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Epidemiology, Microbiology, and Outcomes of Culture- Positive Bacterial Keratitis: The Kent Microbial Keratitis Study

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Abstract

Background

Bacterial keratitis (BK) is a significant cause of corneal blindness worldwide. This study presents the first comprehensive analysis of culture-positive BK in Kent.

Methods

This retrospective observational study analysed culture-positive BK presenting to Maidstone and Tunbridge Wells NHS Trust and East Kent Hospitals University NHS Foundation Trust between January 2020 and December 2024. Clinical data were collected including risk factors, microbiological results, treatment regimens, and outcomes. Poor visual outcome was defined as best-corrected visual acuity < 6/24. Statistical analysis employed univariable and multivariable logistic regression to identify predictors of adverse outcomes.

Results

A total of 198 patients with culture-positive BK were identified with culture positivity rate of 40.1% and mean age of 58 ± 19.4 years. Predisposing factors were identified in 88.4% of patients, with contact lens (CL)-wear predominating (51.0%), followed by ocular surface disease (OSD; 34.9%) and systemic immunosuppression (28.3%). Gram-negative bacteria predominated (63.6%), with *Pseudomonas aeruginosa* representing 40.2% of isolates. CL-wear was significantly associated with *Pseudomonas aeruginosa* (84.2% of CL cases, p = 0.001), whilst OSD, immunosuppression, topical steroid use, and prior corneal surgery were associated with gram-positive infections. Therapeutic keratoplasty was required in 15.2% of patients, with 48.1% achieving poor visual outcomes. Multivariable analysis identified epithelial defect size >3mm as the only independent predictor of poor visual outcomes (OR 3.87, 95% CI 1.68–9.26, p = 0.002).

Discussion

This study demonstrates evolving epidemiological patterns of BK in Kent, with gram-negative predominance, and CL-wear as the primary modifiable risk factor. Epithelial defect size emerged as the strongest predictor of poor visual outcome.

Introduction

Microbial keratitis is a significant cause of corneal blindness worldwide. Global incidence varies considerably by region and ranges from 3.6 to 799 cases per 100,000 population annually(1–6). In developed countries, bacterial keratitis (BK) accounts for 72.1–93.1% of culture-proven microbial

keratitis(7–9). Poor clinical outcomes frequently result without prompt and appropriate antimicrobial therapy. Large series demonstrate that even following infection resolution, only 12.1% to 60% of patients achieve visual improvement from baseline, with surgical intervention rates ranging from 16.3% to 43.2% due to clinical severity or prolonged healing(10–13).

Despite the clinical significance of BK, comprehensive epidemiological data from many UK regions remain limited. This study presents the first comprehensive analysis of BK in Kent, examining epidemiological features, microbiological profiles, treatment responses, and clinical outcomes over a five-year period. By characterising the regional disease burden and identifying predictors of adverse outcomes, we aim to inform clinical practice and contribute to the broader understanding of this sight-threatening condition in contemporary UK practice.

Methods

This was a retrospective observational study of all patients with culture-positive BK who presented to Maidstone and Tunbridge Wells (MTW) NHS Trust, which operates across two hospital sites, and East Kent Hospitals University (EKHU) NHS Foundation Trust, which operates across four hospital sites, between 1st January 2020 and 31st December 2024.

This study was approved by the Clinical Audit Departments at MTW NHS Trust (ID 2763) and EKHU NHS Foundation Trust (ID 2025/GAP/02). As a retrospective audit of routine clinical care, formal ethical approval was not required, though the study adhered to the principles of the Declaration of Helsinki regarding medical research.

BK was defined as a suppurative corneal infiltrate with an overlying epithelial defect, confirmed by positive microbiological culture. Our exclusion criteria included patients with incomplete initial or follow-up data, patients whose care was transferred elsewhere with unknown outcomes and fungal, viral, or parasitic keratitis cases. To avoid duplication in bilateral or recurrent cases, only one eye per patient was included. For recurrent episodes, only the first BK episode was analysed, regardless of the laterality of subsequent infections.

