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Prevalence of healthcare-associated infections and antimicrobial use in Kazakhstan: results of the first nationwide survey in 2023

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Abstract

Background There is a paucity of studies investigating the prevalence of healthcare-associated infections and antimicrobial use at a national level in Kazakhstan. Therefore, this study aims to address this gap by reporting the results of the first nationwide investigation into healthcare-associated infections and antimicrobial use in acute care hospitals.

Methods A point-prevalence survey was conducted in 26 acute care hospitals across Kazakhstan in June 2023. The methodology strictly adhered to Protocol 5.3 of the European Centre for Disease Prevention and Control. The sample consisted of 8,076 patients.

Results The overall rate of healthcare-associated infections was 2.4%, with 42.9% occurring in surgical wards. Pneumonia was the most common type of healthcare-associated infection (25.0%), followed by surgical site infections (13.2%), and gastrointestinal tract infections (11.8%). Antimicrobial use was reported in 40.2% of patients, with cephalosporins being the most frequently prescribed pharmacological group (59.7%). Resistance to third-generation cephalosporins was the most commonly observed resistance in microorganisms isolated from HAI cases (47.6%).

Conclusions Kazakhstan needs to continue implementing infection prevention and control measures and foster the development of antimicrobial stewardship programs tailored to the specific needs of its hospitals.

Keywords Antimicrobial use, Healthcare-associated infections, Point-prevalence survey, Acute-care hospital, Kazakhstan

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Background

Healthcare-associated infections (HAIs), infections acquired while receiving medical care, constitute a significant global health problem, as they are often associated with increased morbidity, mortality, and healthcare costs [1]. According to the World Health Organization (WHO), 7 out of every 100 patients hospitalized in acute care hospitals in high-income countries and 15 out of every 100 patients hospitalized in acute care hospitals in low- and middle-income countries (LMICs) acquire at least one HAI during their hospital stay. Among these patients, 1 in 10 will eventually die as a result of the HAI [2]. The burden of HAIs is considerable. In the European Union, it is estimated that HAIs result in an additional 16 million hospital days and over 37,000 attributable deaths annually [1]. In the United States, more than 680,000 HAIs occur annually in acute care hospitals, leading to approximately 72,000 deaths each year [3]. Strengthening infection prevention and control (IPC) strategies are essential to reduce the incidence and impact of HAIs [4].

Antimicrobial use (AMU) in hospitals is a critical aspect of modern healthcare, but it is also a major driver of HAIs and the development of antimicrobial resistance (AMR) when used inappropriately. Hospitals account for a substantial share of total antimicrobial consumption [5]. Misuse and overuse of antimicrobials in healthcare settings are common and may contribute to the rise of multidrug-resistant organisms, which complicate IPC efforts [6]. It is estimated that around 30–50% of prescribed antimicrobials in hospitals in high-income countries are inappropriate, while in LMICs, this proportion is likely to be even higher due to limited access to antimicrobial stewardship (AMS) programs and diagnostic capacity [7]. Therefore, there is a critical need to investigate factors influencing inappropriate AMU in hospitals, particularly in LMICs, to develop effective AMS strategies.

Kazakhstan is a LMIC located in Central Asia with a population of approximately 20 million people. The country gained independence in 1991 following the dissolution of the Union of Soviet Socialist Republics (USSR). Its healthcare system follows the Semashko model, which continues to influence the current system, including an overreliance on hospital facilities and the overtreatment of patients [8]. Kazakhstan monitors antimicrobial consumption at the national level and has even conducted a pilot point-prevalence (PPS) study on the prevalence of HAIs and AMU in acute care hospitals [9]. However, there is a paucity of studies investigating the prevalence of HAIs and AMU at a national level. Therefore, there is a need for studies addressing this gap.

Materials and methods

Study aim

This study aims to report the results of the first nationwide investigation into HAIs and AMU in acute care hospitals in Kazakhstan.

Study design and settings

This PPS was conducted by a team from the National Center of Public Health (NCPH) under the supervision and with the technical assistance of the WHO country office. Prior to data collection, training was provided to all data collectors and representatives from participating hospitals. Data collection was carried out simultaneously in all hospitals during June 2023 and did not exceed two weeks per hospital. The methodology described in the protocol for the Point Prevalence Survey of Healthcare-Associated Infections and Antimicrobial Use in European Acute Care Hospitals, version 5.3 of the European Centre for Disease Prevention and Control (ECDC), was strictly followed [10].

The selection of hospitals was conducted to ensure representation from all 17 administrative units of Kazakhstan, as well as the three cities of national importance, which have the status of administrative units. An acute-care hospital was defined as a hospital with acute care wards. A hospital's voluntary decision to participate served as an inclusion criterion. According to Ministry of Health (MoH) reports, there were 487 hospitals in the country in 2023; however, the number of acute-care facilities and their distribution by type (e.g., tertiary, regional, district) was not reported [11]. In total, 26 hospitals were included in the study. According to ECDC protocol version 5.3, a minimum of 25 hospitals is required for national PPS representativeness [10]. Furthermore, MoH data indicate that the hospital healthcare network comprised 91,696 beds in 2023 [11], of which 11,975 (13.1%) were covered by this study.

The geographical distribution of hospitals is illustrated in Additional Fig. 1, while Additional Table 1 lists the hospitals along with their type, size, number of beds, and contribution to the overall sample (see Additional file 1).

