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Major Article

Prevalence of health care–associated infections and antimicrobial resistance of the responsible pathogens in Ukraine: Results of a multicenter study (2014-2016)

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Key Words
Prevalence
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Background: The aim of this study was to obtain the first national estimates of the current prevalence and incidence and death of health care–associated infections (HAIs) of all types in acute care hospitals in Ukraine.
Methods: Prospective surveillance was conducted from January 2014 to December 2016 in 17 hospitals. Surveillance case definitions were derived from the Centers for Disease Control and Prevention's National Healthcare Safety Network HAI case definitions. The identification and antimicrobial susceptibility of cultures were determined using a automated microbiology analyzer. Some antimicrobial susceptibility tests used Kirby-Bauer antibiotic testing.
Results: Of 97,340 patients, 10,986 (11.3%) HAIs were observed. The most frequently reported HAI types were surgical site infections (60%), respiratory tract infections (pneumonia and lower respiratory tract, 18.4%), bloodstream infections (10.2%), and urinary tract infections (9.5%). Death during hospitalization was reported in 9.7% of HAI cases. The most common organism reported was *Escherichia coli*, accounting for 21.8% of all organisms, followed by *Staphylococcus aureus* (18.4%), *Enterococcus* spp (15.7%), and *Pseudomonas aeruginosa* (12.4%). Antimicrobial resistance among the isolates associated with HAIs showed that 42.1% and 3.6% of coagulase-negative *Staphylococcus* spp isolates were β-lactam (oxacillin)– and glycopeptide (teicoplanin)-resistant, respectively. Meticillin resistance was reported in 39.2% of *S aureus* isolates.

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Conclusions: HAIs and increasing antimicrobial resistance present a significant burden to the Ukraine hospital system. Infection control priorities in hospitals should include preventing surgical site infections, respiratory tract infections (which also include PNEU and LRTI), bloodstream infections, and urinary tract infections, as well preventing infections due to antimicrobial-resistant pathogens.

Health care–associated infections (HAIs) are a significant global threat to patient safety. HAIs are one of the most common adverse events in patient care and account for substantial morbidity and mortality.[1-6] Despite major advances in infection control interventions, HAIs remain a major public health problem and patient safety threat worldwide.[1] According to published national or multicenter studies, pooled HAI prevalence in mixed patient populations was from 3.5%-12%.[1,5-8]

HAIs annually account for 37,000 attributable deaths in Europe and potentially many more that could be related, and they account for 99,000 deaths in the United States. Annual financial losses due to HAIs are also significant, as they are estimated at approximately €7 billion in Europe, including direct costs only and reflecting 16 million extra days of hospital stay, and approximately $6.5 billion in the United States.[9]

In previous studies, variable proportions of HAIs, considered to be preventable by intensive hygiene and control programs, have been reported.[10,11] Among the infection prevention initiatives, surveillance of HAIs is the cornerstone to decrease infection rates in hospitalized patients, and it is considered to be the best way to ensure patient safety.[12] Continuous monitoring of HAI rates can be used to assess effectiveness of interventions and provides information that may be used for benchmarking comparison.[13] Owing to high morbidity and mortality caused by these infections, early diagnosis and treatment of these infections with appropriate antibiotics are essential.

In Ukraine, a national network for the prospective surveillance of HAIs in all wards is not in place. To identify specific HAI prevention targets and, therefore, reduce disparities between countries, ongoing surveillance is necessary. However, resources are severely limited in Ukraine, creating difficulties implementing surveillance and establishing effective measures for infection control and HAI prevention. In Ukraine, efforts to improve infection control training and to begin HAI surveillance have been under way. However, previous reports of HAIs in Ukraine were limited to surgical site infections (SSIs) and did not address the broad spectrum of HAIs.[14,15]

The aim of this study was to obtain the first national estimates of the current prevalence and incidence burden of HAIs in acute care hospitals in Ukraine and to assess the excess mortality attributable to HAIs, overall and separately, for main sites of infection and trace antimicrobial resistance (AMR) phenotypes and responsible pathogens.

