

Epidemiology, clinical profiles, and antimicrobial susceptibility of *Elizabethkingia meningoseptica* infections

Insights from a tertiary care hospital in Saudi Arabia

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ABSTRACT

الأهداف: دراسة معدل الإصابة، والخصائص السريرية عبر الفئات العمرية المختلفة، والقابلية لمضادات الميكروبات، ونتائج عدوى *إليزابيثكينجيا السحائية*.

المنهجية: أجرينا تحليل بأثر رجعي ليشمل 66 حالة تم تأكيد زراعتها للإشريكية السحائية من عينات معقمة خلال الفترة يناير 2014م ويونيو 2022م في مستشفى الملك فيصل التخصصي ومركز الأبحاث في الرياض، المملكة العربية السعودية.

النتائج: وجدنا إجمالي 66 حالة، بمعدل حدوث 0.3 لكل 1000 حالة قبول. وكانت معظم الحالات مكتسبة من المستشفيات (80.3%)، خاصة في مناطق الرعاية الحرجة. كان جميع المرضى يعانون من أمراض كامنة، وكانت أمراض الجهاز التنفسي (40.9%) وأمراض القلب والأوعية الدموية (39.4%) هي الأكثر شيوعاً. أظهر المينوسكلين أعلى حساسية (96.0%)، يليه تريميثوبريم/سلفاميثوكسازول (77.0%)، في حين كان التوبراميسين والكوليستين مقاومين تماماً. وكان معدل الوفيات داخل المستشفى 34.8%، في حين كان معدل الوفيات لمدة 28 يوماً 22.7%. أظهرت الخصائص السريرية عبر الفئات العمرية ارتفاع معدل انتشار أمراض القلب والأوعية الدموية لدى الأطفال مقارنة بالبالغين، في حين تم الإبلاغ عن التعرض للتهوية الميكانيكية والعلاج المنشط للمناعة والعدوى السابقة وفقر الدم والوفيات داخل المستشفى بشكل متكرر أكثر لدى البالغين ($p < 0.05$).

الخلاصة: توفر دراستنا رؤى قيمة حول عدوى *الإشريكية السحائية* في المملكة العربية السعودية، مع التركيز على أهمية اتخاذ تدابير قوية لمكافحة العدوى. تتوافق معدلات الإصابة والوفيات مع الاتجاهات العالمية. تسلط الاختلافات في الخصائص السريرية عبر الفئات العمرية الضوء على أهمية العلاجات المصممة بناءً على التركيبة السكانية للمريض والأمراض المصاحبة الأساسية.

Objectives: To investigate the incidence rate, clinical characteristics across different age groups, antimicrobial susceptibility, and outcomes of *Elizabethkingia meningoseptica* (*E. meningoseptica*) infections.

Methods: A retrospective analysis was carried out to include 66 cases with confirmed *E. meningoseptica* cultures from sterile samples between January 2014 and June 2022 at King Faisal Specialist Hospital and Research Centre in Riyadh, Saudi Arabia.

Results: A total of 66 cases were identified, with an incidence rate of 0.3 per 1000 admissions. Most cases

were hospital-acquired (80.3%), primarily in critical care areas. All patients had underlying diseases, with respiratory (40.9%) and cardiovascular (39.4%) diseases being the most common. Minocycline showed the highest susceptibility (96.0%), followed by trimethoprim/sulfamethoxazole (77.0%), whereas tobramycin and colistin were fully resistant. The in-hospital mortality rate was 34.8%, whereas the 28-day mortality rate was 22.7%. Clinical characteristics across age groups showed a higher prevalence of cardiovascular disease in pediatrics than in adults, whereas exposure to mechanical ventilation, immunosuppressive therapy, previous infection, anemia, and in-hospital mortality were reported more frequently in adults ($p < 0.05$).