Data collection

All patients, regardless of age, admitted to the participating hospitals were included. The exclusion criteria were visits to outpatient departments, admissions to day-care departments or wards, emergency rooms, or outpatient dialysis wards. Eight o'clock in the morning was used as the definitive time for patient inclusion. A patient was included if they were admitted to the ward before or at 8 a.m. and had not been discharged from the ward at the time of the survey. Similarly, neonates were included if they were born before or at 8 a.m [10]. In Kazakhstan, dialysis departments are often integrated into

Table 1 General characteristics of patients included in the study ($n = 8076$)

Characteristics		Antimicrobial use			Healthcare-associated infection		
		Antimicrobial agents not used ($n = 4825$) *N* (%)	Antimicrobial agents used ($n = 3250$) *N* (%)	*P*-value	HAI* is absent ($n = 7879$) *N* (%)	HAI* is present ($n = 196$) *N* (%)	*P*-value
Age, years	Median (25th ; 75th percentiles)	37.36 (12.00; 61.00)	34.42 (8.00; 58.00)	< 0.001[0]	36.31 (11.00; 60.00)	30.88 (0.25; 60.75)	0.001[0]
Age group, years	< 18	1528 (31.7)	1147 (35.3)	< 0.001[®]	2585 (32.8)	90 (45.9)	0.001[®]
	18–29	488 (10.1)	312 (9.6)		789 (10.0)	11 (5.6)	
	30–45	703 (14.6)	567 (17.4)		1245 (15.8)	25 (12.8)	
	46–64	1158 (24.0)	673 (20.7)		1797 (22.8)	34 (17.3)	
	65–75	717 (14.9)	405 (12.5)		1100 (14.0)	22 (11.2)	
	> 75	232 (4.8)	146 (4.5)		364 (4.6)	14 (7.1)	
Sex	Male	2098 (43.5)	1667 (51.3)	< 0.001[®]	3662 (46.5)	93 (47.4)	0.174
	Female	2701 (56.0)	1577 (48.5)		4185 (53.1)	103 (52.6)	
	Unknown	27 (0.5)	6 (0.2)		33 (0.4)	0 (0.0)	
Type of ward	Medical	3013 (62.4)	1189 (36.6)	< 0.001[®]	4130 (52.4)	72 (36.7)	< 0.001[®]
	Surgical	1708 (35.4)	1855 (57.1)		3479 (44.1)	84 (42.9)	
	Intensive Care	105 (2.2)	206 (6.3)		271 (3.4)	40 (20.4)	

*HAI, healthcare-associated infection

[0]test of difference was Mann-Whitney U

[®]test of difference was Pearson's Chi-Square

hospital facilities, and same-day treatments or surgeries are frequently provided within hospitals [11]. However, although these patients occupied beds in acute-care hospitals, they were not covered by the PPS. Consequently, only 8,076 out of 11,975 beds in the 26 hospitals included in this PPS (67%) were covered.

Upon arrival at each ward, the study team requested a patient list and determined which hospitalized patients met the inclusion criteria. All patients were first examined for the presence of invasive devices (e.g., urinary catheter, peripheral venous catheter, central venous catheter, or ventilator). Subsequently, a set of clinical notes for each patient (including medical, nursing, observation, drug, wound/pressure, and stool charts) was collected and reviewed. If the documentation was unclear, signs and symptoms were clarified with the nursing or medical team, and a decision regarding the presence or absence of HAI as well as AMU was made. AMU was defined as the use of one or more antimicrobials on the day of data collection, with the exception of surgical prophylaxis, which was defined as AMU within 24 h of the data collection period. The presence of HAI was recorded if there was an active infection at the time of data collection or if ongoing treatment for a previous infection was documented. When available, microbiology results were retrieved for all HAIs, and only resistance to specific antimicrobials was included in the analysis.

Statistical analysis

The study dataset comprised continuous and categorical variables. For continuous variables, the normality of distribution was evaluated at an initial stage. The Kolmogorov–Smirnov test, as well as histograms and Q–Q plots, were utilized for this purpose. As the data distribution differed from normal, the variables were presented as the median with the first and third quartiles (25th and 75th percentiles). Between-group comparisons were carried out using the Mann–Whitney U test. Categorical variables were presented as counts (N) and percentages (%), and Pearson's or Likelihood Ratio chi-square tests were used for between-group comparisons. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software, version 24 (Armonk, NY: IBM Corporation), with the significance level for all statistical tests pre-set at 0.05.

All antimicrobial agents used were classified according to their pharmacological groups: cephalosporins, aminoglycosides, fluoroquinolones, imidazoles, penicillins, carbapenems, macrolides, beta-lactams, sulfonamides and their combinations, and antifungals. Tetracyclines, amphenicols, glycopeptides, polymyxins, oxazolidinones, and nitrofuran derivatives were grouped under a broad category of 'other antibacterials' since they were used relatively infrequently. Three broad categories — medical, surgical, and intensive care unit (ICU)—were used to classify all hospital wards. The additional Table 2 presents the categorization used for the types of hospital wards.