METHODS

Setting and patients

Over a 36-month period (January 2014 to December 2016), this multicenter prospective (surveillance for HAIs) study was performed in 17 Ukrainian hospitals (64% general, 18% pediatric, and 18% women's hospitals), which are similar in terms of medical equipment, personnel, laboratory facilities, and number of beds. All participating hospitals were required to have at least 1 full-time infection control professional, a clinical microbiology laboratory with the capacity to process cultures, at least 1 intensive care unit (ICU), and a data manager. Hospital staff participating in HAI surveillance received a training course that covered topics such as HAI case definitions and diagnosis, test ordering practices for microbiology cultures, microbiology laboratory procedures, and instructions for surveillance data collection and reporting.

All eligible patients admitted from January 1, 2014, to December 31, 2015, have been included in the surveillance. Patients who were transferred to the ICU from an outside hospital are also included. Exclusion criteria were patients with a community-acquired infection, ICU stay for less than 48 h, and death within 48 h of ICU admission. The follow-up of each patient was continued until discharge, referral, or death.

Definitions

HAI was considered to be an infection developing during a hospitalization. Major and specific HAI site definitions were adapted from the Centers for Disease Control and Prevention's (CDC's) 2008 National Healthcare Safety Network (NHSN) case definitions.[16] Because of limitations in laboratory infrastructure, clinical sepsis (which is not currently included in NHSN) was included among HAIs under surveillance in neonatal intensive care units. An infection episode met HAI criteria when it occurred on or after the third calendar day in the ICU or within 2 calendar days of discharge from the ICU. Serologic and antigen test results were not included in case definitions because laboratories in participating hospitals did not have the capability to perform these tests. In addition, institution of antimicrobial treatment by a physician was not considered to be sufficient for diagnosis of an HAI because of widespread use of empiric antimicrobial therapy.

Multidrug resistance (MDR) was defined in accordance with current published interim standard definitions, which were used in the most recent NHSN AMR report.[17] Specifically, an isolate of *Acinetobacter* spp was defined as having MDR if it tested nonsusceptible (ie, resistant or intermediate) to at least 1 drug in 3 of the following 6 antimicrobial agents/groups: piperacillin or piperacillin/tazobactam, extended-spectrum cephalosporins (cefepime or ceftazidime), aminoglycosides, ampicillin/sulbactam, carbapenems, and fluoroquinolones. For *Pseudomonas aeruginosa* isolates, MDR was defined as testing nonsusceptible (ie, either resistant or intermediate) to at least 1 drug in 3 of the 5 following antimicrobial groups: piperacillin or piperacillin/tazobactam, extended-spectrum cephalosporins (cefepime or ceftazidime), fluoroquinolones, aminoglycosides, and carbapenems.

Ethics

The data were collected as a part of the hospital's infection prevalence survey. According to the Health Research Act, Ukraine, quality assurance projects, surveys, and evaluations that are intended to ensure that diagnosis and treatment actually produce the intended results do not need ethical committee approval, and patient consent is not required.

Data collection

Surveillance data on all HAIs, both inpatients and their causative pathogens, were collected retrospectively on a form specifically designed by the investigators using medical records comprising charts, daily flow sheets, and laboratory (microbiology) results. The collected data included demographics, intrinsic and extrinsic risk factors for infection, date of infection onset, clinical signs, administered antibiotics, isolated pathogens with antibiogram results, and outcome on discharge from the hospitals. The risk factors were evaluated from the time of admission until the onset of HAI.

Health care workers in hospitals screened patients for signs and symptoms of HAI during clinical rounds. HAIs were identified according to a simplified version of the definitions developed and recommended by the CDC. All types of HAIs were recorded and analyzed, including symptomatic urinary tract infection (UTI), lower respiratory tract infection (LRTI), bloodstream infection (BSI), and surgical site infection (SSI). HAIs with only a few included cases such as skin, soft-tissue infections, and gastrointestinal infections were analyzed together as "other infections." Patients with >1 type of infection simultaneously were analyzed as a separate group.

Coagulase-negative *Staphylococcus* spp and *Corynebacterium* spp were only considered pathogens when isolated from sterile sites. For BSIs specifically, "common commensal" organisms (eg, coagulase-negative staphylococci, *Bacillus* spp) were only considered pathogens if isolated from at least 2 blood cultures with signs or symptoms of a BSI, in accordance with NHSN criteria.

The following variables were recorded for each patient: gender, age, elective versus emergency admission, surgical procedure, use of urinary tract catheter (permanent and intermittent catheter), and antibiotic therapy.