Conclusion: Our study provides valuable insights into *E. meningoseptica* infection in Saudi Arabia, emphasizing the importance of robust infection control measures. Incidence and mortality rates align with global trends. Variations in clinical characteristics across age groups highlight the importance of tailored treatments based on patient demographics and underlying comorbidities.

Keywords: *E. meningoseptica*, *Elizabethkingia*, hospital-acquired infection, multidrug resistance

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Elizabethkingia meningoseptica (*E. meningoseptica*), formerly recognized as *Chryseobacterium meningosepticum* or *Flavobacterium meningosepticum*, is a gram-negative rod characterized by its aerobic, non-motile, non-fermenting nature, absence of spore formation, and multidrug resistance.¹ This bacterium is widely distributed in various environmental sources such as water bodies, fish, soils, insects, and amphibians, as well as frequently encountered in healthcare settings, where it can contaminate medical devices and solutions used for flushing.^{1,2}

Currently, the *Elizabethkingia* genus comprises 6 species: *E. meningoseptica*, *E. miricola*, *E. anophelis*, *E. bruuniana*, *E. ursingii*, and *E. occulta*, with *E. meningoseptica* being recognized as the most pathogenic among them.²⁻⁴

A study by Choi et al⁵ carried out in South Korea stated that the incidence rate of *Elizabethkingia* species increased significantly from 0.02 in 2009 to 0.88 in 2017 per 1,000 admissions. In addition, a study by Ma et al⁶ carried out in China reported a rapid increase in the prevalence rate of *E. meningoseptica* from 0 in 2011 to 0.19 in 2019 per 1000 inpatients.

Infections associated with *E. meningoseptica* primarily occur in patients with indwelling medical devices such as mechanical ventilation.⁵ Being an opportunistic pathogen, *E. meningoseptica* has the ability to form biofilms, enabling it to endure for prolonged periods in moist or aquatic environments, including tap water.⁷ Nevertheless, a study by Nori et al⁸ indicated that *E. meningoseptica* infection is associated with the COVID-19 virus. Furthermore, some studies have reported that *Elizabethkingia* species infect not only immunocompromised individuals but also immunocompetent individuals.⁹⁻¹¹

Given its significance as a nosocomial pathogen, accurate identification of *E. meningoseptica* is crucial for clinical diagnosis and subsequent treatment decisions.¹² Moreover, due to its inherent resistance to commonly used antibiotics such as aminoglycosides and β -lactams, *E. meningoseptica* infections pose a significant challenge in terms of treatment, often resulting in high mortality rates.^{1,13}

In Saudi Arabia, limited studies have been published regarding *E. meningoseptica* infection, and the majority were case reports, case series, or

investigations with relatively small sample sizes.^{4,14-20} Therefore, this study reports a considerable number of cases with *E. meningoseptica* infection over nearly 9 years (2014-2022). The study aims to explore several key aspects related to *E. meningoseptica*, including the incidence rate, clinical characteristics, antimicrobial susceptibility, and outcomes of *E. meningoseptica* infections at a tertiary care center in Saudi Arabia.

Methods. This retrospective single-center study was carried out at King Faisal Specialist Hospital & Research Centre in Riyadh, Saudi Arabia. It is a tertiary referral hospital offering general and highly specialized inpatient and outpatient medical treatment, transplantation, and oncology services.

All patients, with a confirmed culture of *E. meningoseptica* from sterile samples, including blood, drainage fluid, tracheal aspirate, urine, vascular tip, and wound culture, between January 2014 and June 2022 were included in the study. Both pediatric and adult patients were included. In our hospital practice, the pediatric population comprises individuals up to 14 years of age, while adults are defined as those aged above 14 years. Patients with missing documentation were excluded.

The study was carried out in accordance with the Declaration of Helsinki, and approved by the ethics committee of King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia (reference number: 2231011 and date of approval: 19/01/2023).

Data were gathered by chart review and then stored in REDCap (10.8.0 - © 2021 Vanderbilt University). The extracted data included demographic information, medical history, investigations, clinical manifestations, diagnosis, antibiotic susceptibility, and outcomes.