Results

The mean length of hospital stay until PPS was 6.27 days (SD 8.16), while the median was 4.0 days. Systemic antimicrobials were administered to 40.2% of hospitalized

Table 2 Distribution of antimicrobials prescribed by the ward type ($n=4140$)

Characteristics		Type of ward			*P*-value*
		Medical ($n=1550$) *N* (%)	Surgical ($n=2283$) *N* (%)	ICU® ($n=307$) *N* (%)	
Pharmacological group	Cephalosporins	796 (51.4)	1561 (68.4)	114 (37.1)	$P<0.001$
	Aminoglycosides	123 (7.9)	183 (8.0)	28 (9.1)	
	Fluoroquinolons	94 (6.1)	168 (7.4)	39 (12.7)	
	Imidazoles	62 (4.0)	200 (8.8)	18 (5.9)	
	Penicillins	123 (7.9)	27 (1.2)	18 (5.9)	
	Carbapenems	68 (4.4)	39 (1.7)	40 (13.0)	
	Macrolides	61 (3.9)	42 (1.8)	2 (0.7)	
	Beta-lactam	50 (3.2)	17 (0.7)	14 (4.6)	
	Sulfonamides and their combinations	56 (3.6)	2 (0.1)	1 (0.3)	
	Other antibacterials	32 (2.1)	30 (1.3)	17 (5.5)	
	Antifungals	85 (5.5)	14 (0.6)	16 (5.2)	
Route of administration	Parenteral	1420 (91.6)	2209 (96.9)	305 (99.3)	$P<0.001$
	Oral	118 (7.6)	71 (3.1)	1 (0.3)	
	Inhalation	5 (0.3)	2 (0.1)	1 (0.3)	
	Rectal	6 (0.4)	1 (0.0)	0 (0.0)	
	Unknown	1 (0.1)	0 (0.0)	0 (0.0)	
Indication	Treatment intention for community-acquired infection	1101 (71.0)	549 (24.0)	108 (35.2)	$P<0.001$
	Surgical prophylaxis, >1 day	75 (4.8)	1154 (50.5)	53 (17.3)	
	Medical prophylaxis	277 (17.9)	232 (10.2)	69 (22.5)	
	Surgical prophylaxis, single dose	1 (0.1)	163 (7.1))	4 (1.3)	
	Surgical prophylaxis, one day	4 (0.3)	49 (2.1)	0 (0.0)	
	Treatment intention for acute hospital-acquired infection	69 (4.5)	110 (4.9)	48 (15.6)	
	Unknown indication	15 (0.9)	18 (0.8)	10 (3.3)	
	Treatment intention for infection acquired in long-term care facility	8 (0.5)	3 (0.1)	14 (4.6)	
	Other indication	0 (0.0)	5 (0.2)	1 (0.3)	
Diagnoses for which antimicrobial agents were administered	Unknown	415 (26.8)	1688 (74.0)	154 (50.2)	$P<0.001$
	Pneumonia	497 (32.1)	20 (0.9)	65 (21.2)	
	Bronchitis	158 (10.2)	29 (1.3)	6 (2.0)	
	Symptomatic UTI$^{\infty}$	129 (8.3)	65 (2.9)	2 (0.7)	
	Infections of ear, mouth, nose, throat or larynx	106 (6.9)	133 (5.9)	5 (1.6)	
	Cellulitis, wound	39 (2.5)	105 (4.6)	15 (4.9)	
	Systematic inflammatory response	72 (4.6)	4 (0.2)	6 (2.0)	
	Surgical site infection	8 (0.5)	71 (3.1)	3 (1.0)	
	Obstetric or gynaelogical infections	0 (0.0)	77 (3.4)	1 (0.3)	
	Clinical sepsis	12 (0.8)	12 (0.5)	31 (10.1)	
	Gastrointestinal infections	38 (2.5)	7 (0.3)	2 (0.7)	
	Cardiovascular infections	7 (0.5)	31 (1.4)	2 (0.7)	
	Febrile neutropaenia	30 (1.9)	0 (0.0)	0 (0.0)	
	Infections of the CNS^{0}	14 (0.9)	13 (0.6)	8 (2.6)	
	Septic arthritis	14 (0.9)	11 (0.4)	0 (0.0)	
	Intra-abdominal sepsis	7 (0.5)	12 (0.5)	6 (2.0)	
	Asymptomatic bactreriuria	1 (0.1)	3 (0.1)	0 (0.0)	
	Lab-confirmed bacteraemia	2 (0.1)	0 (0.0)	1 (0.3)	
	Endophtalmitis	0 (0.0)	1 (0.0)	0 (0.0)	
	Prostatitis, epididymoorchitis	0 (0.0)	1 (0.0)	0 (0.0)	
	Cystic Fibrosis	1 (0.1)	0 (0.0)	0 (0.0)	

Table 2 (continued)

Characteristics		Type of ward			*P*-value*
		Medical (*n* = 1550) *N* (%)	Surgical (*n* = 2283) *N* (%)	ICU® (*n* = 307) *N* (%)	
Reasoning notes	No	797 (51.5)	1607 (70.8)	182 (59.5)	*P* < 0.001
	Yes	725 (46.9)	533 (23.5)	123 (40.2)	
	Unknown	27 (1.7)	128 (5.6)	1 (0.3)	
Antimicrobial Changed	No change	1366 (88.2)	2093 (91.7)	236 (76.9)	*P* < 0.001
	Escalation	168 (10.8)	95 (4.2)	59 (19.2)	
	Unknown	5 (0.3)	86 (3.8)	4 (1.3)	
	Change for other reason	9 (0.6)	5 (0.2)	1 (0.3)	
	De-escalation	1 (0.1)	1 (0.0)	7 (2.3)	
	Adverse effects	0 (0.0)	2 (0.1)	0 (0.0)	

*Test of difference was Likelihood Ratio Chi-Square

®Intensive Care Unit

⁰Central Nervous System

ᵘᵗUrinary Tract Infection

patients (3250/8076), and HAIs were identified in 2.4% of hospitalized patients (196/8076). Patients receiving antimicrobials were generally younger than those not receiving antimicrobials (median age: 34.42 vs. 37.76 years, respectively). Similarly, patients with HAIs were younger than those without HAIs (median age: 30.88 vs. 36.31 years, respectively). Most antimicrobials were administered to patients hospitalized in surgical wards (57.1%), and a similar trend was observed for HAIs, which were more common among patients hospitalized in surgical wards (42.9%) (Table 1).

