

IMPACT OF THE 2023 KAHRAMANMARAŞ
EARTHQUAKES ON INFECTION RATES AND
ANTIBIOTIC RESISTANCE IN INTENSIVE CARE
UNITS: A RETROSPECTIVE STUDY

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Abstract

Natural disasters such as earthquakes disrupt healthcare systems, increasing patient burden, infection risk, and antimicrobial resistance. This retrospective study evaluated microbiological profiles, infection rates, and antibiotic resistance among patients admitted to an internal medicine ICU before (January–December 2022) and after (February–July 2023) the 2023 Kahramanmaraş earthquakes. The unequal observation periods (12 vs. 6 months) should be considered when interpreting these findings. Adults (≥ 18 years) with ICU stay ≥ 48 hours and available culture data were included ($n = 127$). Gram-positive infections, particularly coagulase-negative staphylococci, increased significantly post-earthquake. *Klebsiella pneumoniae* showed markedly increased carbapenem resistance. Nosocomial infections (VAP, CRBSI) rose, and mortality increased from 14.5% to 18.2%. However, a direct causal relationship cannot be established due to the retrospective design and limited sample size. These findings underscore the need for disaster-resilient infection control and antimicrobial stewardship strategies.

Key words: natural disasters, nosocomial infections, antimicrobial resistance, intensive care unit, carbapenem resistance, MDR organisms

Introduction. Natural disasters such as earthquakes can overwhelm health-care systems, leading to overcrowding, disrupted supply chains, and reduced capacity for infection control. These conditions, together with increased empirical broad-spectrum antibiotic use and environmental contamination, may facilitate the emergence and spread of multidrug-resistant (MDR) organisms. MDR organisms are defined per international consensus criteria as non-susceptibility to at least one agent in three or more antimicrobial categories [1–3]. In intensive care units (ICUs), high patient density and staff workload further increase the risk of healthcare-associated infections (HAIs) [4, 5].

On February 6, 2023, two major earthquakes (Mw 7.7 and 7.6) struck Türkiye, centred in Kahramanmaraş [6]. Our hospital is located in the affected region and directly received earthquake victims. ICU occupancy increased by approximately 35% following the earthquakes, with concurrent changes in staffing ratios and temporary modifications to infection-control protocols due to resource constraints. This study evaluated changes in microbiological profiles, infection patterns, and antimicrobial resistance among patients admitted to the internal medicine ICU before and after the earthquake.

Methods. This retrospective study was conducted in the internal medicine ICU of a university hospital following ethics approval. Patients admitted during pre-earthquake (January–December 2022) and post-earthquake (February–July 2023) periods were evaluated. Adults (≥ 18 years) with ICU stay ≥ 48 hours, suspected infection, and available culture sampling were included; those with ICU stay < 48 hours or missing data were excluded.

The unequal observation periods (12 vs. 6 months) reflect the natural design constraint, as the post-earthquake period was defined until patient flow returned to baseline. To account for this, infection rates were also calculated per 1000 patient-days. This asymmetry is acknowledged as a limitation.

Blood, sputum, urine, and tracheal aspirate cultures were obtained per routine clinical protocols. Antimicrobial susceptibility testing was performed with disk diffusion and MIC methods per CLSI standards [7]. MIC determinations used broth microdilution (manual) and/or automated Vitek[®]2. Although EUCAST is increasingly adopted internationally, CLSI was the institutional standard during the study period; results are reported accordingly. Molecular characterization of carbapenemase types (OXA-48, KPC, NDM) was not performed – acknowledged as a limitation. Antibiotic consumption data were not systematically available in a format suitable for DDD analysis; this is acknowledged as a significant limitation.

Statistical analysis. Data were analyzed using SPSS v21. Continuous variables are reported as mean $\pm$ SD or median (IQR); categorical variables as n (%). Comparisons used Student's t -test or Mann–Whitney U test, and chi-square or Fisher's exact test as appropriate. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for key outcomes including VAP, CRBSI, and mortality. Statistical significance was set at $p < 0.05$ (Bonferroni correction where applicable).

Results. A total of 127 patients were included: 83 pre-earthquake and 44 post-earthquake. Demographic characteristics did not differ significantly between groups. Mean age was 74.81 ± 15.19 pre-earthquake and 71.18 ± 11.82 post-earthquake ($p = 0.21$). Significant changes were observed in microbiological sample distribution (Table 1).