Relevant clinical data were collected using a standardised proforma including demographic characteristics (age, sex, laterality), predisposing risk factors, presenting symptoms duration, best corrected visual acuity (BCVA) measurements, clinical examination findings, microbiological results, treatment regimens, and clinical outcomes. Clinical features included the widest dimensions of the epithelial defect and infiltrate, ulcer location (central, paracentral, or peripheral), presence of hypopyon, and associated complications. Treatment data encompassed initial antimicrobial therapy, surgical interventions, and time to complete corneal healing. Systemic and ocular comorbidities were recorded to identify potential predisposing factors and their influence on clinical outcomes. Poor visual outcome was defined as BCVA worse than 6/24 Snellen (0.6 LogMAR).

The specimen collection and laboratory processing protocols summarised below have been described in full detail in our earlier publication reporting the microbiological profiles and in vitro antimicrobial susceptibility in our region over a 10-year period(14).

Corneal scraping was performed using sterile technique. Specimens were obtained when epithelial defects and infiltrates exceeded 1mm in diameter, appeared clinically atypical, or failed to respond to initial empirical treatment. Following topical anaesthetic administration, samples were collected using sterile 21- or 30-gauge needles, with individual instruments employed for each culture medium to avoid cross-contamination.

Specimens were inoculated onto one Columbia blood agar plate (incubated at 35–37°C in 5–10% CO_2 for 40–48 hours), one chocolate agar plate (identical conditions), and one Sabouraud dextrose agar plate (maintained at 30°C for seven days). Microscopy slides were prepared for Gram staining of all specimens. Blood and chocolate agar were assessed after five days of incubation, whilst Sabouraud plates were monitored for the full seven-day period. When clinically indicated, additional specimens were processed for anaerobic culture using fastidious anaerobe agar (incubated anaerobically at 35–37°C for 40–48 hours, with extended monitoring up to ten days for *Actinomycetes* detection). MacConkey agar was utilised when Gram-negative rods were identified on initial staining to facilitate isolation of *Enterobacterales* organisms.

Bacterial identification utilised MALDI-TOF mass spectrometry. Antimicrobial susceptibility testing followed disc diffusion methodology and VITEK2 automated systems; some specimens were processed using MicroScan Walkaway platforms at the EKHU microbiology lab. For specimens yielding polymicrobial growth, each organism was documented individually. Repeat sampling from the same eye was considered a single episode unless distinct organisms or altered susceptibility patterns were identified.

Treatment protocols employed intensive topical antimicrobial therapy, typically commencing with hourly fluoroquinolone monotherapy or combined fortified antibiotics based on clinical severity. Hospitalisation was indicated for severe cases or when patient compliance with intensive regimens was uncertain. Treatment modifications were made according to clinical response and microbiological results.

Statistical analyses were performed using R version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were compared using t-tests or Mann-Whitney U tests, whilst categorical variables were analysed using chi-square or Fisher's exact tests as appropriate. For variables with expected cell counts below 5, Fisher's exact test was preferentially employed. Snellen visual acuities (VA) were converted to logarithm of the minimum angle of resolution (logMAR) for analysis, with counting fingers, hand movements, perception of light, and no perception of light assigned values of 1.9, 2.3, 2.8, and 3.0 logMAR, respectively(13, 15).

Multivariable logistic regression identified independent predictors of poor visual outcomes using stepwise variable selection. Variables with $p < 0.05$ in univariable analysis were considered for inclusion

in the final model. Missing data were handled using listwise deletion, with infiltrate size measurements excluded from multivariable analysis due to substantial missingness (72.2%). The final model retained only variables that meaningfully contributed to predictive accuracy, with results presented as odds ratios (OR) with 95% confidence intervals (CI).

Results

Patient Demographics and Clinical Characteristics

494 patients were scraped and treated for microbial keratitis, of which 198 patients (198 eyes) with culture-positive BK were identified during the five-year period (40.1% culture positivity rate). The mean age was 58 ± 19.4 years (range 13–97 years), with a slight female predominance (51.6%). Full baseline characteristics and demographics are shown in Table 1.