Overall, 3250 patients who received antimicrobials were administered a total of 4140 antimicrobials (1.3 antimicrobials per patient), with a maximum of 5 antimicrobials administered to a single patient. Cephalosporins were the most common class of antimicrobials (59.7% of all antimicrobial use, or 2471/4140), with ceftriaxone being the most frequently prescribed antimicrobial. The parenteral route significantly prevailed across all types of wards, exceeding 90%. In patients hospitalized in medical and ICU wards, the main treatment intention was for community-acquired infections, whereas in patients hospitalized in surgical wards, it was for surgical prophylaxis lasting more than one day. The diagnosis for which antimicrobials were prescribed was unknown in the majority of cases (54.5%, 2257/4140), and no reasoning was documented in the accompanying medical files in 62.5% of cases (2586/4140). De-escalation of antimicrobials was practiced extremely rarely (0.3%, 9/4140) (Table 2).

A total of 196 patients with HAIs had 212 HAIs overall (1.1 HAIs per patient), with a maximum of 2 HAIs per patient. Pneumonia was the most common type of HAI in patients hospitalized in medical and ICU wards (32.9% and 42.6%, respectively), while in patients hospitalized in surgical wards, the most common HAI was a surgical site infection (27.0%, 24/89 cases). The current hospital was the most frequent site where HAIs were acquired (60.8%, 129/212) (Table 3).

Of the 212 HAI cases, cultures were ordered for 170 (80.2%), but results were either unavailable at the time of this PPS or missing from patient files in 27.6% of cases (47/170). In general, ICU wards had missing culture results in only 4 cases (8.5%), while missing culture results were reported in 34.3% of cases in medical wards and 35.7% of cases in surgical wards. *Pseudomonas aeruginosa* was the most commonly identified pathogen in ICU and medical wards (in medical wards, *Klebsiella pneumoniae* was identified as frequently as *P. aeruginosa*), while *Staphylococcus aureus* was the most commonly identified pathogen in surgical wards. Overall, resistance to at least one antimicrobial was identified in 42 of the 170 cultures ordered (24.7%). Resistance to third-generation cephalosporins was most common in medical wards, while resistance to carbapenems was most frequently identified in surgical and ICU wards (Table 4).

Discussion

This study aimed to provide the first nationwide report on HAIs and AMU in acute care hospitals in Kazakhstan using an international methodology. Comparisons between medical, surgical, and ICU wards enabled a deeper understanding of the patterns and differences in HAI prevalence, antimicrobial use, and associated microbial resistance across different hospital settings. The overall rate of HAIs was 2.4%, with 42.9% of these occurring in surgical wards. Pneumonia was the most common type of HAI, accounting for 25% of cases, followed by surgical site infections at 13.2%. Systemic antimicrobials were administered to 40.2% of hospitalized patients. Among these, 52.1% of patients in surgical wards and 66.2% of patients in ICUs received at least one

Table 3 Distribution of healthcare-associated infection cases by the ward type ($n=212$)

Characteristics		Type of ward			*P*-value*
		Medical ($n=76$), *N* (%)	Surgical ($n=89$), *N* (%)	ICU® ($n=47$), *N* (%)	
Infection site	Pneumonia	25 (32.9)	8 (9.0)	20 (42.6)	$P<0.001$
	Surgical site	4 (5.3)	24 (27.0)	0 (0.0)	
	Gastrointestinal tract	14 (18.4)	10 (11.2)	1 (2.1)	
	Eye, ear, nose, and throat	9 (11.8)	8 (9.0)	1 (2.1)	
	Disseminated infection/sepsis	5 (6.6)	2 (2.2)	9 (19.1)	
	Skin and soft tissues	2 (2.6)	9 (10.1)	1 (2.1)	
	Bloodstream/CVC∞	6 (7.9)	7 (7.9)	4 (8.5)	
	Urinary tract	3 (3.9)	3 (3.4)	4 (8.5)	
	Central nervous system	1 (1.3)	6 (6.7)	2 (4.3)	
	Lower respiratory tract	5 (6.6)	3 (3.4)	1 (2.1)	
	Bone and joint	0 (0.0)	5 (5.6)	0 (0.0)	
	Reproductive tract	0 (0.0)	4 (4.5)	1 (2.1)	
	Cardiovascular system	0 (0.0)	0 (0.0)	1 (2.1)	
	Pneumonia in neonates	1 (1.3)	0 (0.0)	1 (2.1)	
	Peripheral vascular catheter	1 (1.3)	0 (0.0)	0 (0.0)	
	Necrotizing enterocolitis	0 (0.0)	0 (0.0)	1 (2.1)	
Infection present at admission	No	41 (53.9)	36 (40.4)	23 (48.9)	0.285
	Yes	31 (40.8)	48 (53.9)	21 (44.7)	
	Unknown	4 (5.3)	5 (5.7)	3 (6.4)	
Origin of the infection	Current hospital	45 (59.2)	50 (56.2)	34 (72.3)	0.017
	Other acute care hospital	14 (18.4)	20 (22.5)	12 (25.5)	
	Other origin / unknown	16 (21.1)	19 (21.3)	1 (2.1)	
	Long-term care facility	1 (1.3)	0 (0.0)	0 (0.0)	

*Test of difference was Likelihood Ratio Chi-Square

®Intensive Care Unit

∞Central vascular catheter

antimicrobial. Cephalosporins were the most frequently prescribed pharmacological group, accounting for 59.7% of all antimicrobial use. Resistance to third-generation cephalosporins was the most frequently observed resistance in microorganisms isolated from HAI cases, comprising 47.6% of all resistance cases. The findings of this study should be discussed in light of other research on the topic.