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Microbiological characteristics comparison

Microbiological characteristics	Pre-EQ (n=167)	Post-EQ (n=128)	p-value
Sample type			
Sputum	79 (47.3%)	44 (34.4%)	0.008
Urine	49 (29.3%)	33 (25.8%)	
Blood	39 (23.4%)	51 (39.8%)	
Organism types			
Gram-positive	38 (22.8%)	47 (36.7%)	0.031
Gram-negative	105 (62.9%)	65 (50.8%)	
Fungi	24 (14.4%)	16 (12.5%)	
Organism species			
<i>Acinetobacter baumannii</i>	17 (10.2%)	9 (7.0%)	0.027
<i>Acinetobacter calcoaceticus</i>	22 (13.2%)	15 (11.7%)	
<i>Enterococcus durans</i>	1 (0.6%)	0 (0.0%)	
<i>Enterococcus faecalis</i>	7 (4.2%)	8 (6.3%)	
<i>Enterococcus faecium</i>	6 (3.6%)	6 (4.7%)	
<i>Escherichia coli</i>	31 (18.6%)	8 (6.3%)	
<i>Klebsiella pneumoniae</i>	18 (10.8%)	23 (18.0%)	
<i>Pseudomonas aeruginosa</i>	17 (10.2%)	10 (7.8%)	
<i>Staphylococcus aureus</i>	6 (3.6%)	3 (2.3%)	
Coagulase-negative staphylococci	18 (10.8%)	30 (23.4%)	

Pre-EQ: Pre-earthquake; Post-EQ: Post-earthquake

Blood sample collection increased from 23.4% to 39.8% post-earthquake ($p < 0.05$). Sputum samples decreased from 47.3% to 34.4% ($p < 0.05$). Gram-positive organisms increased from 22.8% to 36.7% ($p = 0.031$), mainly due to coagulase-negative staphylococci. TMP-SMX susceptibility among Gram-positive isolates declined from 50.0% to 23.5% ($p = 0.041$); susceptibility to vancomycin, linezolid, and daptomycin remained $>90\%$ (Table 2).

Among gram-negative isolates, resistance increased significantly (Table 3). Ampicillin resistance rose from 77.6% to 96.8% ($p = 0.043$); ertapenem resistance from 34.0% to 64.5% ($p = 0.016$); meropenem resistance from 58.4% to 76.6% ($p = 0.026$); PIP-TAZ resistance from 47.0% to 73.2% ($p = 0.004$).

In *Klebsiella pneumoniae*, meropenem resistance increased from 47.1% to 82.6% ($p = 0.042$), and ertapenem resistance from 52.9% to 78.3%. *Escherichia coli* resistance profiles remained relatively stable (Table 4). The increase in

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Antibiotic susceptibility and resistance – Gram-positive isolates

Antibiotic	Pre-EQ S % (n)	Pre-EQ R % (n)	Post-EQ S % (n)	Post-EQ R % (n)	p-value
Ampicillin	42.9 (6)	57.1 (8)	42.9 (6)	57.1 (8)	1.000
Ciprofloxacin	21.4 (3)	78.6 (11)	21.4 (3)	78.6 (11)	1.000
Gentamicin	44.1 (15)	55.9 (19)	45.0 (18)	55.0 (22)	1.000
Levofloxacin	40.5 (15)	59.5 (22)	27.9 (12)	72.1 (31)	0.340
TMP-SMX	50.0 (18)	50.0 (18)	23.5 (8)	76.5 (26)	0.041
Amikacin	0.0 (0)	100.0 (13)	0.0 (0)	100.0 (13)	–
Vancomycin	91.9 (34)	8.1 (3)	97.7 (42)	2.3 (1)	0.504
Clindamycin	40.0 (12)	60.0 (18)	24.3 (9)	75.7 (28)	0.267
Daptomycin	100.0 (35)	0.0 (0)	100.0 (31)	0.0 (0)	–
Erythromycin	26.1 (6)	73.9 (17)	38.1 (8)	61.9 (13)	0.596
Fusidic acid	10.0 (2)	90.0 (18)	24.0 (6)	76.0 (19)	0.486
Nitrofurantoin	36.4 (4)	63.6 (7)	20.0 (2)	80.0 (8)	0.730
Cefoxitin	10.0 (3)	90.0 (27)	10.0 (4)	90.0 (36)	1.000
Linezolid	97.2 (35)	2.8 (1)	93.0 (40)	7.0 (3)	0.739
Oxacillin	17.4 (4)	82.6 (19)	13.8 (4)	86.2 (25)	1.000
Rifampin	51.9 (14)	48.1 (13)	47.2 (17)	52.8 (19)	0.913
Tetracycline	63.0 (17)	37.0 (10)	66.7 (18)	33.3 (9)	1.000
Teicoplanin	91.9 (34)	8.1 (3)	97.7 (42)	2.3 (1)	0.504

