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Impact of community-acquired invasive *Escherichia coli* disease on mortality and readmissions in elderly patients: a multi-center study in Germany

Fruzsina Kosa[1*], Olaf Radunz[2], Jeroen Geurtsen[3], Michal Sarnecki[4], Julia Krieger[5], Fränce Hardtstock[5], Thomas Wilke[6], Thomas Schilling[7], Matthias Oelke[8,9], Hansjürgen Piechota[10], Eberhard Schneider[11], Ute Rohr[12], Christoph Fisser[13], Mustapha Addali[14], Jennifer Kranz[15,16], Konrad Schmidt[17,18,19,20] and Florian Wagenlehner[21]

Abstract

Background Extraintestinal pathogenic *Escherichia coli* (ExPEC) causes invasive *E. coli* disease (IED), resulting in significant morbidity and mortality, particularly among the elderly. IED can present as bacteremia or sepsis and poses serious health risks for adults aged ≥ 60 years, compounded by increasing antimicrobial resistance. However, real-world data on IED's clinical burden and risk factors in Europe are sparse. This study systematically reviews medical charts across 11 hospitals in Germany to address this gap by evaluating the impact of IED on patient outcomes, mortality rates, and hospital readmission within the elderly cohort.

Through rigorous clinician review of all related medical records, we ensured accurate identification of patients with community-acquired, microbiologically confirmed, mono-infections due to E. coli. The results of this investigation not only confirm previous reports of elevated mortality rates associated with IED but also contribute essential epidemiological insights into the management of these serious infections among older adults.

Methods A retrospective medical chart review was conducted using data from 11 hospitals across Germany (January 2016–February 2020). Eligible IED cases were identified using separate criteria: patients with microbiologically confirmed *E. coli* in the blood or another sterile body site, and patients with *E. coli* identified in the urine that suffered from sepsis. Results were stratified by the absence or presence of antimicrobial resistance. Regression models were used to assess case fatality and readmission rates.

Results Among 134 IED cases, 107 (79.9%) were culture-confirmed bacteremic IED and 67 (50.0%) were antimicrobial resistant. Median age was 79 years. Fourteen (10.4%) patients died during index hospitalization and 41 (35.7%) were readmitted within 12 months. Almost 80% of patients showed a SOFA score increase of ≥2 points, and 9.0% suffered from septic shock. Bacteremic patients had higher readmission rates (35.8% versus 28.0%), and longer hospital stays

*Correspondence:
Fruzsina Kosa
fkosa@ITS.JNJ.com

Full list of author information is available at the end of the article

(mean 13.1 days). Patients with AMR infections were admitted with significantly worse SOFA scores (3.5 versus 2.9; p=.048).

Conclusions These findings confirm IED poses a substantial burden among older patients in Germany, which is consistent with other published studies. The high fatality and readmission rates highlight the need for novel and effective IED intervention strategies.

Keywords Invasive escherichia coli disease, Elderly patients, Community-acquired infections, Antimicrobial resistance, Mortality rates, Hospital readmissions, Sepsis

Introduction

Extraintestinal pathogenic *Escherichia coli* (ExPEC) causes severe infections like urinary tract infections (UTI), sepsis, or pneumonia [1, 2]. Invasive *E. coli* disease (IED) is an acute illness defined by the presence of *E. coli* in the blood, sterile body sites, or urine of septic patients without other identifiable infection sources [1]. IED poses a significant risk to adults age ≥ 60 years, where bacteremia and sepsis are leading causes of death [3], particularly with increasing antimicrobial resistance (AMR) [4]. Most IED cases are community-acquired [5].

Real-world evidence on IED's clinical burden in Europe remains limited, partly due to inconsistent coding, complicating the retrospective identification of sepsis and pathogen-specific instructions [6, 7], as seen in the OPTIMISE study [8] in Germany.

This study uses a clinical case definition (CCD) to identify culture-confirmed bacteremic and non-bacteremic IED cases through a medical chart review (MCR) in Germany, evaluating disease burden and predictors of IED clinical outcomes.