Microbiological sampling

All sample isolates from HAI cases were sent to the microbiology laboratory for identification and AMR testing. The identification and antimicrobial susceptibility of the cultures were determined using the automated microbiology analyzer (VITEK 2 Compact; bioMérieux, Marcy l'Etoile, France). Susceptibility to antibiotics was determined using AST cards (bioMérieux). Some antimicrobial susceptibility tests used Kirby-Bauer antibiotic testing. Interpretative criteria were those suggested by the Clinical and Laboratory Standards Institute. All *Klebsiella* spp and *Escherichia coli* isolates were tested for extended-spectrum β-lactamase (ESBL) production by combination disk testing according to guidelines from the Clinical and Laboratory Standards Institute. Inhibition of growth with ceftazidime and cefotaxime disks was compared to ceftazidime/clavulanate and cefotaxime/clavulanate disks, respectively. Isolates were considered to be ESBL-producing if the combination disk increased the zone of inhibition by >5mm.

Statistical analysis

HAIs were analyzed as a binary exposure variable (no HAI, any HAI). We also analyzed HAIs by type of infection (no HAI, UTI, LRTI, BSI, SSI, and other HAIs), which were mutually exclusive. Statistical data analysis was performed using Microsoft Excel for Windows (Microsoft Corp, Redmond, WA). Results are expressed as median (range), mean±standard deviation for continuous variables, and the number with the corresponding percentage for qualitative variables. The primary endpoint was the epidemiology of the microorganisms isolated in intra-abdominal samples and their resistance to antibiotics. Comparisons were carried out using the Student t and the $\chi 2$ tests. Statistical significance was defined as $P < .05$. Multivariate analysis was carried out using stepwise logistic regressions to assess the predictive factors of the occurrence of death during hospitalization.

RESULTS

Patient characteristics and prevalence of HAIs

Of 97,340 patients included in the study, 10,986 patients had HAIs and 86,354 did not have HAIs. The most frequently reported HAI types were SSIs (60%), RTIs (18.4%, pneumonia [PNEU] and lower repiratory tract infection [LRTI]), BSIs (10.2%), and UTIs (9.5%). SSIs, RTIs, BSIs, and UTIs together accounted for 98.2% of all HAIs reported. Most PNEU and UTI cases were device-associated infections, and a minority of BSI cases were central line–associated infections. Of BSI, 69% occurred in patients <1 year old, of which 83% were laboratory-confirmed BSI, and the remainder (17%) had clinical sepsis.

The overall prevalence of HAIs was 11.3%, and the prevalence of the 4 most frequently recorded types of infections was the following: SSI, 6.8 % (95% confidence interval [CI], 6.7-7.0), PNEU, 2.1% (95% CI, 2.0-2.2), BSI, 1.2% (95% CI, 1.1-1.3), and UTI, 1.1% (95% CI, 1.0-1.2). Prevalence among operated patients was 19.0% (Table 1).

A general overview of the analyzed variables is shown in Table 2. Fifty-two percent of the patients were women. The overall prevalence was higher in men than in women (12.7% vs 10%) and increased with age. For the oldest patients (>74 years old), we found a prevalence of 16.7% versus 3.8 % for the youngest patients (<14 years old). A total of 34,625 (35.6%) patients had undergone surgery, and the prevalence of HAIs among operated patients was 19.0% compared with 7% for the nonoperated patients. Acute admission patients had a higher prevalence of HAIs than those with elective admission, 12.4% and 9.5%, respectively. Seventeen percent (16.7%) of the patients had urinary tract catheters (29.8% permanent and 18.2% intermittent), and 30.4% of the patients received antibiotics. We found an association between hospital stay before the date of prevalence study and the prevalence of HAIs. Charlson comorbidity index up to 3 was associated with a higher prevalence of HAI, whereas patients with a Charlson comorbidity index 4 or higher had a lower prevalence (Table 2).

Impact of HAI on inpatient mortality

Of the HAI case-patients identified, 1,067 (9.7%) died before discharge. We found that mortality was higher among men than women, whereas mortality increased with age for both men and women. Patients with acute admission to the hospital had higher mortality than patients with elective admission. Increased mortality was also related to a longer pre-prevalence period, with an exception for patients having a pre-prevalence stay of >30 days. A high Charlson comorbidity index also gave increased mortality.