Hospital-acquired or healthcare-associated infection was documented if it occurred >48 hours after admission to the healthcare facility.²¹ In addition, previous infection, antimicrobial use, and interventions such as ventilation were defined as occurring within 30 days prior to *Elizabethkingia* infection.

Elizabethkingia species were identified using the VITEK® 2 (bioMérieux, located in Marcy-l'Étoile, France). Gram-Negative Card 292 was used to determine antibiotic susceptibility. The Clinical and Laboratory Standards Institute (CLSI M100) recommendations were used to interpret zone dimensions for classification as susceptible, intermediate, or resistant.²²

Furthermore, leukopenia was defined as white blood count <4.5×10⁹/L, thrombocytopenia as platelet count <150×10⁹/L, neutropenia as an absolute neutrophil count <1.5×10⁹/L, and anemia as hemoglobin (Hb)

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concentration <12.5 g/dL in adults, <11 g/dL in children aged 6 months to 6 years, and <12 g/dL in children aged 6-14 years.

Statistical analysis. Data analysis was carried out using STATA, version 18 (College Station, TX: StataCorp LLC). Categorical variables were reported as frequencies and percentages (%), and continuous variables as medians and interquartile ranges (IQRs) due to a lack of normality assumption using the Kolmogorov-Smirnov test. In addition, Fisher's exact test was used to compare clinical characteristics across age groups (pediatrics age ≤14 years versus adults age >14 years). Graphs were generated in Microsoft Excel 2016.

Results. A total of 66 patients with *E. meningoseptica* infection were identified from January 2014 to June 2022, with overall incidence rate of 0.3 per 1000 admissions (66/204,426), the peak incidence was noted in 2016 with a rate of 1 per 1000 admissions (20/20,514), then it was gradually decreased to 0.1 per 1000 admissions in June 2022 (2/22,625, **Table 1**). Of these, 31 (47.0%) were females. Regarding age, 35 (53.0%) were pediatrics (aged ≤14 years) with a median age of 0.4 years (IQR: 0.25-2), and 31 (47.0%) were adults (aged ≥15 years) with a median age of 51 years (IQR: 36-62, **Table 2**).

The origin of infection indicated that 13 (19.7%) cases were community-acquired, whereas the majority (53 [80.3%] cases) were hospital-acquired. Among hospital-acquired infections, the majority (98.1%) occurred in critical care areas such as the intensive care unit (ICU), operating room (OR), or emergency room (ER, **Table 2**).

Table 1 - The incidence of *Elizabethkingia meningoseptica* over the years (2014-mid 2022).

Years	Number of admissions	<i>E. meningoseptica</i> cases	Incidence rate per 1000 admissions
2014	20,093 (10.0)	3 (4.5)	0.1
2015	19,764 (10.0)	7 (10.6)	0.4
2016	20,514 (10.0)	20 (30.3)	1
2017	21,116 (10.0)	10 (15.2)	0.5
2018	22,539 (11.0)	11 (16.7)	0.5
2019	26,280 (13.0)	5 (7.6)	0.2
2020	23,235 (11.0)	3 (4.5)	0.1
2021	28,260 (14.0)	5 (7.6)	0.2
Mid-2022	22,625 (11.0)	2 (3.0)	0.1
Overall	204,426 (100)	66 (100)	0.3

Values are presented as numbers and percentages (%).
E. meningoseptica: *Elizabethkingia meningoseptica*

Table 2 - Characteristics of study participants (N=66).