The prevalence of HAIs identified in this study was lower than in the pilot PPS conducted one year earlier (2.4% vs. 3.8%) [9]. This difference is best explained by the different composition of study hospitals. The hospitals included in the pilot PPS were large, multidisciplinary, tertiary-level hospitals located in two metropolitan areas of Kazakhstan. In contrast, the present study had a broader hospital composition, including not only tertiary-level hospitals but also primary and secondary-level facilities, as well as specialized hospitals. This broader representation may explain the lower overall rate of HAIs observed. Two Kazakhstani studies by Viderman et al. reported HAI rates in ICU wards of 19.8% [12] and 24.7% [13], which were higher than the rate reported for ICU wards in this study (12.9%). This difference may be attributed to variations in study design and hospital context. Specifically, the studies by Viderman et al. covered an earlier time period (2014–2015), were not PPS-based, and focused on high-risk wards—ICU units in a tertiary oncology center—where patients are typically at a greater risk of acquiring HAIs [12, 13].

Comparing the prevalence of HAIs identified in this study with other studies reporting HAI prevalence in neighboring countries reveals some notable differences. A study from the Russian Federation reported an HAI rate of 11.26% [14], while a study from Ukraine reported an HAI rate of 16.4% [15]. These rates are higher than those observed in the present study, which may be attributed to the fact that both were surveillance studies, a design that tends to result in better identification of HAI cases. A PPS study conducted in the Russian Federation reported an HAI rate of 7.61% [16], which was also higher than that observed in the present study. Upper respiratory tract infections were the most commonly reported HAI in one study from Russia, while pneumonia was the most common HAI reported in the study from Ukraine [15] and another study from Russia [16], which aligns with the findings of this study. However, a key difference was observed for urinary tract infections (UTIs), which were the second most common HAI in all of the mentioned studies [14–16] but ranked only eighth in the present study. There is a need to investigate the factors contributing to these differences, particularly the potential underreporting or misclassification of UTIs in Kazakhstan.

The 2022–2023 ECDC PPS in the European Union (EU) and the European Economic Area (EEA) countries reported an average HAI prevalence of 7.1% (country range: 3.1–13.8%) [17]. This rate is higher than that observed in the present study. It is important to acknowledge that more established HAI surveillance systems in many EU/EEA countries might lead to more complete

Table 4 Microorganisms isolated from healthcare-associated infection cases and their resistance patterns ($n=170$)

Characteristics		Type of ward			*P*-value*
		Medical ($n=67$), *N* (%)	Surgical ($n=56$), *N* (%)	ICU® ($n=47$), *N* (%)	
Microorganism	Gram-positive				0.010
	Staphylococcus aureus	4 (6.0)	6 (10.7)	2 (4.3)	
	Streptococcus pyogenesis	1 (1.5)	3 (5.4)	3 (6.4)	
	Staphylococcus epidermidis	0 (0.0)	5 (8.9)	3 (6.4)	
	Streptococcus pneumoniae	2 (3.0)	0 (0.0)	0 (0.0)	
	Enterococcus faecalis	2 (3.0)	1 (1.8)	3 (6.4)	
	Streptococcus agalactiae (group B)	1 (1.5)	1 (1.8)	0 (0.0)	
	Streptococcus spp., other	0 (0.0)	2 (3.6)	0 (0.0)	
	Staphylococcus haemolyticus	0 (0.0)	0 (0.0)	1 (2.1)	
	Enterococcus spp., other	1 (1.5)	0 (0.0)	0 (0.0)	
	Other coagulase-negative staph.	1 (1.5)	0 (0.0)	0 (0.0)	
	Gram-negative				
	Pseudomonas aeruginosa	7 (10.4)	3 (5.4)	12 (25.5)	
	Klebsiella pneumoniae	7 (10.4)	1 (1.8)	5 (10.6)	
	Acinetobacter baumannii	2 (3.0)	5 (8.9)	5 (10.6)	
	Enterobacter cloacae	3 (4.5)	1 (1.8)	3 (6.4)	
	Escherichia coli	2 (3.0)	3 (5.4)	1 (2.1)	
	Enterobacter aerogenes	2 (3.0)	1 (1.8)	0 (0.0)	
	Acinetobacter haemolyticus	0 (0.0)	1 (1.8)	0 (0.0)	
	Klebsiella oxytoca	0 (0.0)	1 (1.8)	0 (0.0)	
	Proteus mirabilis	0 (0.0)	0 (0.0)	1 (2.1)	
	Stenotrophomonas maltophilia	0 (0.0)	0 (0.0)	1 (2.1)	
	Fungi				
	Candida albicans	5 (7.5)	0 (0.0)	0 (0.0)	
	Candida glabrata	0 (0.0)	0 (0.0)	1 (2.1)	
	Candida krusei	1 (1.5)	0 (0.0)	0 (0.0)	
	Other fungi	0 (0.0)	0 (0.0)	1 (2.1)	
	Sterile examination	3 (4.5)	2 (3.6)	1 (2.1)	
	Microbiology not available or missing	23 (34.3)	20 (35.7)	4 (8.5)	
Antimicrobial resistance is present	Third-generation cephalosporins	8 (11.9)	4 (7.1)	8 (17.0)	0.476
	Carbapenems	4 (6.0)	7 (12.5)	9 (19.1)	
	Glycopeptides	0 (0.0)	0 (0.0)	1 (2.1)	
	Oxacillin	0 (0.0)	0 (0.0)	1 (2.1)	