Table 1
Prevalence of HAIs among 97,340 patients in Ukrainian hospitals, 2014-2016

Type of HAI	No. of HAIs	% (95% CI)
All infections	10,986	11.3 (11.2-11.4)
SSI	6,595	6.8 (6.7-7.0)
SSI*	6,595	19.0 (18.6-19.4)
PNEU	2,021	2.1 (2.0-2.2)
UTI	1,049	1.1 (1.0-1.2)
BSI	1,123	1.2 (1.1-1.3)
Other**	198	0.2 (0.16-0.24)

BSI, bloodstream infection; *CI*, confidence interval; *HAI*, health care–associated infection; *PNEU*, pneumonia; *SSI*, surgical site infection.
*Among 34,625 operated patients.
**Other infection types include bone and joint infection; central nervous system infection; cardiovascular system infection; eye, ear, nose, throat, and mouth infection; reproductive system infection; skin and soft tissue infection; and gastrointestinal tract infection.

Table 2
Characteristics of patients with and without HAIs treated in Ukrainian hospitals, 2014-2016

Characteristics	All patients n (%)	HAIs		P value*	Prevalence of HAIs (%)
		No n (%)	Yes n (%)		
All	97,340 (100)	86,354 (88.7)	10,986 (11.3)		11.3
Gender					
Men	46,640 (47.9)	40,729 (47.2)	5,911 (53.8)		12.7
Women	50,700 (52.1)	45,625 (52.8)	5,075 (46.2)		10.0
Age (y)				<.001	
0-14	10,655 (10.9)	10,244 (11.9)	411 (3.7)		3.8
15-35	12,235 (12.6)	11,646 (13.5)	589 (6.4)		4.8
36-59	16,725 (17.2)	15,322 (17.7)	1,403 (12.8)		8.4
60-74	30,565 (31.4)	26,524 (30.7)	4,041 (36.8)		13.2
>74	27,160 (27.9)	22,618 (26.2)	4,542 (41.3)		16.7
Admission type				<.001	
Acute	60,400 (62.3)	52,925 (61.3)	7,475 (68.0)		12.4
Elective	36,940 (37.7)	33,429 (38.7)	3,511 (32.0)		9.5
Surgery				<.001	
No	62,715 (64.4)	58,324 (67.5)	4,391 (40.0)		7.0
Yes	34,625 (35.6)	28,030 (32.5)	6,595 (60.0)		19.0
Urinary tract catheter				<.001	
No	81,080 (83.3)	74,610 (86.4)	6,470 (58.9)		8.0
Yes, permanent	13,410 (13.8)	9,414 (10.9)	3,996 (36.4)		29.8
Yes, intermittent	2,850 (2.9)	2,330 (2.7)	520 (4.7)		18.2
Use of antibiotics				<.001	
No	71,860 (73.8)	68,729 (79.6)	3,131 (28.5)		4.4
Yes	25,480 (26.2)	17,625 (20.4)	7,855 (71.5)		30.8
Pre-prevalence period (d)**				<.001	
2	25,910 (26.6)	24,922 (28.9)	988 (9.0)		3.8
3-5	22,685 (23.3)	21,061 (24.4)	1,624(14.8)		7.2
6-10	20,665 (21.2)	18,122 (21.0)	2,543 (23.1)		12.3
11-15	11,475 (11.8)	9,490 (11.0)	1,925 (18.1)		17.3
16-20	11,290 (11.6)	8,922 (10.3)	2,368 (21.6)		21.0
>20	5,315 (5.5)	3,837 (4.4)	1,478 (13.6)		27.8
Charlson comorbidity index†				<.001	
0	48,790 (50.3)	46,010 (51.9)	2,780 (33.6)		5.7
1	17,120 (17.7)	15,425 (17.4)	1,695 (20.5)		9.9
2	16,130 (16.6)	14,095 (15.9)	2,035 (24.6)		12.6
3	5,590 (5.8)	4,755 (5.4)	835 (10.1)		14.9
4	2,190 (2.3)	1,975 (2.2)	215 (2.6)		9.8
>4	7,110 (7.3)	6,390 (7.2)	720 (8.7)		10.1

HAIs, health care–associated infections.
*Performed by the X^2 test.
**Time from hospital admission to study inclusion.
†Information was missing for 410 patients on Charlson comorbidity index.

Following adjustment for confounding factors, we found that patients with HAIs had a significantly increased mortality risk compared to patients without HAIs. The highest mortality risk was observed in patients with BSI, followed by patients with PNEU. No increased risk of death was found in patients with UTI and SSI (Table 3).