Table 1
Demographic factors and baseline clinical characteristics of culture-positive bacterial keratitis in Kent (2020–2024)

Parameters	All patients (n = 198)
Population characteristics	
Age, mean ± SD (range), years	58 ± 19.4 (13–97)
Duration of symptoms before presentation, mean ± SD (range), days	5.4 ± 6.6 (0–42)
Initial BCVA (mean) ± SD (range), logMAR	1.12 ± 1.13 (-0.08-3) [n = 181]
Sex (Male), n (%)	95 (48.0)
Laterality (Right eye), n (%)	104 (52.5)
Risk factors	
CL wear	101 (51)
Trauma	5 (2.5)
OSD	69 (34.9)
Immunosuppression	56 (28.3)
Topical steroids	27 (13.6)
Prior corneal surgery	20 (10.1)
Presenting BCVA n (%)	
< 0.3	60 (30.3)
0.3 ≤ BCVA < 0.6	34 (17.2)
0.6 ≤ BCVA < 1.0	8 (4.0)
≥ 1.0	79 (39.9)
Epithelial defect size, n (%) [n = 157]	
Small (≤ 3 mm)	91 (58.0)
Medium (3.1-6 mm)	45 (28.7)
Large (> 6 mm)	21 (13.4)
Infiltrate size at presentation, n (%) [n = 59]	
Small (≤ 3 mm)	39 (66.1)

SD, standard deviation; BCVA, best corrected visual acuity; logMAR, logarithm of the Minimum Angle of Resolution; CL, contact lens; OSD, ocular surface disease; Values in square brackets indicate the number of patients for whom data were available for that specific parameter

Parameters	All patients (n = 198)
Population characteristics	
Medium (3.1-6 mm)	12 (20.3)
Large (> 6 mm)	8 (13.6)
Ulcer location, n (%) [n = 173]	
Central	57 (33.0)
Paracentral	68 (39.3)
Peripheral	48 (27.8)

SD, standard deviation; BCVA, best corrected visual acuity; logMAR, logarithm of the Minimum Angle of Resolution; CL, contact lens; OSD, ocular surface disease; Values in square brackets indicate the number of patients for whom data were available for that specific parameter

Risk factors

Predisposing factors were identified in the majority of patients (175, 88.4%). Contact lens (CL)-wear was the predominant risk factor (51.0%), followed by ocular surface disease (OSD; 34.9%), systemic immunosuppression (28.3%), topical steroid use (13.6%), prior corneal surgery (10.1%) and trauma (2.5%). Risk factor distribution showed age-related associations, with CL-wear significantly more prevalent in patients 30–60 years old (51.5%) compared to those over 60 years (32.7%, $p < 0.001$). Conversely, OSD, immunosuppression, and topical steroid use were significantly associated with older age groups ($p = 0.007$, $p < 0.001$, and $p = 0.010$ respectively). No significant associations were found between individual risk factors and sex.

Patients with single risk factors achieved the best visual outcomes (mean logMAR 0.83 ± 1.02), whilst patients with no identifiable risk factors had intermediate outcomes (1.37 ± 1.17 logMAR) (Table 2). Patients with multiple risk factors did not show progressively worse outcomes, with those having three or more risk factors achieving similar results to the no-risk-factor group (1.47 ± 1.01 logMAR). The microbiological profile varied according to risk factor burden, with *P. aeruginosa* predominating in single risk factor cases, whilst *Staph aureus (SA)* and *Coagulase-negative Staphylococci (CoNS)* became more prevalent in patients with multiple risk factors (Table 2).

Table 2
Visual outcomes and microbiological profiles stratified by number of risk factors in Kent bacterial keratitis

Number of Risk Factors	N (%)	Age (mean), years	Most Common Organisms, n	Final BCVA (mean) ± SD (range), logMAR
0 RF	24 (12.1)	62.7	*Pseudomonas spp*: 7 *CoNS*: 5 *Moraxella nonliquefaciens*: 3	1.37 ± 1.17 (-0.08-2.8)
1 RF	96 (48.5)	52.9	*Pseudomonas spp*: 57 *CoNS*: 15 *SA*: 10	0.83 ± 1.02 (-0.08-3)
2 RFs	58 (29.3)	65.2	*Pseudomonas spp*: 27 *SA*: 11 *CoNS*: 7	1.37 ± 1.22 (-0.08-3)
≥ 3 RFs	20 (10.1)	66.3	*CoNS*: 6 *SA*: 5 *Pseudomonas spp*: 4	1.47 ± 1.01 (0.1-3)

RF, risk factor; BCVA, best corrected visual acuity; SD, standard deviation; logMAR, logarithm of the Minimum Angle of Resolution; CoNS, Coagulase-negative Staphylococci; SA, Staphylococcus aureus

Risk factors showed distinct microbiological patterns (Table 3). OSD, immunosuppression, topical steroid use, and prior corneal surgery were all significantly associated with Gram-positive infections ($p = 0.001$, $p = 0.034$, $p = 0.004$, and $p = 0.027$, respectively). No significant associations were found between risk factors and polymicrobial infections.