*test of difference was Likelihood Ratio Chi-Square

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case ascertainment. However, a key explanatory factor is the fundamental difference in the patient populations surveyed. This is evidenced by the mean length of stay until the PPS in the ECDC study, which was 28.2 days [17]—significantly longer than that in the present study (6.27 days). A longer duration of hospitalization is a well-established risk factor for HAIs, as it increases exposure to pathogens and the use of invasive devices [18]. This difference in patient populations is further evidenced by the low use of invasive devices observed in this study. This low utilization rate suggests a patient population with a higher prevalence of milder illness [19]. Consequently, the ECDC PPS inherently captures a patient cohort with higher acuity and complexity of care needs, who are naturally at greater risk of developing HAIs [20].

P. aeruginosa was the most frequently isolated pathogen in this study, followed by *K. pneumoniae* and *S. aureus*. In a study by Viderman et al., the most commonly isolated microorganisms were *P. aeruginosa*, *E. faecalis*, and *K. pneumoniae* [12]. The predominance of *P. aeruginosa* was also observed in a pilot PPS study [9]. In contrast, a study from Ukraine identified *E. coli*, Enterobacter spp., and *K. pneumoniae* as the predominant pathogens [15], while in a study from Russia, the leading pathogens were Klebsiella spp., *E. coli*, and *S. aureus* [16]. The microbial landscape varies significantly between countries, hospitals, and even within the same hospital

over time due to differences in healthcare practices, local epidemiology, and the implementation of IPC measures [21]. Resistance patterns are also influenced by antimicrobial consumption [22]. In the present study, resistance to third-generation cephalosporins was the most frequently observed, followed by resistance to carbapenems, which was more commonly detected in ICU wards. A study by Viderman et al. reported a similar resistance pattern, with resistance to third-generation cephalosporins and carbapenems being the most frequent [13]. Studies from Ukraine [15] and Russia [16] also reported predominant resistance to third-generation cephalosporins, followed by methicillin resistance.

The finding that the healthcare sector in Kazakhstan relies heavily on cephalosporins is not novel. An earlier nationwide evaluation of AMU revealed that ceftriaxone was the second most consumed antibiotic after azithromycin [23]. A pilot PPS also demonstrated that ceftriaxone was the most consumed antibiotic, followed by cefazolin, another cephalosporin [9]. The use of cephalosporins surged during the COVID-19 pandemic [24], a period when Kazakhstan experienced high rates of hospitalizations and widespread empirical use of antibiotics as part of COVID-19 treatment protocols [25]. A pre-pandemic study by Zhussupova et al. investigated AMU in the hospital sector during the period of 2017–2019. Doxycycline was the most consumed antibiotic, and cephalosporins ranked fourth, with cefazolin being the most consumed cephalosporin [26]. Another striking yet unsurprising finding is the predominance of parenteral administration of antibiotics, which accounted for 95% of all prescriptions. A pilot PPS reported a similar rate [9], although best international practices recommend a more judicious use of parenteral antibiotics to reduce the risk of complications and improve patient comfort [27].

Most patients receiving antibiotics in surgical and ICU wards did not have a documented diagnosis justifying their use. This could be attributed to the widespread application of both medical and surgical prophylaxis. Notably, surgical prophylaxis was frequently administered for more than one day (50.5% of patients hospitalized in surgical wards), despite current evidence recommending that prophylactic antibiotics be limited to a single preoperative dose or, at most, a 24-hour postoperative course to minimize the risk of AMR and other adverse effects [28]. Another concerning finding is the lack of antibiotic de-escalation, which aligns with results from a pilot PPS that highlighted similar issues with AMU in Kazakhstani hospitals [9]. These findings underline the urgent need for hospital AMS programs to promote more judicious use of antibiotics.

Study limitations

This study has several strengths but is not without limitations, the most significant being its sample size and reliance on a non-probability sampling approach. According to ECDC protocol version 5.3, inclusion of at least 25 hospitals is necessary to ensure good representativeness; however, this threshold is not sufficient to achieve optimal representativeness, which requires inclusion of at least 75% of all hospitals or occupied beds in the country [10]. While the exact number of acute care hospitals in Kazakhstan is not known, it is unlikely that this study covered 75% of them. Furthermore, the sampling frame consisted of hospitals that were non-randomly selected, as participation in the PPS was voluntary. Another limitation relates to potential misinterpretation of data. For more than 50% of cases, the diagnosis for which antimicrobial agents were prescribed was unknown. As a result, some indications may have been incorrectly classified as community-acquired infections.

The strengths of this study include its representative nationwide design, a substantial sample size affording strong statistical power, and data validation procedures that showed good agreement with PPS results. Technical support from the WHO country office was also instrumental in maintaining high-quality data collection. The reliable data generated are a critical first step for informing and strengthening national infection prevention, control, and antimicrobial stewardship policies. Ultimately, the implementation of such evidence-based policies is expected to improve healthcare quality, which may in turn help to restore patient trust and satisfaction—a critical need in the Kazakhstani healthcare system [29].

