 Susceptibility to Linezolid, Teicoplanin, and Daptomycin

Most studies show preserved susceptibility:

Linezolid susceptibility: 96–100% (Patel et al.) [55]

Daptomycin efficacy retained in >95% isolates (Miller et al.) [56]

Hence, these remain the drugs of choice for resistant Enterococcal UTIs.

6. REGIONAL VARIATIONS IN INDIA

Multiple Indian studies consistently show rising resistance patterns:

Study	Ampicillin R	Ciprofloxacin R	HLAR	VRE
Praharaj et al. (South India) [34]	42%	78%	41%	5%
Desai et al. (Gujarat) [37]	52%	74%	46%	7%
Karmarkar et al. (Mumbai) [47]	48%	80%	55%	6%

This indicates an alarming pattern that mirrors global reports but is more severe in South Asian countries due to antibiotic misuse, poor sanitation, and limited infection-control policies.

7. COMPARISON OF BIOFILM & RESISTANCE PATTERNS

Several authors have shown strong associations between biofilm-forming isolates and multidrug resistance.

Mohamed et al. reported 82% resistance to ciprofloxacin in biofilm-producers vs. 38% in non-producers [44].
Rahman et al. found HLAR in 61% of biofilm-producing strains [57].

These findings highlight that biofilm-forming Enterococci are more difficult to eradicate, especially in catheterized patients.

8. SIGNIFICANCE IN SPECIAL POPULATIONS

8.1 Elderly

UTI prevalence increases sharply with age. Reports confirmed Enterococci in up to 20% of nursing-home residents with UTIs [58].

8.2 Pregnant Women

Enterococcal bacteriuria may cause complications such as preterm labor or pyelonephritis. In a Ugandan study, Enterococcus was isolated in 13% of antenatal samples (Nabbugodi et al.) [59].

8.3 Diabetics

There are reports that 3-fold higher risk of Enterococcal UTI in diabetics [60].

8.4 Catheterized Patients

Most authors report 3–6 times higher prevalence in catheterized patients due to biofilm formation [61].

9. DIAGNOSTIC ADVANCES: COMPARISON OF STUDIES

Automated methods have drastically improved Enterococcus identification.
VITEK-2 showed 98% accuracy in species identification [62].
MALDI-TOF MS has become the gold standard, with accuracy of 99.8% [63].
Molecular methods also allow detection of resistance genes such as vanA, vanB, aac(6')-Ie-aph(2"), esp, and gelE.

10. TREATMENT IMPLICATIONS: SYNTHESIS OF LITERATURE

All major studies agree that:

Uncomplicated UTI caused by E. faecalis can still respond to ampicillin or nitrofurantoin (if susceptible).
Complicated UTI or resistant strains require linezolid, teicoplanin, or daptomycin.
Treatment of VRE infections remains challenging and may require combination regimens.
Studies by another author stress that antibiotic stewardship and infection control are key to preventing VRE spread [38].

11. PUBLIC HEALTH IMPORTANCE

Several authors emphasize that Enterococcus is now considered:

- A WHO priority pathogen
- A major cause of healthcare-associated infection
- A significant reservoir for resistance genes transmissible to other bacteria
- Thus, continuous surveillance is critical (WHO) [64,65].

CONCLUSION

Enterococcus species—particularly *E. faecalis* and *E. faecium*—have emerged as major pathogens responsible for UTIs, especially in hospitalized, catheterized, diabetic, and elderly populations. Global literature consistently demonstrates rising antimicrobial resistance, including HLAR and VRE, which severely limit treatment options. Biofilm formation significantly enhances pathogenicity and resistance.
This comprehensive review highlights substantial regional variability in resistance patterns, with particularly high resistance in South Asia. Strengthening laboratory capacity, infection control practices, and antibiotic stewardship policies is essential to limit the spread of multidrug-resistant Enterococci.

Limitations of This Review

- Being a narrative review, it may not include every regional study.
- Some older studies had variable diagnostic methodologies.
- Antimicrobial resistance patterns change rapidly; new data may evolve.
- Lack of uniformity in susceptibility testing methods across studies.

DECLARATIONS:

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