Table 3
Predisposing risk factors and microbiological patterns in Kent bacterial keratitis

Risk Factor	Aetiologies	N (%)	Age (mean), years	Most frequently isolated organisms, n*	Final BCVA (mean) ± SD (range), logMAR
CL wear	*Soft lenses* Daily disposables: 25 Weekly: 8 Bi-weekly: 6 Monthly: 27 Extended-wear: 3 *Rigid lenses*: 22 *Unknown*: 22	101 (51)	50.5	*Pseudomonas spp*: 79 *CoNS*: 12 *Streptococcus spp*: 6	1.46 ± 1.01 (-0.08-3)
Trauma		5 (2.5)	50.6	*Enterococcus faecalis*: 2 *Pseudomonas spp*: 1 *Moraxella non-liquefasciens*: 1 *MRSA*: 1	1.76 ± 1.27 (0–3)
OSDs	Band keratopathy: 5 Corneal erosion syndrome: 1 Cicatricial conjunctivitis: 2 Dry eye disease: 8 Endothelial dysfunctions: 2 Exposure keratitis: 2 Eyelid malposition: 13	69 (34.9)	66.5	*Pseudomonas spp*: 19 *CoNS: 16* *SA*: 16	1.44 ± 1.17 (-0.08-3)

CL, contact lens; OSD, ocular surface disease; BCVA, best corrected visual acuity; SD, standard deviation; logMAR, logarithm of the Minimum Angle of Resolution; CoNS, Coagulase-negative Staphylococci; SA, Staphylococcus aureus

* Top 3 most frequently isolated organisms are listed; where ties occurred, all equally-represented organisms were included.

Risk Factor	Aetiologies	N (%)	Age (mean), years	Most frequently isolated organisms, n*	Final BCVA (mean) ± SD (range), logMAR
	Herpetic keratitis: 11 Meibomian gland dysfunction: 10 Neurotrophic keratitis: 8 Peripheral ulcerative keratitis: 3 Recurrent keratitis: 23				
Immunosuppression	Diabetes: 20 Use of systemic immunosuppressive drugs: 18 Malignancy = 31	56 (28.3)	67.4	*Pseudomonas spp*: 17 *CoNS*: 12 *SA*: 13	1.45 ± 1.15 (-0.08-3)
Topical steroids		27 (13.6)	69	*Streptococcus spp*: 8 *SA*: 7 *CoNS: 6*	2.01 ± 0.99 (0.3-3)
Prior corneal surgery	Penetrating Keratoplasty: 20 Refractive surgery: 2	20 (10.1)	69.2	*SA*: 5 *CoNS: 4* *Serratia spp: 4*	1.76 ± 0.99 (-0.08-3)

CL, contact lens; OSD, ocular surface disease; BCVA, best corrected visual acuity; SD, standard deviation; logMAR, logarithm of the Minimum Angle of Resolution; CoNS, Coagulase-negative Staphylococci; SA, Staphylococcus aureus

* Top 3 most frequently isolated organisms are listed; where ties occurred, all equally-represented organisms were included.

P. aeruginosa was isolated in 84.2% of CL-related cases versus 15.8% of non-CL cases (p = 0.001), whilst *Moraxella* species demonstrated the inverse relationship (6.7% vs 93.3%, p < 0.001). Gram-negative organisms overall were significantly associated with CL-wear (OR 9.24, 95% CI 4.61–18.51, p < 0.001).

Microbiological Characteristics

234 organisms were isolated from total of 198 positive cultures. Pure bacterial growth occurred in 170 cases (85.9%). Polymicrobial growth was identified in 28 cases (14.1%), comprising 18 cases (9.1%) with two bacterial species and eight cases (4.0%) with three or more bacterial species. Mixed microbial growth occurred in two cases: one case (0.5%) involved bacteria and fungi, whilst another case (0.5%) demonstrated bacteria and acanthamoeba co-infection.

Gram-negative bacteria predominated, representing 126 cases (63.6%) compared to 72 cases (36.4%) Gram-positive ($p < 0.001$). *P. aeruginosa* was the most frequently isolated organism (94 isolates, 40.2%), followed by *CoNS* (36 isolates; 15.4%) and *SA* (28 isolates, 12%). One case of *methicillin-resistant Staphylococcus aureus (MRSA)* was identified. One patient had bacterial superinfection on a background of chronic herpetic keratitis. The complete microbiological profile is detailed in Table 4.