S: Susceptible; R: Resistant; Pre-EQ: Pre-earthquake; Post-EQ: Post-earthquake;
 TMP-SMX: Trimethoprim-sulphamethoxazole

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Antibiotic susceptibility and resistance – Gram-negative isolates

Antibiotic	Pre-EQ S % (n)	Pre-EQ R % (n)	Post-EQ S % (n)	Post-EQ R % (n)	p-value
Ampicillin	22.4 (11)	77.6 (38)	3.2 (1)	96.8 (30)	0.043
Ertapenem	66.0 (31)	34.0 (16)	35.5 (11)	64.5 (20)	0.016*
Ceftazidime	80.0 (12)	20.0 (3)	60.0 (6)	40.0 (4)	0.524
Ciprofloxacin	47.1 (8)	52.9 (9)	60.0 (6)	40.0 (4)	0.812
Colistin	92.1 (70)	7.9 (6)	84.0 (42)	16.0 (8)	0.260
Ceftriaxone	31.9 (15)	68.1 (32)	16.7 (5)	83.3 (25)	0.222
Cefazolin	15.4 (6)	84.6 (33)	7.4 (2)	92.6 (25)	0.553
Levofloxacin	4.0 (1)	96.0 (24)	0.0 (0)	100.0 (22)	1.000
Meropenem	41.6 (42)	58.4 (59)	23.4 (15)	76.6 (49)	0.026
TMP-SMX	29.7 (11)	70.3 (26)	33.3 (8)	66.7 (16)	0.989
PIP-TAZ	53.0 (44)	47.0 (39)	26.8 (15)	73.2 (41)	0.004
Amikacin	43.6 (24)	56.4 (31)	44.1 (15)	55.9 (19)	1.000
Cefixime	23.1 (3)	76.9 (10)	60.0 (3)	40.0 (2)	0.352

S: Susceptible; R: Resistant; Pre-EQ: Pre-earthquake; Post-EQ: Post-earthquake;
 PIP-TAZ: Piperacillin-tazobactam; * $p < 0.05$

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Antibiotic susceptibility/resistance – *E. coli* and *K. pneumoniae*

Antibiotic	<i>E. coli</i> Pre-EQ S/R%(n)	<i>E. coli</i> Post-EQ S/R%(n)	<i>p</i>	<i>K. pneu.</i> Pre-EQ S/R%(n)	<i>K. pneu.</i> Post-EQ S/R%(n)	<i>p</i>
Ampicillin	32.3(10)/67.7(21)	12.5(1)/87.5(7)	0.505	5.6(1)/94.4(17)	0.0(0)/100(23)	0.901
Ertapenem	76.7(23)/23.3(7)	75(6)/25(2)	1.000	47.1(8)/52.9(9)	21.7(5)/78.3(18)	0.171
Colistin	100(14)/0(0)	100(3)/0(0)	–	66.7(8)/33.3(4)	61.9(13)/38.1(8)	1.000
Ceftriaxone	36.7(11)/63.3(19)	42.9(3)/57.1(4)	1.000	23.5(4)/76.5(13)	8.7(2)/91.3(21)	0.395
Cefazolin	20.8(5)/79.2(19)	20(1)/80(4)	1.000	6.7(1)/93.3(14)	4.5(1)/95.5(21)	1.000
Meropenem	86.2(25)/13.8(4)	71.4(5)/28.6(2)	0.706	52.9(9)/47.1(8)	17.4(4)/82.6(19)	0.042
PIP-TAZ	92.6(25)/7.4(2)	80(4)/20(1)	0.958	37.5(6)/62.5(10)	21.1(4)/78.9(15)	0.486
Cefixime	22.2(2)/77.8(7)	75(3)/25(1)	0.217	25(1)/75(3)	0(0)/100(1)	1.000

S/R: Susceptible/Resistant; Pre-EQ: Pre-earthquake; Post-EQ: Post-earthquake;
PIP-TAZ: Piperacillin-tazobactam.

carbapenem-resistant *K. pneumoniae* may reflect clonal spread under selection pressure from empirical carbapenem use during the post-earthquake period; however, molecular typing was not available to confirm this.