Characteristics	n (%)
Gender	
Female	31 (47.0)
Male	35 (53.0)
Age group	
Pediatrics aged ≤14 years	35 (53.0)
Adults aged ≥15 years	31 (47.0)
Age at infection for patients aged ≤14 years (n=35)	0.4 (0.25-2)
Age at infection for patients aged ≥15 years (n=31)	51 (36-62)
Origin of infection	
Community-acquired	13 (19.7)
Hospital-acquired	53 (80.3)
Time between admission and positive culture (days)	17 (6-37)
Admission location for hospital-acquired (n=53)	
General ward	1 (1.9)
Critical care areas (ICU, OR, and ER)	52 (98.1)
Previous hospitalization[†]	
Previous ICU admission [†]	36 (75.0)
Underlying disease	
Metabolic disease	4 (6.1)
Prematurity	5 (7.6)
Solid tumors	5 (7.6)
Seizure disorder	5 (7.6)
Cerebrovascular disease	7 (10.6)
Diabetes	7 (10.6)
Hypertension	11 (16.7)
Renal disease	12 (18.2)
Hematology/oncology	14 (21.2)
Immunodeficiency	16 (24.2)
Liver disease	16 (24.2)
Cardiovascular disease	26 (39.4)
Respiratory disease	27 (40.9)
Stem cell transplant	7 (10.6)
Solid organ transplant	13 (19.7)
Previous infection[†]	
Bacteria	32 (84.2)
Fungus	16 (42.1)
Previous antimicrobial use [†]	55 (83.3)
Previous medications	
Immunosuppressant therapy	20 (30.3)
Chemotherapy	7 (10.6)
Clinical presentation	
Colonization	5 (7.6)
Infection	61 (92.4)
Symptoms for cases with infection presentation (n=61)	
Fever	20 (32.8)
Tachycardia	21 (34.4)
Hypotension	14 (23)
Respiratory distress	28 (45.9)
Lethargy	11 (18)
Gastrointestinal symptoms	4 (6.6)

Values are presented as numbers and percentages (%) or median and interquartile range (IQR). [†]Within one month before the episode (infection). ICU: intensive care unit, OR: operation room, ER: emergency room

Many patients had previous hospitalization (72.7%), infections (57.6%), and antimicrobial use (83.3%) within one month prior to *E. meningoseptica* infection (Table 2).

Remarkably, all 66 patients had underlying diseases (100%). The most reported primary diagnosis was respiratory disease (40.9%), followed by cardiovascular disease (39.4%), immunodeficiency, and liver disease (24.2%), hematological/oncological diseases (21.2%), and renal disease (18.2%). Furthermore, 10.6% had a stem cell transplant, and 19.7% had a solid organ transplant. Immunocompromising therapies such as immunosuppressant therapy was reported in 30.3% and chemotherapy was reported in 10.6% of patients (Table 2).

Moreover, 55 of the 66 (83.3%) patients had received previous interventions within one month before the episode; of them, 85.4% had arterial/central line insertion, 74.5% were on mechanical ventilation, 58.2% had urinary catheterization, 45.4% had nasogastric tube placement, 23.6% underwent heart surgeries, 16.4% were on hemodialysis, and 9.1% underwent cardiac catheterization (Figure 1).

Of the total cases, 7.6% had *E. meningoseptica* colonized infection, whereas the majority (92.4%) presented with an active infection. Among the active infection cases, various symptoms were reported, with fever being the most common (32.8%), followed by respiratory distress (45.9%), tachycardia (34.4%), hypotension (23%), lethargy (18%), and gastrointestinal symptoms (6.6%, Table 2).

The most common source used in isolating *E. meningoseptica* in our series was tracheal aspirate (77.3%). Furthermore, 42 (63.6%) patients had polymicrobial infections at the time of the episode; of them, 40 (95.2%) had a bacterial infection, including gram-positive bacterial infection in 6 patients (*Enterococcus*, *Staphylococcus*) and gram-negative bacterial infection in the remaining 36 patients (gram-negative rods, *Pseudomonas*, *Stenotrophomonas*, *Acinetobacter*, *Enterobacter*, *Chryseobacterium*, *Escherichia coli*, *Klebsiella*, and *Serratia*). Lastly, 12 (28.6%) patients had a fungal infection (*Candida* species). Notably, 10 patients had both fungal and bacterial infections (Table 3).