Table 4
Microbiological profile and organism distribution of culture-positive bacterial keratitis in Kent (2020–2024)

Organism	Count (%)
Total organisms isolated	**234**
Gram-positive bacteria, n (%)	**101 (43.2)**
Streptococcus spp.	19 (8.1)
CoNS[a]	36 (15.4)
SA	28 (12.0)
Others[b]	17 (7.3)
Gram-negative bacteria, n (%)	**131 (56.0)**
P. aeruginosa	94 (40.2)
Moraxella spp.	15 (6.4)
Serratia spp.	6 (2.6)
Others[c]	17 (6.8)
Mixed growth, n (%)	**64 (27.4)**
Other organisms	
Acanthamoeba	1 (0.4)
Yeast	1 (0.4)

CoNS, *Coagulase-negative Staphylococci*; SA, *Staphylococcus aureus* (includes *Methicillin-resistant staphylococcus aureus*).

[a] *CoNS* include, *S. epidermidis* (n = 19), *S. haemolyticus* (n = 4), *S. hominis* (n = 4), *S. capitis* (n = 6), *S. warneri* (n = 1), *S. lugdunensis* (n = 1) and other unspecified (n = 1).

[b] Other Gram-positive organisms included *Enterococcus faecalis* (n = 3), *Corynebacterium spp.* (n = 4), *Cutibacterium acnes* (n = 2), *Bacillus spp*. (n = 5), *Rothia mucilaginosa* (n = 1), *Actinomyces oris* (n = 1), *Paenibacillus spp*. (n = 1)

[c] Other Gram-negative organisms included *Klebsiella oxytoca* (n = 3), *Haemophilus influenzae* (n = 3), *Enterobacter cloacae* (n = 2), *Providencia rettgeri* (n = 1), *Achromobacter xylosoxidans* (n = 1), *Stenotrophomonas maltophilia* (n = 1), *Neisseria flavescens* (n = 1), *Psychrobacter phenylpyruvicus* (n = 1), *Acinetobacter ursingii* (n = 1), *Enterobacter hormaechei* (n = 1), *Serratia liquefaciens* (n = 1), *Pseudomonas alcaligenes* (n = 1)

P. aeruginosa demonstrated a strong association with younger patients, decreasing significantly with age ($p = 0.005$). Conversely, *Moraxella* species was significantly more common in older patients ($p = 0.008$).

Other major isolated organisms showed no significant age associations.

Hypopyon was present in 100 cases (50.5%) and occurred more frequently with Gram-negative infections (75.0% vs 25.0%, p = 0.017), as did corneal abscesses (78.6% vs 21.4%, p = 0.012). Gram-positive infections were more likely to develop corneal neovascularisation (55.6% vs 44.4%, p = 0.009). Epithelial defects and infiltrates > 3mm showed no significant associations with specific organisms.

Polymicrobial Infections

Polymicrobial infections constituted 64 organisms (14.1%). They showed no significant associations with age groups (p = 0.967), CL-wear (p = 0.222), or final BCVA outcomes (p = 0.827). *CoNS* (n = 19) were the predominant organisms in these mixed infections (29.7%). Final BCVA in these cases was 1.11 ± 1.13 (-0.08-3) logMAR.

Medical and Surgical Treatment

Monotherapy dominated initial treatment approaches (132 cases, 66.7%), with fluoroquinolones representing the most commonly prescribed first-line agents. Ofloxacin was the most frequently used antibiotic (113 cases, 57.1%). Combination therapy was used in 66 cases (33.3%), with gentamicin plus cefuroxime as the predominant dual regimen (25 cases, 12.6%). Nine patients (4.5%) received combination therapy with antiseptic or antiviral agents.

Prognostic Factors and Clinical Outcomes

Complete corneal healing time data was available for 143 patients, demonstrating a mean time to resolution of 38.7 ± 26.8 days (range 4-148 days). Healing time was unavailable for 55 patients due to external referral (n = 16), incomplete patient records (n = 18), therapeutic keratoplasty (n = 9), evisceration (n = 6), patient mortality (n = 2), or other causes (n = 4).