Methods

Data sources

We conducted a retrospective MCR using data from 11 hospitals throughout 7 German states. Eligible hospitals had inpatient services, laboratory access, and ≥ 500 beds. An electronic case report form (eCRF) documented clinical characteristics, hospitalization parameters (length of stay, treatments, interventions, healthcare resource utilization [HCRU]), and outcomes (readmissions and death) of patients with community-acquired IED.

Participating sites identified IED cases between 1 January 2016, and 28 February 2020, excluding COVID-19 cases. Two subgroups were included: (1) patients diagnosed with *E. coli* bacteremia (maximized in the 15 most recent cases per hospital); and (2) any patient with non-bacteremic *E. coli* urosepsis.

Inclusion criteria

Patients with microbiologically confirmed *E.coli* mono infection, aged ≥ 60 years at hospitalization, and a complete hospitalization record (ending in discharge or death) were included. Community-acquired infection meant the first *E.coli*-positive sample was drawn within 48 h of admission; otherwise, the infection was considered nosocomial, and these patients were excluded.

Clinical case definition (CCD)

Bacteremic IED was defined by a positive *E. coli* culture from the blood or any other sterile site (e.g., cerebrospinal fluid, pleural fluid) with patients meeting ≥ 1 of the Systemic Inflammatory Response Syndrome Criteria [9]. Non-bacteremic IED required a positive urine culture (≥ 10^5 CFU/mL) and UTI symptoms where the urinary tract was the only infection source, with a sequential organ failure assessment (SOFA) score increase of ≥ 2 points from admission, or two-thirds quick SOFA (qSOFA) criteria if ≥ 3 SOFA elements were missing [9].

Antimicrobial resistance definition

Antimicrobial resistance was defined according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) standards regarding minimum inhibitory concentration (MIC) breakpoints [10]. Multidrug resistance was defined as resistance to ≥ 3 antibiotic classes [11].

Data analysis

Outcomes were analyzed using descriptive statistics. Procedures were recorded using operation and procedure keys (OPS), and sepsis/septic shock were defined per the third international consensus [12]. We compared culture-confirmed bacteremic versus non-bacteremic cases and antimicrobial resistant versus non-antimicrobial resistant IED, using Mann-Whitney U or Fisher exact tests. Predictive models included patient characteristics (age, sex, body mass index [BMI], Charlson Comorbidity Index [CCI] score), clinical characteristics (SOFA score, septic shock, renal replacement therapy) and hospitalization parameters (origin, intensive care unit [ICU] admission). Length of stay, ICU admission, and readmission factors were analyzed in multivariable regressions, and case fatality in bivariate logistic regressions.

Data were anonymized and collected retrospectively; informed consent was not required. Ethical approval was obtained from the ethics committees of Justus Liebig University Giessen, Aachen, Thuringia, Westfalen-Lippe,

Magdeburg University Hospital A.ö.R, Ruhr University Bochum, and Hesse. There was no pre-defined sample size calculation, as the study was exploratory and focused on the retrospective identification of clinically confirmed invasive *Escherichia coli* disease (IED).

Results

Patients

Across 11 study sites from 7 German states (Supplementary Results, Figure S1), 134 IED cases meeting the CCD definition were identified (Fig.1).

Abbreviations: CCD, clinical case definition; IED, invasive *E. coli* disease; n, number of patients.

Of these, 107 (79.9%) cases were culture-confirmed bacteremic IED and 27 (20.1%) were non-bacteremic. Antimicrobial resistance was found in 67 (50.0%) cases, of which 11 (8.2%) and 5 (3.7%), respectively, were resistant to 3rd and 4th/5th generation cephalosporines, 6 (9.0%) to ciprofloxacin, and 5 (7.5%) to moxifloxacin (Supplementary Results, Table **S1**). The median patient age was 79 years, with 53.0% male (Table 1). Mean CCI score was 2.8, higher in culture-confirmed bacteremic cases (3.1 versus 1.9; $P = 0.078$). Approximately half (48.5%) of patients lived in assisted living facilities before admission. In total, 119 (88.8%) IED cases had an ICD-10 code for *E. coli* infection and/or sepsis. The most frequently classified diagnoses were A41.51, sepsis due to *E. coli* (38.1%) and N39.0, site unspecific UTIs (11.9%).