Nosocomial infections increased post-earthquake. VAP rose from 21% to 35% (OR 2.02; 95% CI 0.98–4.14; $p = 0.057$), and CRBSI from 17.8% to 29.5% (OR 1.93; 95% CI 0.87–4.28; $p = 0.103$). Although these increases did not reach statistical significance, the magnitude of effect is clinically meaningful. The study was likely underpowered to detect these differences. Overall mortality increased from 14.5% to 18.2% (OR 1.30; 95% CI 0.52–3.27; $p = 0.58$). Mortality increased numerically; however, this difference was not statistically significant, and the study was not designed to identify factors independently associated with mortality. This finding should be interpreted with caution.

Discussion. This study is the first to investigate changes in microbiological profiles and antibiotic resistance in an internal medicine ICU following the 2023 Kahramanmaraş earthquakes. Although Gram-negative bacteria remained predominant in the post-earthquake period, a significant increase in Gram-positive isolates and higher MDR pathogen resistance rates were observed.

Previous studies have reported wound infections involving Gram-positive organisms (staphylococci, streptococci) and Gram-negative bacteria (*Acinetobacter*, *Pseudomonas*, *Klebsiella*), and sometimes anaerobes and fungi [8]. YEŞİL et al. [9] reported 81% Gram-negative infections within the first month post-earthquake. KEVEN et al. [10] identified Gram-negative bacteria and staphylococci as predominant after the Marmara earthquake. Infections have been reported as a significant complication in post-earthquake intensive care patients [11]. KAYA et al. [12] confirmed Gram-negative predominance in a multicentre post-Kahramanmaraş study. The relatively higher Gram-positive proportion in our cohort may reflect inclusion

of all ICU infections (not only soft tissue) and frequent patient transfers during the early disaster phase.

Natural disasters increase hospital infections and resistance due to infrastructure damage, displacement, and overloaded healthcare systems [10,13,14]. Despite the increase in TMP-SMX resistance, linezolid susceptibility (about 90%) was preserved, consistent with Yeşil et al. [9]. The increased PIP-TAZ resistance in *Klebsiella pneumoniae* is consistent with previous antimicrobial susceptibility studies in disaster victims and infection reports in patients with post-earthquake musculoskeletal injuries [13,15]. The dramatic rise in carbapenem-resistant *K. pneumoniae* is a major clinical concern. Although molecular characterization was unavailable, this pattern is consistent with carbapenemase-producing strains (OXA-48, KPC, or NDM), increasingly reported in Turkish ICUs. Confirmation of carbapenemase type is essential for appropriate therapy and infection control.

Mortality increased numerically from 14.5% to 18.2% ($p = 0.58$; OR 1.30; 95% CI 0.52–3.27). As this difference was not statistically significant and multivariable analysis was not performed, a causal relationship between earthquake-related infection patterns and mortality cannot be established. These findings emphasize the importance of strengthening infection control and rational antimicrobial use in post-disaster settings.

Limitations. This retrospective single-centre analysis is subject to data collection bias. The unequal observation periods (12 vs. 6 months) may introduce seasonal bias; per-1000-patient-day rates are recommended. The small post-earthquake sample limits power for VAP, CRBSI, and mortality comparisons. Molecular characterization was unavailable, limiting analysis of clonal spread. Antibiotic consumption data were not available for DDD analysis. CLSI rather than EUCAST was used, limiting comparability with some European studies.

Conclusion. This study provides insights into the impact of the 2023 Kahramanmaraş earthquakes on ICU infection control, antibiotic resistance, and patient outcomes. While a temporal association between the earthquakes and worsening microbiological profiles was observed, causal inference is limited by the retrospective design and sample size. Disaster-resilient healthcare systems and strengthened infection prevention are critical. Future research should employ larger multicentre cohorts with molecular epidemiology and antibiotic stewardship data.

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