Conclusions

The findings of this study offer valuable insights for Kazakhstani healthcare policymakers. In particular, they highlight the need to continue implementing IPC measures and foster the development of AMS programs tailored to the specific needs of Kazakhstani hospitals. Continuous monitoring and periodic evaluations are essential to track progress and ensure that interventions effectively reduce the burden of HAIs and improve AMU practices. Moreover, this first nationwide PPS provides a critical opportunity to benchmark Kazakhstan's performance against international standards, facilitating cross-country comparisons. Kazakhstan has demonstrated a strong commitment to tackling AMR and improving healthcare quality, and this study serves as a crucial step toward strengthening national efforts and guiding future interventions in this area.

Supplementary Information

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Supplementary Material 1

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Author contributions
Manar Smagul: writing—original draft, writing - review & editing, visualization, formal analysis, conceptualization.Aizhan Yessmagambetova: writing—original draft, methodology, investigation, data curation, conceptualization. Bibigul Aubakirova: writing—review and editing, methodology, investigation, conceptualization. Yuliya Semenova: writing—original draft, formal analysis, data curationKateryna Soiak: writing—review and editing, methodology, investigationGaukhar Agazhaeva: writing—review and editing, investigation; formal analysis.Akniyet Zharylkassynova: writing—review and editing; investigation; formal analysis, data curation.Ademi Yergaliyeva: writing—review and editing; investigation; data curation.All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the National Center of Public Healthcare (Protocol #23 dated February 11, 2022). All participants gave written informed consent for participation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Haque M, Sartelli M, McKimm J, Abu Bakar M. Health care-associated infections - an overview. Infect Drug Resist. 2018;11:2321–33. https://doi.org/10.2147/IDR.S177247.
2. World Health Organization. Global report on infection prevention and control, Geneva. 2022. https://www.who.int/publications/i/item/9789240051164. Accessed 9 Feb 2025.
3. Centers for Disease Control and Prevention. National and state healthcare-associated infections progress, report A. 2022. https://www.cdc.gov/healthcare-associated-infections/media/pdfs/2022-Progress-Report-Executive-Summary-H.pdf. Accessed 9 Feb 2025.
4. Lohiya R, Deotale V. Surveillance of health-care associated infections in an intensive care unit at a tertiary care hospital in central India. GMS Hyg Infect Control. 2023;18:Doc28. https://doi.org/10.3205/dgkh000454.
5. Tamma PD, Avdic E, Li DX, Dzintars K, Cosgrove SE. Association of adverse events with antibiotic use in hospitalized patients. JAMA Intern Med. 2017;177(9):1308–15. https://doi.org/10.1001/jamainternmed.2017.1938.
6. Tang KWK, Millar BC, Moore JE. Antimicrobial resistance (AMR). Br J Biomed Sci. 2023;80:11387. https://doi.org/10.3389/bjbs.2023.11387.
7. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, Guerin PJ, Piddock LJ. Understanding the mechanisms and drivers of antimicrobial resistance. Lancet. 2016;387(10014):176–87. https://doi.org/10.1016/S0140-6736(15)00473-0.
8. Glushkova N, Semenova Y, Sarria-Santamera A, Editorial. Public health challenges in post-Soviet countries during and beyond COVID-19. Front Public Health. 2023;11:1290910. https://doi.org/10.3389/fpubh.2023.1290910.
9. Semenova Y, Yessmagambetova A, Akhmetova Z, Smagul M, Zharylkassynova A, Aubakirova B, Soiak K, Kosherova Z, Aimurziyeva A, Makalkina L, Ikhambayeva A, Lim L. Point-Prevalence survey of antimicrobial use and healthcare-associated infections in four acute care hospitals in Kazakhstan. Antibiotics. 2024;13(10):981. https://doi.org/10.3390/antibiotics13100981.
10. European Centre for Disease Prevention and Control. Point prevalence survey of healthcareassociated infections and antimicrobial use in European acute care hospitals – protocol version 5.3. Stockholm. 2016. https://www.ecdc.europa.eu/en/publications-data/point-prevalence-survey-healthcare-associated-infections-and-antimicrobial-use-3. Accessed 9 Feb 2025.
11. Salidat Kairbekova National Research Center for Health Development. Statistical yearbooks Public health in the Republic of Kazakhstan and activities of healthcare facilities.
12. Viderman D, Khamzina Y, Kaligozhin Z, Khudaibergenova M, Zhumadilov A, Crape B, Azizan A. An observational case study of hospital associated infections in a critical care unit in Astana, Kazakhstan. Antimicrob Resist Infect Control. 2018;7:57. https://doi.org/10.1186/s13756-018-0350-0.
13. Viderman D, Brotfain E, Khamzina Y, Kapanova G, Zhumadilov A, Poddighe D. Bacterial resistance in the intensive care unit of developing countries: report from a tertiary hospital in Kazakhstan. J Glob Antimicrob Resist. 2019;17:35–8. https://doi.org/10.1016/j.jgar.2018.11.010.
14. Krieger EA, Grjibovski AM, Samodova OV, Eriksen HM. Healthcare-associated infections in Northern Russia: results of ten point-prevalence surveys in 2006–2010. Med (Kaunas). 2015;51(3):193–9. https://doi.org/10.1016/j.medici.2015.05.002.
15. Salmanov A, Shchehlov D, Svyrydiuk O, Bortnik I, Mamonova M, Korniyenko S, Rud V, Artyomenko V, Gudym M, Maliarchuk R, Bondar T. Epidemiology of healthcare-associated infections and mechanisms of antimicrobial resistance of responsible pathogens in ukraine: a multicentre study. J Hosp Infect. 2023;131:129–38. https://doi.org/10.1016/j.jhin.2022.10.007.
16. Yakovlev SV, Suvorova MP, Beloborodov VB, Basin EE, Eliseev EV, Kovelenov SV, Portyagina US, Rog AA, Rudnov VA, Barkanova ON. Multicentre study of the prevalence and clinical value of hospital-acquired infections in emergency hospitals of russia: ERGINI study team. Antibiot Khimioter. 2016;61(5–6):32–42.
17. European Centre for Disease Prevention and Control. Point prevalence survey of healthcare associated infections and antimicrobial use in european acute care hospitals. European Centre for Disease Prevention and Control, Stockholm. 2024. https://www.ecdc.europa.eu/en/publications-data/PPS-HAI-AMR-acute-care-europe-2022-2023. Accessed 20 Aug 2025.
18. Sandu AM, Chifiriuc MC, Vrancianu CO, Cristian RE, Alistar CF, Constantin M, Paun M, Alistar A, Popa LG, Popa MI, Tantu AC, Sidoroff ME, Mihai MM, Marcu A, Popescu G, Tantu MM. Healthcare-associated infections: the role of microbial and environmental factors in infection Control-a narrative review. Infect Dis Ther. 2025;14(5):933–71. https://doi.org/10.1007/s40121-025-01143-0.
19. Dadi NCT, Radochová B, Vargová J, Bujdáková H. Impact of healthcare-associated infections connected to medical devices-an update. Microorganisms. 2021;9(11):2332. https://doi.org/10.3390/microorganisms9112332.
20. Urbina A, Adamuz J, Juvé-Udina ME, Peñafiel-Muñoz J, Munoa-Urruticoechea V, González-Samartino M, Delgado-Hito P, Jacob J, Romero-García M. Care complexity factors and discharge destination in an emergency department: a retrospective cohort study. Arch Acad Emerg Med. 2025;13(1):e27. https://doi.org/10.22037/aaemj.v13i1.2517.
21. Garcia R, Barnes S, Boukidjian R, Goss LK, Spencer M, Septimus EJ, Wright MO, Munro S, Reese SM, Fakih MG, Edmiston CE, Levesque M. Recommendations for change in infection prevention programs and practice. Am J Infect Control. 2022;50(12):1281–95. https://doi.org/10.1016/j.ajic.2022.04.007.
22. Saxena S, Priyadarshi M, Saxena A, Singh R. Antimicrobial consumption and bacterial resistance pattern in patients admitted in I.C.U at a tertiary care center. J Infect Public Health. 2019;12(5):695–9. https://doi.org/10.1016/j.jiph.2019.03.014.
23. Semenova Y, Yergaliyeva A, Aimurziyeva A, Manatova A, Kuntuganova A, Makalkina L, Aldiyarova N, Semenov D, Lim L. A nationwide evaluation of antibiotic consumption in Kazakhstan from 2019 to 2023. Antibiotics. 2024;13(12):1123. https://doi.org/10.3390/antibiotics13121123.
24. Balapasheva AA, Smagulova GA, Mussina AZ, Ziganshina LE, Nurgaliyeva ZZ. Pharmacoepidemiological analysis of antibacterial agents used in a provisional hospital in Aktobe, Kazakhstan, in the context of COVID-19: a