Laboratory results revealed a high prevalence of anemia (81.8%) and thrombocytopenia (48.5%). Elevated procalcitonin levels (>0.25 ng/mL) were observed in 53.5% of cases, whereas C-reactive protein (CRP) levels (>50 mg/L) were elevated in 27.3% of cases (Table 3).

In terms of antibiotic susceptibility, minocycline had the highest susceptibility (96.0%), followed by trimethoprim/sulfamethoxazole (77.0%) and ciprofloxacin (75.0%). In contrast, *E. meningoseptica* was resistant to most antibiotics, including tobramycin (100%), colistin (100%), amikacin (98%), ceftazidime (97%), cefepime (97%), imipenem (96%), meropenem (95%), gentamicin (92%), and piperacillin/tazobactam (90%, Figure 2).

A total of 43 (65.2%) patients received targeted antimicrobial treatment for the episode, with a median treatment duration of 20 days (IQR: 14-29). The most prescribed antimicrobial agents were ciprofloxacin (46.5%) and trimethoprim/sulfamethoxazole (23.3%) (Table 3).

Outcomes varied, with 59.1% of patients recovering, 34.8% succumbing to the infection, 3.0% exhibiting a relapse infection (while on treatment), and 3.0% exhibiting recurrence of the infection within one month. The in-hospital mortality rate was 34.8% (23/66 patients), with a median duration of 17 (IQR: 5-41) days from infection to death. The 28-day mortality rate was 22.7% (Table 3).

The majority of clinical characteristics did not significantly differ across age groups. However, cardiovascular disease was twice as high in pediatrics than in adults (51.4% vs. 25.8%; $p < 0.05$), whereas exposure to mechanical ventilation (80.6% vs. 45.7%), immunosuppressive therapy (51.6% vs. 11.4%), previous infection (74.2% vs. 42.9%), anemia (93.5% vs. 71.4%), and in-hospital mortality (54.8% vs. 17.1%) were more frequently reported in adults than in pediatrics ($p < 0.05$, Table 4).

Discussion. The emergence of *E. meningoseptica* as a significant nosocomial pathogen has raised concerns globally, particularly due to its inherent resistance to common antibiotics and association with high mortality rates. This retrospective study, carried out over nearly 9 years, aimed to shed light on various aspects of *E. meningoseptica* infection, including its incidence rate, clinical characteristics, antimicrobial susceptibility, and mortality rate.

The study highlights the clinical importance of *E. meningoseptica* infections, with an overall incidence rate of 0.3 per 1000 admissions, mainly being hospital-acquired. Interestingly, the highest incidence rate was observed in 2016 (1 per 1000 admissions), then gradually decreased to (0.1 per 1000 admissions) in mid-2022, which could be explained by the increase of infection control precautions in our center post-COVID-19. Thus, our overall incidence rate aligns with

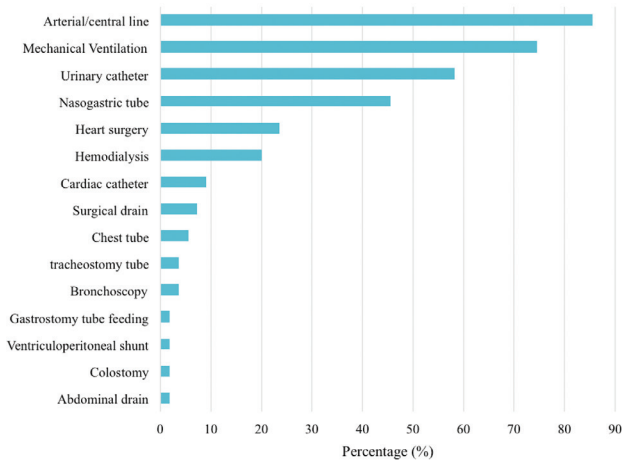


Figure 1 - Previous interventions within one-month prior the infection (n=55).

those of similar studies reporting annual incidences of *E. meningoseptica* ranging from 0.007-0.399 cases per 1,000 admissions.^{23,24} Moreover, Choi et al⁵ stated that the incidence rate of *Elizabethkingia* species increased significantly from 2009 (0.02) to 2017 (0.88) per 1,000 admissions during 2009-2017, with mechanical ventilation being a significant risk factor. Similarly, in our study, a significant proportion of adult patients had a history of prior mechanical ventilation exposure (within one month prior to the infection).