For patients with complete VA data (n = 175), baseline BCVA ranged from − 0.18 to 3.0 logMAR. The mean change in BCVA was − 0.51 ± 0.922 logMAR (range + 2.5 to -2.52), indicating overall visual improvement. At final follow-up, 106 patients (60.6%) demonstrated improvement, 23 patients (13.1%) experienced deterioration, and 46 patients (26.3%) showed no change.

Poor visual outcome occurred in 87 patients (48.1%) of the 181 with valid final BCVA measurements. Univariate analysis identified factors significantly associated with poor outcomes including OSD (OR 1.21, 95% CI 0.48–3.08, p = 0.02), prior corneal surgery (OR 2.01, 95% CI 0.48–9.61, p = 0.016) and topical steroid use (OR 1.77, 95% CI 0.47–7.35, P = 0.001). CL-wear demonstrated protective effects (mean final BCVA 0.60 ± 0.84 logMAR, OR 0.17, 95% CI 0.09–0.32, p < 0.001). Age also influenced outcomes: patients aged 30–60 years had lower odds of poor outcome relative to those under 30 (OR 0.46, 95% CI 0.25–0.84, p = 0.012), whereas patients over 60 years had substantially higher odds (OR

3.21, 95% CI 1.74–5.92, p < 0.001). Clinical factors significantly associated with poor outcomes included epithelial defect size >3mm (OR 4.56, 95% CI 2.09–9.46, p < 0.001), infiltrate size >3mm (OR 3.47, 95% CI 1.02–11.82, p = 0.047), and presenting BCVA ≥ 0.6 logMAR (OR 11.50, 95% CI 4.55–29.05, p < 0.001). Among microbiological factors, *P. aeruginosa* was protective (OR 0.33, 95% CI 0.18–0.61, p < 0.001), whilst *Moraxella spp.* were associated with increased risk (OR 5.91, 95% CI 1.26–27.79, p = 0.025).

Multivariable analysis identified epithelial defect size >3mm as the only factor that remained independently associated with poor visual outcomes (OR 3.87, 95% CI 1.68–9.26, p = 0.002). Presenting BCVA ≥ 0.6 logMAR showed a strong trend towards significance (OR 2.84, 95% CI 0.96–9.30, p = 0.069).

Treatment and Surgical Interventions

Corneal perforation occurred in 14 patients (7.1%), with a trend toward association with *Strep. pneumoniae*, though this did not reach statistical significance (50% perforation rate, p = 0.058).

20 patients had undergone keratoplasty prior to developing BK. Therapeutic keratoplasty was the most common surgical intervention, performed in 30 patients (15.0%). The distribution of surgical interventions and their associated microbiological profiles are detailed in Table 5.

Table 5
Surgical interventions and visual outcomes in Kent bacterial keratitis (2020–2024)

Intervention	N (%)	Age (mean), years	Most frequently isolated microorganisms, n*	Final BCVA (mean) ± SD (range), logMAR
Corneal gluing	5 (2.5)	59	*Streptococcus spp*: 4 *Enterobacter cloacae*: 1 *Serratia marscescens*: 1 *Achromobacter xylosoxidans*: 1 *Corynebacterium propinquum*: 1	2.4 ± 0.56 (1.9-3)
Therapeutic keratoplasties	30 (15)	56.2	*Pseudomonas spp*: 16 *CoNS*: 4 *SA*: 3 *Streptococcus spp: 3*	1.39 ± 1.02 (0.18–2.8)
Amniotic membrane transplantation	7 (3.5)	75.6	*Pseudomonas spp*: 2 *SA*: 2 *CoNS*: 2	1.8 ± 0.87 (0.6–2.8)
Tarsorrhaphy	17 (8.5)	73.1	*Pseudomonas spp*: 5 *Moraxella spp*: 5 *CoNS*: 3 *Streptococcus spp*: 3	2.18 ± 0.93 (0.18-3)
Eviscerations / enucleations	11 (5)	69.9	*Pseudomonas spp*: 6 *SA*: 2 *CoNS*: 2	2.5 ± 0.87 (0.3-3)

BCVA, best-corrected BCVA; logMAR, logarithm of the minimum angle of resolution; RF, risk factor; SD, standard deviation; SA, Staphylococcus aureus; CoNS, coagulase-negative staphylococci

* Top 3 most frequently isolated organisms are listed; where ties occurred, all equally-represented organisms were included.