Case fatality

The case fatality rate during index hospitalization was 10.4% (Table 2). Post-hospitalization mortality data available for 91/120 discharged patients, showing 8 (8.8%) deaths within 12 months.

The risk of death increased by 74% with each SOFA score point increase (Odds ratio [OR]: 1.74; $P < 0.001$; Supplementary Results, Table S2). Higher CCI scores (OR: 1.20; $P = 0.037$), renal replacement therapy (OR: 6.46; $P = 0.008$), ICU admission (OR: 3.67; $P = 0.025$), and septic shock (OR: 6.00; $P = 0.011$) significantly increased mortality risk during hospitalization.

Index hospitalizations

Unplanned emergency admissions accounted for 91.8% of hospitalizations (Table 3). Patients were admitted to general wards (46.3%), emergency departments (32.1%) or the ICU (20.9%). Intensive care was required for 29.8% of patients, with 48.8% staying ≥ 1 week. The risk of ICU admission increased with BMI (OR: 1.04; $P = 0.024$) and

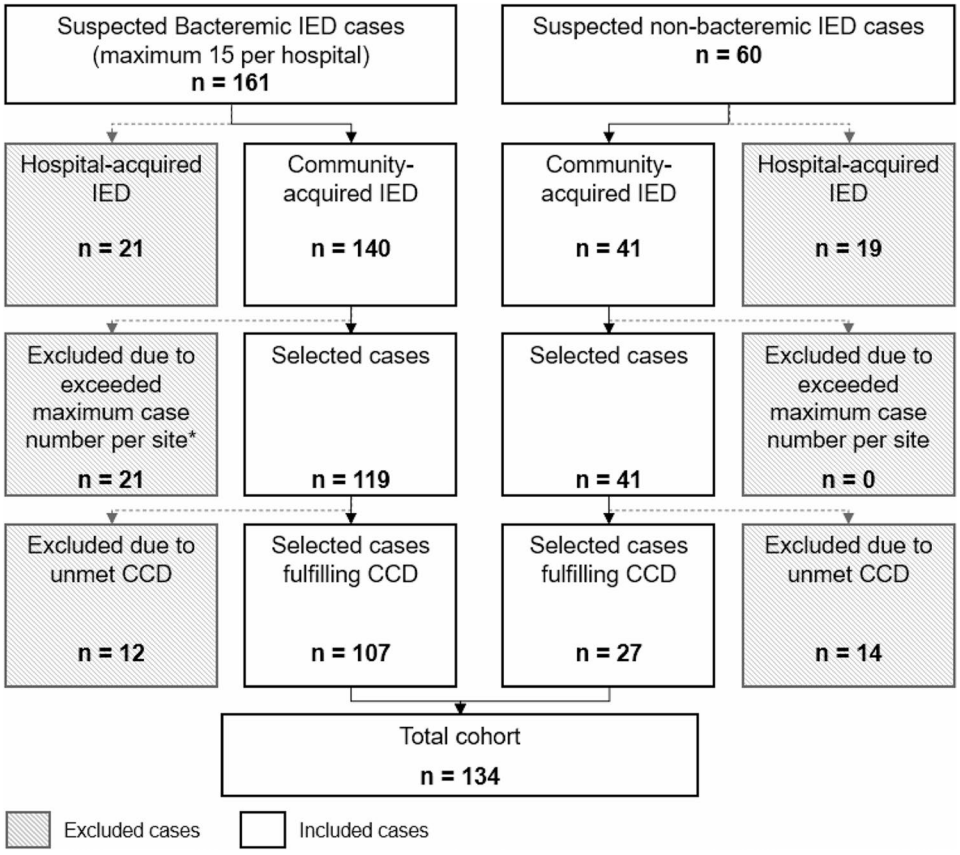

Fig. 1 Patient selection from suspected IED cases

Table 1 Characteristics of included patients

		Total Cohort (*N* = 134)	Bacteremic IED Cohort[a] (*N* = 107)	Non-bacteremic IED Cohort[b] (*N* = 27)	*P* value	AMR (*N* = 67)	No AMR (*N* = 67)	*P* value
Sex	Females N (%)	63 (47.01)	48 (44.86)	15 (55.56)	0.390	31 (46.27)	32 (47.76)	1.000
	Males N (%)	71 (52.99)	59 (55.14)	12 (44.44)		36 (53.73)	35 (52.24)	
Age	Mean (SD)	77.98 (8.52)	78.36 (8.44)	76.50 (8.67)	0.382	77.29 (8.70)	78.45 (8.27)	0.277
	Median (Min-Max)	79 (60–95)	79 (60–95)	77 (60–90)		78 (60–95)	80 (61–95)	
CCI	Mean (SD)	2.84 (2.73)	3.07 (2.91)	1.89 (1.58)	0.078	2.87 (2.47)	2.81 (2.99)	0.425
Living situation at admission								
Full autonomy	N (%)	26 (19.40)	21 (19.63)	5 (18.52)	0.280	17 (25.37)	9 (13.43)	0.227
Home care	N (%)	23 (17.16)	15 (14.02)	8 (29.63)		13 (19.40)	10 (14.93)	
Assisted living facilities	N (%)	65 (48.51)	55 (51.40)	10 (37.04)		29 (43.28)	36 (53.73)	
Unknown	N (%)	20 (14.93)	16 (14.95)	4 (14.81)		8 (11.94)	12 (17.91)	

[a]With positive blood culture. [b]Without positive blood culture.