Microorganisms causing HAI

Among all 10,986 HAIs, a total of 11,231 organisms were identified (Table 4). Considering all HAI types together, *E coli* were most commonly reported, accounting for 21.8% of all organisms, followed by *Staphylococcus aureus* (18.4% of all organisms), *Enterococcus* spp (15.7% of all organisms), and *P aeruginosa* (12.4% of all organisms). These were the same organisms reported most commonly for SSI cases. For PNEU, *Acinetobacter* spp were most commonly reported, accounting for 27.4% of all organisms, followed by *Klebsiella* spp (23.8% of all organisms). For BSI, *Klebsiella* spp were most commonly reported (26.1% of all organisms), followed by *S aureus* and coagulase-negative staphylococci (14.6% of all organisms each). In contrast, for UTI, *Candida* spp were most commonly reported (17.6% of all organisms), followed by *P aeruginosa* (16.7% of all organisms).

AMR

AMR in the isolates associated with HAIs showed, among the gram-positive bacteria, that 42.1% and 3.6% of coagulase-negative staphylococci isolates were β-lactam (oxacillin)– and glycopeptide

Table 3
Mortality in 97,340 patients with HAIs in Ukrainian hospitals, 2014-2016

Type of infection	Infections (n)	Mortality	
		n (%)	95% CI
All infections	10,986	1,067 (9.7)	9.4-10.0
UTI	1,049	92 (8.8)	7.9-9.7
LRTI	2,021	325 (16.1)	15.3-16.9
BSI	1,123	158 (14.1)	13.1-15.1
SSI*	6,595	477 (1.4)	1.3-1.5
Other**	198	15 (7.6)	5.7-9.5

BSI, bloodstream infection; *HAI*, health care–associated infection; *LRTI*, lower respiratory infection; *SSI*, surgical site infection; *UTI*, urinary tract infection.
*Among 34,625 operated patients.
**Other infection types include bone and joint infection; central nervous system infection; cardiovascular system infection; eye, ear, nose, throat and mouth infection; and reproductive system infection; skin and soft tissue infection; gastrointestinal tract infection.

Table 4
Pathogens reported during surveillance for HAIs in Ukrainian hospitals, 2014-2016

Microorganism	Organisms reported (%)				
	All HAI (n = 11,231)	SSI (n = 523)	PNEU (n = 523)	BSI (n = 523)	UTI (n = 523)
Escherichia coli	21.8	18.4	5.8	1.9	14.2
Staphylococcus aureus	18.4	27.8	14.9	1.6	5.4
Enterococcus spp	15.7	15.7	2.1	4.2	14.9
Pseudomonas aeruginosa	12.4	11.3	17.6	5.2	16.7
Klebsiella spp	9.4	5.3	23.8	26.1	7.3
Coagulase-negative staphylococci	5.4	6.2	0.3	14.8	2.2
Candida spp	5.1	4.2	0.6	8.3	17.6
Acinetobacter spp	4.9	2.5	27.4	12.5	6.1
Enterobacter spp	2.5	4.2	2.7	4.2	4.8
Proteus spp	2.3	2.1	1.7	1.1	3.7
Other*	2.1	2.3	3.1	7.1	7.1

BSI, bloodstream infection; *HAI*, health care–associated infection; *PNEU*, pneumonia; *SSI*, surgical site infection; *UTI*, urinary tract infection.
*"Other" includes 11 different organisms.

(teicoplanin)-resistant, respectively. Meticillin resistance was reported in 39.2% of *S aureus* isolates, with known AST results. Vancomycin resistance was reported in 11.3% of isolated enterococci. Among the gram-negative bacteria, third-generation cephalosporins (cefotaxime or ceftazidime) resistance was found in 53.8% of *Klebsiella* spp and in 32.1% of *E coli* isolates. Carbapenem resistance was reported in 8.1% of all included Enterobacteriaceae, also highest in *Klebsiella* spp, and in 31.8% of *P aeruginosa* isolates and in 76.2% of *Acinetobacter* spp isolates.

Results of univariate analysis showed that no statistically significant difference between infection and the independent covariates was found (data not shown).