Demographic and clinical characteristics of patients with *E. meningoseptica* infection revealed that pediatrics comprised a substantial portion of the series, with respiratory and cardiovascular diseases being the most prevalent underlying conditions in this population.

Moreover, previous studies have reported that the majority of patients with *Elizabethkingia* infections have underlying chronic conditions such as diabetes, cardiovascular disease, malignancy, renal disease, and liver cirrhosis.²⁵ Additionally, cardiovascular disease was significantly associated with *E. meningoseptica* infection in the pediatric group in this study, whereas previous infection, immunosuppressive therapy, and anemia were significantly reported in adult patients. This emphasizes the need for heightened surveillance and infection prevention strategies among high-risk populations.

Additionally, a significant proportion of patients had a history of previous hospitalization, infections, and antimicrobial use within one month prior to the *E. meningoseptica* infection. Moreover, most cases in the study had an active infection, with only 7.6% having a colonized infection of *E. meningoseptica*. In contrast, a retrospective study by Alyami et al⁴ investigated *Chryseobacterium/Elizabethkingia* species infections in

Table 3 - Investigations and hospital course.

Investigations	n (%)
Diagnosis	
Blood culture	6 (9.1)
Drainage fluid culture	3 (4.5)
Tracheal aspirate	51 (77.3)
Urine culture	3 (4.5)
Vascular tip culture	1 (1.5)
Wound culture	2 (3.0)
Polymicrobial infection at the time of the episode*	
Bacteria	40 (95.2)
Fungus	12 (28.6)
Lab results	
Leukopenia	19 (19.8)
Anemia	54 (81.8)
Thrombocytopenia	32 (48.5)
Neutropenia	3 (4.5)
Procalcitonin levels (>0.25 ng/mL)	35 (53.53)
C-reactive protein levels (>50 mg/L)	18 (27.3)
Received target antimicrobial treatment	
Monotherapy	
Trimethoprim/sulfamethoxazole	35 (81.4) [†]
Ciprofloxacin	10 (23.3) [†]
Levofloxacin	20 (46.5) [†]
Meropenem	2 (4.7) [†]
Imipenem	1 (2.3) [†]
Combination therapy	
Trimethoprim/sulfamethoxazole + levofloxacin	2 (4.7) [†]
Trimethoprim/sulfamethoxazole + ciprofloxacin	4 (9.3) [†]
Trimethoprim/sulfamethoxazole + tigecycline	1 (2.3) [†]
Gentamycin + trimethoprim/sulfamethoxazole + levofloxacin + minocycline	1 (2.3) [†]
Antimicrobial treatment period (days) (n=43)	20 (14-29)
Outcome	
Recovered	39 (59.1)
Died	23 (34.8)
Relapsed (while on treatment)	2 (3.0)
Recurrence (within one month)	2 (3.0)
Days from the episode to death (n=23)	17 (5-41)
28-day mortality	15 (22.7)

Values are presented as numbers and percentages (%) or median and interquartile range (IQR). *A total of 10 patients had both bacteria and fungi. [†]Percentages were calculated using 43 (number of patients who were on treatment) as a denominator.

27 patients at Prince Sultan Military Medical City in Riyadh, Saudi Arabia, and reported a hospital-acquired infection in 92.5%, colonization rate in 22.2%, previous hospitalization within 90 days prior to the infection in 33.3%, and a 28-day mortality rate of 11.0%. The reason for the difference in findings could be that most of our patients were critically ill and had previously undergone multiple hospitalizations.