Abbreviations: *AMR* antimicrobial resistance, *CCI* Charlson comorbidity index, *IED* invasive *E. coli* disease, *Min* minimum, *Max* maximum, *N* number of patients, *SD* standard deviation

Table 2 Fatality among patients

	Total Cohort	Bacteremic IED Cohort[a]	Non-bacteremic IED Cohort[b]	*P* value	AMR	No AMR	*P* value
	(*N* = 134)	(*N* = 107)	(*N* = 27)		(*N* = 67)	(*N* = 67)	
Death during index hospitalization							
Yes – N (%)	14 (10.45)	12 (11.21)	2 (7.41)	0.733	7 (10.45)	7 (10.45)	1.000
No – N (%)	120 (89.55)	95 (88.79)	25 (92.59)		60 (89.55)	60 (89.55)	
Death after discharge from index hospitalization [c]	91	77	14		47	44	
3 months – N (%)	2 (2.20)	1 (1.30)	1 (7.14)	0.285	0 (0.00)	2 (4.55)	0.231
6 months – N (%)	3 (3.30)	2 (2.60)	1 (7.14)	0.398	0 (0.00)	3 (6.82)	0.109
9 months – N (%)	7 (7.69)	5 (6.49)	2 (14.29)	0.293	2 (4.26)	5 (11.36)	0.257
12 months – N (%)	8 (8.79)	6 (7.79)	2 (14.29)	0.356	3 (6.38)	5 (11.36)	0.476

[a]With positive blood culture, [b]Without positive blood culture, [c]For 29 patients, the fatality status was "unknown"

Abbreviations: *AMR* antimicrobial resistance, *IED* invasive *E. coli* disease, *N* number of patients

Table 3 Characteristics of index hospitalization

		Total Cohort (*N* = 134)	Bacteremic IED Cohort[a] (*N* = 107)	Non-bacteremic IED Cohort[b] (*N* = 27)	*P* value	AMR (*N* = 67)	No AMR (*N* = 67)	*P* value
Origin of hospitalization								
Planned admission	N (%)	3 (2.24)	3 (2.80)	0 (0)	0.853	3 (4.48)	0 (0)	0.131
Readmission	N (%)	1 (0.75)	1 (0.93)	0 (0)		0 (0)	1 (1.49)	
Transfer	N (%)	7 (5.22)	5 (4.67)	2 (7.41)		55 (82.09)	51 (76.12)	
Emergency	N (%)	123 (91.79)	98 (91.59)	25 (92.59)		59 (88.06)	64 (95.52)	
Others	N (%)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	
≥ 2 of 3 qSOFA criteria fulfilled	N (%)	73 (54.48)	64 (59.81)	9 (33.33)	0.012	5 (7.46)	2 (2.99)	1.000
Intensive care received	N (%)	40 (29.85)	30 (28.04)	10 (37.04)	0.358	24 (35.82)	16 (23.88)	0.186
Length of hospitalization (in days)	Mean (SD)	13.07 (11.37)	13.65 (12.04)	10.74 (7.99)	0.170	14.21 (11.55)	11.93 (11.16)	0.196
	Median (Min-Max)	9 (1–77)	10 (1–77)	8 (1–32)		10 (1–68)	9 (1–68)	

[a]With positive blood culture. [b]Without positive blood culture.