Seasonal Variation and Temporal Trends

Peak BK incidence was in July and September (23 cases each, 11.6%), with lowest numbers in March (eight cases, 4.0%). No significant seasonal variation was observed.

Discussion

This study represents the first comprehensive analysis of BK in Kent, examining 198 culture-positive cases over five years.

Relevant risk factors were identified in 87.9% of patients. CL-wear remained the leading risk factor (51%), aligning with European studies reporting 31-50.3% prevalence(10, 11, 16). This reflects epidemiological patterns characteristic of developed nations, contrasting with developing countries where trauma predominates(9, 10, 17). These findings underscore the persistent role of CL-wear as the primary modifiable risk factor in developed countries.

OSD represented the second most common risk factor (34.9%), consistent with several other studies though exceeding proportions reported in recent European series (21.3–25%)(10, 11, 16). This elevation may reflect our restriction to culture-positive cases, potentially enriching for severe presentations associated with compromised ocular surfaces. Some UK studies report reversed prevalence hierarchies, with OSDs preceding CL-wear(13, 18). International variations exist; Australian data showed CL-wear (63%) and topical steroid use (24%) as predominant factors, whilst a US series reported CL-wear (51.4%) and prior intraocular surgery (25.1%)(19, 20).

The temporal consistency of CL-wear and OSD as leading risk factors suggests stable epidemiological patterns in the UK. Identification of these risk factors remains important for guiding antimicrobial selection in culture-negative cases and enabling targeted prevention strategies.

Immunosuppression emerged as the third most common risk factor, accounting for 56 cases (28.3%), similar to the 52 (18.4%) reported by Ting et al. across a similar five-year duration(16). The growing prevalence may reflect an increasing population of patients with diabetes and those receiving immunosuppressive therapies. Compromised host defence mechanisms in this population create favourable conditions for bacterial colonisation and invasion. These patients represent a particular clinical challenge, often requiring modified treatment approaches and demonstrating prolonged healing times(21–23).

Our microbiological findings revealed Gram-negative bacteria predominance (63.6%), with *P. aeruginosa* as the leading pathogen (40.2% of isolates). These findings align with recent observations by Bertret et al. and Ting et al., who reported 59.9% and 49.3% Gram-negative prevalence, and *P. aeruginosa* rates of 32.5% and 31.9%, respectively(13, 16). The near-equal distribution between Gram-positive and Gram-negative organisms in Ting et al.'s cohort, alongside Bertret et al.'s findings, contrasts markedly with earlier studies by Bourcier et al. (2003) and Ibrahim et al. (2009), which demonstrated 83% and 71.1% Gram-positive prevalence, respectively(10, 11). Given that both Bourcier and Bertret et al.'s studies were conducted in the same Parisian setting yet demonstrate divergent microbiological profiles, temporal changes in bacterial ecology appear more likely than simply regional variations. This shift may be related to increased CL-wear prevalence, given the strong association between lens use and Gram-negative infections.

The strong association between *P. aeruginosa* and CL-wear (84.2% of CL cases versus 15.8% of non-CL-cases, p = 0.001) follows well-established epidemiological patterns with important implications for empirical therapy(9, 11, 13, 16). This reflects the organism's propensity for biofilm formation on CL surfaces and ability to thrive in hypoxic lens environments(24). Conversely, *Moraxella spp.* showed inverse CL association, with only 6.7% occurring in CL users versus 93.3% in non-CL cases (p < 0.001).

Significant associations existed between risk factors and causative organisms. OSD, immunosuppression, topical steroid use, and prior corneal surgery all significantly associated with Gram-positive infections (p = 0.001, p = 0.034, p = 0.004, and p = 0.027, respectively). These findings follow previous patterns and has important therapeutic implications, as non-CL-related culture-negative cases unresponsive to fluoroquinolone monotherapy may benefit from cephalosporin addition for enhanced Gram-positive coverage(10, 13, 21, 23).

Most cases (66.7%) healed with medical treatment alone, whilst 61 patients (30.8%) required additional surgical interventions. Our rate aligns with other tertiary centre experiences, such Gopinathan et al. reporting 43% surgical intervention, whilst remaining higher than Ting et al.'s 16% in Nottingham.

Therapeutic keratoplasty was required in 30 patients (15.2%), exceeding rates in several international series, including the Asia Cornea Society Infectious Keratitis Study (~ 10%) and an Australian cohort (6% requiring keratoplasty, evisceration or enucleation) (19, 25).