Moreover, laboratory investigations demonstrated common hematological abnormalities such as anemia and thrombocytopenia, along with elevated inflammatory markers. Similarly, a retrospective study by Li et al²⁶ investigated *E. meningoseptica* infections

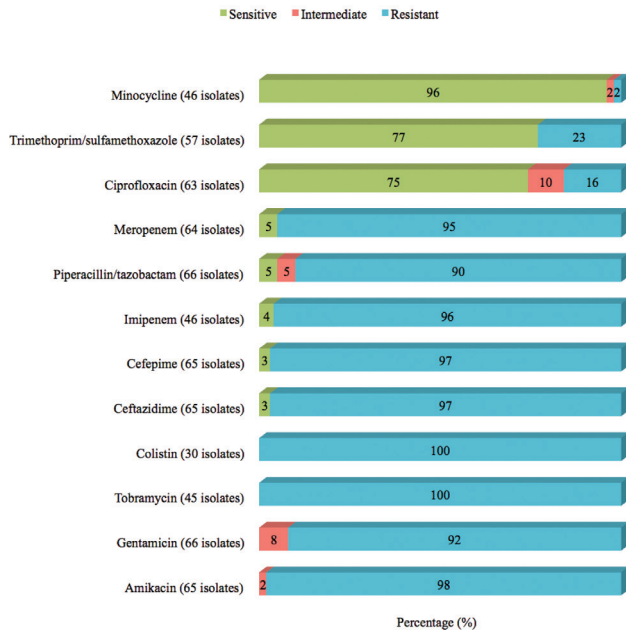


Figure 2 - The antibiotic susceptibility of *Elizabethkingia meningoseptica* isolates.

among 24 patients at a tertiary care center in China and reported anemia in 75%, hypoproteinemia in 75%, elevated CRP in 66.7%, neutrophilia in 54.2%, and leukocytosis in 50.0%. These findings are indicative of the systemic nature of *E. meningoseptica* infections.

The antimicrobial susceptibility profile in this study revealed limited treatment options, with some variability observed in the susceptibility of different antibiotics. Notably, minocycline and trimethoprim/sulfamethoxazole showed the highest susceptibility, suggesting their potential utility in the management of *E. meningoseptica* infections. Furthermore, the antibiotic resistance profile of *Elizabethkingia spp.* is characterized by intrinsic resistance to several antibiotic classes due to the presence of unique metallo-β-lactamases (MBLs) and extended-spectrum β-lactamases (ESBLs).²⁷⁻²⁹ Notably, *Elizabethkingia spp.* possess multiple chromosomally encoded MBLs, distinguishing them from other bacteria.³⁰ Reports indicate resistance to β-lactams, aminoglycosides, macrolides, and vancomycin, with variable susceptibility to other antibiotics such as fluoroquinolones, tetracycline, and trimethoprim-sulfamethoxazole.^{2,28,31-33} However, susceptibility testing is challenging due to the lack of established minimum inhibitory concentration breakpoints, necessitating alternative methods such as broth microdilution for accurate determination.^{2,13} Despite anecdotal success with vancomycin, its efficacy is uncertain,

Table 4 - Clinical characteristics by age group (N=66).