comparison with the pre-pandemic period. Antibiotics. 2023;12(11):1596. https://doi.org/10.3390/antibiotics12111596.
25. Semenova Y, Kalmatayeva Z, Oshibayeva A, Mamyrbekova S, Kudirbekova A, Nurbakyt A, Baizhaxynova A, Colet P, Glushkova N, Ivankov A, Sarria-Santamera A. Seropositivity of SARS-CoV-2 in the population of Kazakhstan: a nationwide Laboratory-Based surveillance. Int J Environ Res Public Health. 2022;19(4):2263. https://doi.org/10.3390/ijerph19042263.
26. Zhussupova G, Utepova D, Orazova G, Zhaldybayeva S, Skvirskaya G, Tossekbayev K. Evaluation of antibiotic use in Kazakhstan for the period 2017–2019 based on WHO access, watch and reserve classification (AWaRe 2019). Antibiotics. 2021;10(1):58. https://doi.org/10.3390/antibiotics10010058.
27. Doron S, Davidson LE. Antimicrobial stewardship. Mayo Clin Proc. 2011;86(11):1113–1123. https://doi.org/10.4065/mcp.2011.0358
28. Farrell MS, Agapian JV, Appelbaum RD, Filiberto DM, Gelbard R, Hoth J, Jawa R, Kirsch J, Kutcher ME, Nohra E, Pathak A, Paul J, Robinson B, Cuschieri J, Stein DM. Surgical and procedural antibiotic prophylaxis in the surgical ICU: an American association for the surgery of trauma critical care committee clinical consensus document. Trauma Surg Acute Care Open. 2024;9(1):e001305. https://doi.org/10.1136/tsaco-2023-001305.
29. Dauletyarova M, Semenova Y, Kaylubaeva G, Manabaeva G, Khismetova Z, Akilzhanova Z, Tussupkaliev A, Orazgaliyeva Z. Are women of East Kazakhstan satisfied with the quality of maternity care? Implementing the WHO tool to assess the quality of hospital services. Iran J Public Health. 2016;45(6):729–38.

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