Abbreviations: *AMR* antimicrobial resistance, *IED* invasive *E. coli* disease, *Min* minimum, *Max* maximum, *N* number of patients, *qSOFA* quick sequential organ failure assessment, *SD* standard deviation

Table 4 Cumulative readmissions to the same hospital within 3, 6, 9, and 12 months after discharge

		Total Cohort *N* = 120[a]	Bacteremic IED Cohort[b] *N* = 95[a]	Non-bacteremic IED Cohort[c] *N* = 25[a]	*P* value	AMR Cohort *N* = 60[a]	Non-AMR Cohort *N* = 60[a]	*P* value
Same hospital readmission								
3 months	N (%)	22 (18.33)	15 (15.79)	7 (28.00)	0.597	9 (15.00)	13 (21.67)	0.485
6 months	N (%)	28 (23.33)	21 (22.11)	7 (28.00)	0.636	12 (20.00)	16 (26.67)	0.524
9 months	N (%)	32 (26.67)	25 (26.32)	7 (28.00)	1.000	14 (23.33)	18 (30.00)	0.544
12 months	N (%)	41 (34.17)	34 (35.79)	7 (28.00)	0.636	20 (33.33)	21 (35.00)	1.000

[a]Analyses of readmissions were performed on 120 patients who survived index hospitalization, including all those readmitted for calculating days to first readmission). [b]With positive blood culture. [c]Without positive blood culture

Abbreviations: *AMR* antimicrobial resistance, *IED* invasive *E. coli* disease, *N* number of patients

Table 5 Clinical characteristics recorded during the index hospitalization

		Total Cohort	Bacteremic IED Cohort[a]	Non-bacteremic IED Cohort[b]	*P* value	AMR	No AMR	*P* value
		(*N* = 134)	(*N* = 107)	(*N* = 27)		(*N* = 67)	(*N* = 67)	
SOFA score [c]								
Average first SOFA score	Mean (SD)	3.21 (2.43)	3.23 (2.44)	3.11 (2.41)	0.695	3.48 (2.21)	2.94 (2.62)	0.048
Average worst SOFA score	Mean (SD)	3.96 (3.15)	4.09 (3.24)	3.41 (2.79)	0.277	4.30 (3.01)	3.61 (3.28)	0.070
Acute increase ≥ 2 points	N (%)	106 (79.10)	84 (78.50)	22 (81.48)	1.000	55 (82.09)	51 (76.12)	0.524
≥ 2/3 qSOFA criteria fulfilled	N (%)	73 (54.48)	64 (59.81)	9 (33.33)	0.012	37 (55.22)	36 (53.73)	1.000
Septic shock suffered [d]	N (%)	12 (8.96)	8 (7.48)	4 (14.81)	0.260	7 (10.45)	5 (7.46)	0.560
Detection of ≥ 1 multidrug resistant pathogen	N (%)	13 (9.70)	10 (9.35)	3 (11.11)	0.725	13 (9.70)	0 (0)	< 0.001

[a]With positive blood culture; [b]Without positive blood culture; [c]More information on SOFA score inSupplementary Results, Table S7 and Table S8. The total SOFA score sums 0–4 points per organ system (missing elements = 0); [d]Septic shock was identified by vasopressor use to maintain mean arterial pressure of ≥ 65 mmHg and serum lactate level > 2 mmol/L (> 18 mg/dL [12]. Status was "unknown" for 3.73% of patients

Abbreviations: *AMR* antimicrobial resistance, *IED* invasive *E. coli* disease, *N* number of patients, *qSOFA* quick sequential organ failure assessment, *SOFA* sequential organ failure assessment, *SD* standard deviation

SOFA score (OR: 1.47; $P = 0.004$) (Supplementary Results, Table S3).