Clinical features	Pediatrics (n=35)	Adults (n=31)	P-values
Male gender	20 (57.1)	15 (48.4)	0.622
Hospital-acquired infection	27 (77.1)	26 (83.9)	0.549
Previous hospitalization*	22 (62.9)	26 (83.9)	0.095
Previous ICU admission*	16 (45.7)	20 (64.5)	0.751
Respiratory disease	15 (42.9)	12 (38.7)	0.805
Cardiovascular disease	18 (51.4)	8 (25.8)	0.045 [†]
Previous infection*	15 (42.9)	23 (74.2)	0.013 [†]
Previous antimicrobial use*	28 (80)	27 (87.1)	0.521
Previous mechanical ventilation*	16 (45.7)	25 (80.6)	0.005 [†]
Colonized infection	2 (5.7)	3 (9.7)	0.659
Polymicrobial infection	21 (60)	21 (67.7)	0.611
Intubation*	13 (37.1)	19 (61.3)	0.083
Immunosuppressive therapy	4 (11.4)	16 (51.6)	0.000 [†]
Chemotherapy	2 (5.7)	5 (16.1)	0.240
Stem cell/solid organ transplant	7 (20)	13 (41.9)	0.065
Leukopenia	6 (17.1)	7 (22.6)	0.758
Anemia	25 (71.4)	29 (93.5)	0.026 [†]
Thrombocytopenia	17 (48.6)	15 (48.4)	1.000
Procalcitonin levels (>0.25 ng/mL)	17 (48.6)	18 (58.1)	0.469
C-reactive protein levels (>50 mg/L)	9 (25.7)	9 (29.0)	0.789
28-day mortality	5 (14.3)	10 (32.3)	0.140
In-hospital mortality	6 (17.1)	17 (54.8)	0.002 [†]

Values are presented as numbers and percentages (%). *Within one month before the episode (infection). [†]Indicates statistical significance ($p < 0.05$).
ICU: intensive care unit

prompting recommendations for combination therapy involving ciprofloxacin, linezolid, or rifampicin.¹³ Whole-genome sequencing has revealed a multitude of antibiotic resistance genes in *Elizabethkingia spp.*, offering insights into their resistance mechanisms.^{28,29} Nevertheless, genomic studies from the Middle East on *Elizabethkingia spp.* are lacking, highlighting the need for further research in this region.

Despite treatment efforts, the 28-day mortality rate in this study was 22.7%, and the in-hospital mortality rate was 34.8%. Notably, the in-hospital mortality was significantly higher in adults, highlighting the challenges in managing this pathogen among adult patients. Similarly, Seong et al³⁴ reported a 28-day mortality rate of 25.2% among patients with *Elizabethkingia* infections, with a mean age of 66.5 years in their study cohort. Moreover, a systematic review by Ma et al⁶ revealed that the fatality rate associated with *E. meningoseptica* infection varied between 11.0-66.6%. After accounting for the influence of limited sample size, mortality rates fell within the range of 23.4-65.6% across 5 studies

encompassing over 30 patients.⁶ However, it is unclear whether *E. meningoseptica* infection or the underlying disease was the cause of death in our study and other studies.

Thus, the comparison of clinical characteristics across age groups revealed some interesting differences, particularly in the prevalence of cardiovascular disease and the utilization of mechanical ventilation and immunosuppressive therapy. These findings underscore the importance of tailoring treatment approaches based on patient age and underlying comorbidities.

Study limitations. Although this study reported a considerable number of *E. meningoseptica* infection cases, its retrospective and single-center design inevitably constrain its generalizability.

In conclusion, our study provides valuable insights into the epidemiology and clinical characteristics of *E. meningoseptica* infections at a tertiary care center in Riyadh, Saudi Arabia. Aligning with global trends, the incidence rate of *E. meningoseptica* infection in this study was 0.3 per 1000 admissions, with most cases being hospital-acquired, emphasizing the importance of robust infection control measures. Laboratory investigations revealed common hematological abnormalities and elevated inflammatory markers, indicative of the systemic nature of *E. meningoseptica* infections. Antimicrobial susceptibility testing revealed limited treatment options, including trimethoprim/sulfamethoxazole or minocycline, highlighting the challenges in managing these infections. The mortality rates were substantial, aligning with the findings of other studies, particularly among adults. Variations in clinical characteristics across age groups highlight the importance of tailored treatment approaches based on patient demographics and underlying comorbidities. Further research, particularly genomic studies, is warranted to better understand the antibiotic resistance mechanisms and improve treatment strategies for *E. meningoseptica* infections in the Middle East region.

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