The visual outcomes were notably favourable, with 60.6% demonstrating improved BCVA at final follow-up, though 48.1% had poor visual outcome. Mean healing time of 38.7 days was longer than the 11.5 days reported in Portsmouth, possibly reflecting our culture-positive restriction, and consequently more severe cases(11).

Multivariable analysis identified epithelial defect size >3mm as the only independent predictor of poor visual outcomes (OR 3.87, p = 0.002), whilst presenting BCVA ≥ 0.6 logMAR showed a strong trend towards significance (OR 2.84, p = 0.069). Most univariable associations were attenuated in multivariable analysis, suggesting confounding between clinical variables.

These findings partially align with other series, though direct comparison remains challenging due to variable outcome definitions. Ting et al. identified older age, larger infiltrate, central ulcer location, and poor presenting BCVA as significant predictors(13). Khoo et al. and Parmar et al. similarly demonstrated associations with advanced age, worse presenting vision, and larger ulcerations(19, 26). Bertret et al. found poorer visual acuity correlated with age, infiltrate size, and OSD(16).

CL-related cases achieved superior outcomes, with mean final BCVA of 0.60 ± 0.84 logMAR. The protective effect of CL-related keratitis likely reflects earlier presentation, younger patient demographics, and more aggressive treatment approaches. Bertret et al., similarly identified CL-wear as protective alongside ocular trauma and absence of risk factors(16). Conversely, prior topical steroid use emerged

as the strongest predictor of poor outcomes, potentially indicating pre-existing ocular inflammation, delayed presentation due to masked symptoms, or steroid-induced healing complications.

Regarding, antimicrobial resistance (AMR), our separate 10-year analysis of microbial keratitis in the region revealed concerning trends, particularly a 16.9% reduction in fluoroquinolone susceptibility among Gram-positive isolates ($p < 0.001$). Similar fluoroquinolone resistance has been reported in the US and India(27–32). However, Gram-negative organisms maintained excellent susceptibility to fluoroquinolones (93.4%) and aminoglycosides (99.3%). Given fluoroquinolone monotherapy dominated initial treatment and represents widely used empirical therapy globally, these resistance trends have important clinical implications and may necessitate earlier combination therapy consideration for Gram-positive infections(11, 18).

Our study has several limitations. Our retrospective design limits data completeness, potentially influencing multivariate analysis as substantial missing data prevented inclusion of several parameters. Additionally, our culture positivity rate (40.1%) was lower than international studies (63.8–82.5%), though comparable to UK reports (32.6–54.0%)(10, 11, 16, 33–35). The restriction to culture-positive cases ensured diagnostic certainty but excluded a considerable proportion of clinically diagnosed BK failing to yield positive cultures, potentially introducing selection bias towards severe disease.

Conclusions

The evolving AMR landscape, combined with persistent CL-related burden, underscores the importance of targeted prevention strategies, ongoing surveillance, and evidence-based treatment protocols. CL hygiene education remains a priority given the excellent outcomes achievable with appropriate management.

Declarations

Conflict of Interest:

none to be declared

Ethics statement

This study does not involve human participants or animal subjects.

Funding:

none obtained

Author Contribution

IKJ conceived and designed the study. IKJ, ST, OO, LF and CR collected the data. IKJ wrote the manuscript for publication. IKJ performed the statistical analyses. SM, LF and ME provided expert input and commentary on the manuscript.

SD, standard deviation; BCVA, best corrected visual acuity; logMAR, logarithm of the Minimum Angle of Resolution; CL, contact lens; OSD, ocular surface disease; Values in square brackets indicate the number of patients for whom data were available for that specific parameter

RF, risk factor; BCVA, best corrected visual acuity; SD, standard deviation; logMAR, logarithm of the Minimum Angle of Resolution; CoNS, Coagulase-negative Staphylococci; SA, Staphylococcus aureus

CL, contact lens; OSD, ocular surface disease; BCVA, best corrected visual acuity; SD, standard deviation; logMAR, logarithm of the Minimum Angle of Resolution; CoNS, Coagulase-negative Staphylococci; SA, Staphylococcus aureus

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Data Availability

The data collected and analysed in this study contains sensitive information and is therefore not publicly accessible. However, researchers may contact the corresponding author to request access to the dataset subject to appropriate review.

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