The median hospital stay was 9 days (range: 1–77). Length of stay increased with BMI (+ 0.18 days per point; $p = 0.010$), intensive care (+ 9.47 days; $p < 0.001$), and renal replacement therapy (+ 12.49 days; $p < 0.001$), and decreased with higher SOFA scores (–1.73 days per point; $p < 0.001$) (Supplementary Results, Table S4).

Hospital readmissions

Same-hospital readmissions of 120 discharged patients were subsequently analyzed (Table 4). The CCI score was significantly associated with readmission risk (OR: 1.25, $P = 0.013$; Supplementary Results, Table S5).

Among 41 patients readmitted within 12 months, median time to readmission was 79 days (range: 1–362). Non-bacteremic IED patients were readmitted sooner than bacteremic IED patients (13 versus 122 days; $P = 0.005$). Due to small sample sizes, analysis of readmission reasons (e.g., sepsis, *E. coli* infection) lacked statistical significance. Common primary diagnoses for readmissions are in Supplementary Results, Table S6.

SOFA and qSOFA scores

Most patients (85.8%) had ≥ 4/6 SOFA elements available for assessment. The mean first SOFA score during the hospitalization was 3.2. Multidrug resistant IED patients had significantly higher first SOFA scores than susceptible cases (3.5 versus 2.9; $p = 0.048$). An acute SOFA increase of ≥ 2 points, indicating sepsis, occurred in 79.1% of patients, with septic shock in 9.0% (Table 5). Males accounted for 90.1% of sepsis patients. Over half (54.5%) fulfilled ≥ 2 qSOFA criteria, more common in bacteremic IED patients (59.8% versus 33.3%, $P = 0.012$).

Multidrug resistant ied cases

Multidrug resistance was observed in 13 (9.7%) patients (Table 5**).** Of 50 IED isolates tested for susceptibility, 48 were penicillin-resistant (35.8%), with a numerically higher rate in bacteremic IED patients (37.4% versus 29.6%, $P = 0.508$). Fourteen (10.4%) patients were resistant to second-generation cephalosporine, with a numerically lower rate in bacteremic IED patients (9.3% versus 14.8%, $P = 0.480$).

Healthcare resource utilization

During their index hospitalization, 72 (53.7%) patients were treated by urologists, 46 (34.3%) by intensive care specialists, and 42 (31.3%) by gastroenterologists (**Supplementary Results**, **Table S9**). Life support measures during hospitalization was required for 31 (23.1%) patients, more frequently in antimicrobial-resistant IED patients (31.3% versus 14.9%, $P = 0.039$). Invasive mechanical ventilation was the most common measure (20.2%), and 11 (8.2%) patients received renal replacement therapy during index hospitalization. All patients received medications during the index stay, with 95.5% receiving antibiotics.

Discussion

This study is the first to reliably use laboratory data to identify IED patients and report real-world clinical characteristics, care, readmissions and mortality rates of older patients with community-acquired IED in German hospitals.

The findings show that ICD-10-GM codes are insufficient for identifying unspecified sepsis or *E. coli* infections [13]: 11.2% of patients with confirmed IED were not classified using relevant codes, potentially due insufficient financial incentives for accurate coding [14]. Among patients with septic shock, 72.7% and 63.6% had sepsis-related ICD-10 or DRG codes recorded, respectively. In sepsis cases (with a ≥ 2 SOFA score increase), 75.5% had sepsis-related ICD-10 codes, and 44.9% DRG codes. A more sensitive approach using qSOFA could have identified 80.9% and 54.5% of patients with ICD-10 or DRG codes, respectively.

Bacteremic IED patients showed increased severity, with longer hospital stays, higher in-hospital deaths and more than 12-month readmissions compared to IED patients without a positive blood culture. Bacteremia caused by cephalosporin-resistant bacteria has been linked to hospital readmissions [15], and *E. coli* has been associated with severe sepsis and septic shock readmissions [16]. Culture-confirmed bacteremic IED patients were more likely to be admitted from assisted living facilities, leading to hospitalization at earlier stages of disease [17]. Studies have shown that nursing home residents are hospitalized more often [18, 19], consistent with this study's findings that ~ 50% of patients were in assisted living facilities before admission, and over 90% were admitted through the emergency department.

Half of the study population had IED resistant to ≥ 1 antimicrobial agent, with ~ 10% resistant to ≥ 3 antibiotic groups. Multidrug-resistant IED patients were more likely to require life support, had longer hospital stays, and exhibited a trend of increased septic shock risk. The European Centre for Disease Prevention and Control similarly reported that 54.0% of invasive *E. coli* isolates in Europe were resistance to ≥ 1 antimicrobial group, with 6.8% demonstrating MDR [20]. Poolman et al. [2] also noted rising antibiotic resistance in *E. coli*, often causing treatment failure in IED patients.

The 10.4% case fatality rate during index hospitalization aligns with previous studies, showing 9.5% in *E. coli* bloodstream infections [21] and 4.3% in *E. coli*-related UTIs [22]. Increased SOFA scores correlated with shorter hospital stays, and higher fatality rates. Increased CCI scores, renal replacement therapy, ICU admission, and septic shock were significant predictors of case fatality. A multi-country study also linked older age, male sex, MDR, and hospital-acquired *E. coli* with increased risk of 30-day mortality [23]. In another European study, healthcare-associated infections and high CCI scores were associated with in-hospital fatality [21]. Complicated UTIs have been linked to higher fatality rates, especially in older, bedridden patients, and those with septic shock or on mechanical ventilation [24].

Overall, 80% of IED patients had a SOFA score increase of ≥ 2 points, meeting the sepsis-3 definition [9]. These patients were more likely to be admitted to the ICU, aligning with a Dutch study that found 71% of critically ill patients experienced septic shock on the day of the *E. coli* bloodstream infection [25]. Over half (54.5%) of the study population met ≥ 2 qSOFA criteria during hospitalization, an independent predictor of in-hospital death [26]. Culture-confirmed bacteremic IED patients were more likely to meet these criteria (59.8% versus 33.3%; $P = 0.012$).

Limitations

This study only included large hospitals (≥ 500 beds) and was geographically biased toward Western Germany. The sample size was limited to 134 patients; consequently, subgroup analyses and their statistical significance were also limited, highlighting the need for future studies with larger sample sizes to generate more definitive findings. Baseline characteristics were unbalanced, with 55.6% of non-bacteremic cases recorded from only two hospitals, which had a significantly higher proportion of patients admitted from assisted living facilities compared to the remaining nine hospitals (72.2% vs. 39.8%; $p = 0.001$). Furthermore, the method of obtaining urine samples (mid-stream or catheter urine) and the rate of indwelling urinary tract catheters were not available for this study.

The findings on community-acquired infections may not apply to hospital-acquired IED. Confirming nosocomial infections is challenging for patients living in assisted care facilities, despite physician verification. Data on outpatient care, post-hospitalization mortality, and readmissions to other hospitals were limited. Data completeness was also a challenge, as expected in MCRs. Missing SOFA elements likely led to an underestimation

of true SOFA scores. To enhance the reliability of our findings, complementary measures (e.g., qSOFA score) were included. Furthermore, recent discussions around lowering the bacterial count to define UTI [27, 28] are not reflected as they were not published at the time of study design.

Administrative data coding is often assumed accurate for specific conditions; however, less specific conditions are at higher risk of misclassification [29]. In this study, sepsis was defined using proxies before being reviewed by clinical experts and site investigators. This conservative approach may have led to an underestimation of the total number of eligible patients with IED without a positive blood culture.

Conclusions

IED is associated with a substantial clinical burden among patients ≥ 60 years of age, with severe cases often requiring ICU care. Half of the patients had antimicrobial-resistant *E. coli* infections, complicating treatment. Nearly 80% experienced a SOFA score increase of ≥ 2 points and in-hospital fatality exceeded 10%, highlighting the severity of IED. To reduce IED impact, optimized prevention strategies, such as broader ExPEC vaccine use for at-risk groups, and advances in detection methods, are essential.

Abbreviations

AMR	Antimicrobial Resistance
BMI	Body Mass Index
CCD	Clinical Case Definition
CCI	Charlson Comorbidity Index
COVID	Coronavirus Disease
DRG	Disease-Related Groups
eCRF	electronic case report form
ExPEC	Extraintestinal Pathogenic Escherichia coli Disease
HCRU	Healthcare Resource Utilization
ICD-10	International Classification of Diseases, Tenth Revision
ICU	Intensive care Unit
IED	Invasive Escherichia coli Disease
MCR	Medical Chart Review
MDR	Multidrug Resistance
OPS	Operation and Procedure Keys
OR	Odds Ratio
SD	Standard Deviation
SOFA/qSOFA	Sequential Organ Failure Assessment / quick Sequential Organ Failure Assessment
UTI	Urinary Tract Infection

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-025-11788-4.

Supplementary Material 1

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Authors' contributions

F. K., F. W., J. G., K. S., M. S. and O. R. designed the study and the protocol. J. K. and F. H. contributed to protocol development. T. S., M. O., H. P., E. S., U. R., C. F., M. A., and J. K. contributed to data provision. F. K. and J. K. conducted data analysis. F. K., J. G., K. S., J. K., F. H. collaborated on publication writing. J. G., M. S., T. W., T. S., M. O., H. P., E. S., U. R., C. F., M. A., J. K., K. S., and F. W. critically reviewed the manuscript drafts. All authors critically approved the final publication.

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Data availability

The data analyzed in present study are anonymized individual medical chart records from 11 hospitals and therefore not publicly available, but are available from the respective individual hospitals on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the ethics committees of Justus Liebig University Giessen, Aachen, Thuringia, Westfalen-Lippe, Magdeburg University Hospital A.ö.R, Ruhr University Bochum, and Hesse. The retrospectively analyzed data was anonymized, no informed consent was required.

Consent for publication

No individual person's data has been included in the study and in the publication.

Competing interests

F. K., J. G., M. S., O. R. are employees of Janssen. F. H. and J. K. are employees of Cytel, and the work of Cytel in this study was financed by Janssen. J. K. received honorarium for lectures from Janssen. F. W. participated in advisory boards for Janssen.

Author details

[1]Janssen-Cilag, Budapest, Hungary
[2]Janssen-Cilag, Berlin, Germany
[3]Bacterial Vaccines Discovery and Early Development, Janssen Vaccines and Prevention B.V, Leiden, Netherlands
[4]Janssen Research & Development, Janssen Vaccines, Bern, Switzerland
[5]Cytel, Berlin, Germany
[6]Institute for Pharmacoeconomics and Pharmaceutical Logistics, Wismar, Germany
[7]University Hospital for Anesthesiology and Intensive Care, Magdeburg, Germany
[8]St Antonius-Hospital Gronau, Gronau, Germany
[9]Kantonsspital Thurgau, Frauenfeld und Münsterlingen, Switzerland
[10]Mühlenkreis Kliniken, Clinic for Urology, Pediatric Urology and Surgical Uro-oncology, Minden, Germany
[11]GPR Klinikum Rüsselsheim, Rüsselsheim, Germany
[12]DRK Kliniken Berlin Köpenick, Berlin, Germany
[13]Department for Internal Medicine II, University Hospital Regensburg, Regensburg, Germany
[14]Kreisklinikum Siegen, Siegen, Germany
[15]Department of Urology and Pediatric Urology, RWTH Aachen University, Aachen, Germany
[16]Department of Urology and Kidney Transplantation, Martin-Luther-University, Halle (Saale), Germany
[17]Institute for Family Medicine, Charité University Medicine, Berlin, Germany
[18]Institute for Family Medicine, Center of Sepsis Control , Jena University Hospital, Jena, Germany
[19]Care (CSCC), Jena University Hospital, Jena, Germany
[20]Brandenburg Medical School, Institute for Family Medicine, Brandenburg, Germany
[21]Clinic for Urology, Pediatric Urology and Andrology, Justus Liebig University Giessen, Giessen, Germany

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