DISCUSSION

To our knowledge, this study was the first attempt to assess the overall burden of HAIs at the national level in Ukraine. We estimate that HAIs are encountered with an average prevalence of 11.3% (95% CI, 11%-11.6%), and the prevalence of the 4 most frequently recorded types of infections was for the following: SSI, 6.8 % (95% CI, 6.7-7.0), PNEU, 2.1% (95% CI, 2.0-2.2), BSI, 1.2% (95% CI, 1.1-1.3), and UTI, 1.1 % (95% CI, 1.0-1.2). Prevalence of HAIs among operated patients was 19.0%. Of all reported HAIs, the most frequently reported HAI types were SSIs (60%), RTIs (18.4%, PNEU and LRTI), BSIs (10.2%), and UTIs (9.5%). Of the HAI case-patients identified, 9.7% died before discharge. We found that patients with HAIs had a significantly increased mortality risk compared with patients without HAIs. The highest mortality risk was observed in patients with BSIs, followed by patients with RTIs (PNEU and LRTI). No increased risk of death was found in patients with UTIs and SSIs.

Few comparable studies of the burden of HAIs have been performed to date, with most conducted at the regional or single-center level,[1,18] and even fewer at the national level.[1,4,5] Most multicenter studies assessing the impact of HAIs have been primarily conducted in ICUs or have focused on a single type of HAI and/or resistance phenotype.[19,20]

Comparison of results between different studies remains difficult primarily because of differences in patient-case mix and methodology. According to published national or multicenter studies, pooled HAI prevalence in mixed patient populations was from 3.5%-12%.[1,5-8] In our study, the overall prevalence of patients with HAI was 11.3%.

Only a few studies have estimated the global impact of HAIs on mortality in hospital settings, and, as in this study, they all reported increased mortality.[2,4] As shown in other studies,[2,4,5] we also found that patients with BSIs or LRTIs had increased risk of dying during the follow-up period, even after adjusting for the effects of age, comorbidity, underlying disease severity, and other important risk factors for death. SSIs and UTIs were not associated with increased mortality risk, which has also been seen by others.[4,5,21]

We identified several patient characteristics that increased the risk of HAIs and death. Male sex, old age, use of urinary tract catheter, longer pre-prevalence period, and comorbidity were all factors affecting patient outcome. These factors should always be taken into account in assessing each patient's risk of HAIs, and in targeting infection control and prevention measures in care and treatment. To adjust for comorbidity we used the Charlson comorbidity index.

In this study, we found that gram-negative bacteria were the most common causal pathogens, in agreement with several surveillance studies in the United States,[22] Europe,[23] Saudi Arabia,[24] and Brazil.[25] Among these gram-negative bacteria, *E coli*, *P aeruginosa*, *Klebsiella* spp, and *Acinetobacter* spp were the most frequently reported. This finding is of particular concern, since these organisms are often involved in outbreaks that require the activation of an organizational response until the outbreak is under control.[19]

In addition, we found the high level of resistance to multiple antibiotics is a great concern. This condition represents an indication of seriously limited options for the treatment of patients infected with those microorganisms.

The strengths of the study lie in the prospective nature and application of NHSN methodology. It is well known that indicators of HAIs provided by surveillance activities require comparison with adequate reference data to stimulate further infection control actions and to enhance quality of care.

Study limitations

The absence of global national surveillance data in Ukraine compelled us to rely entirely on data from the only existing national point prevalence survey to assess the global burden of HAIs. Data validation efforts suggested a low sensitivity for detection of HAI, which likely stems from the following factors: (a) case definitions are complex and health care workers were unfamiliar with definitions prior to the start of surveillance; (b) owing to limitations in resources, occasionally microbiology and laboratory testing becomes temporarily unavailable; and (c) in Ukraine there is widespread use of empiric antimicrobial therapy and limited use of the clinical microbiology laboratory for therapeutic decision. Factors (b) and (c) may contribute to why PNEU, which can be identified without positive culture results, was reported more often than either UTIs or BSIs, which do require laboratory confirmation.However, during data validation all reported HAI cases were found to satisfy surveillance criteria for HAI. The strengths of the study lie in the prospective nature, and application of NHSN methodology. It is well known that indicators of HAIs provided by surveillance activities require comparison with adequate reference data to stimulate further infection control actions and to enhance quality of care. [23]

CONCLUSIONS

This study provides a detailed summary of the burden of HAIs from a public health care provider's perspective, showing thatthe incidence of HAIs, as well as their associated impact on mortality, presents a significant burden to the Ukraine hospital system. These findings, together with the increasing AMR in hospital settings, suggest that it is time to consider systematic interventions to reduce HAI incidence, including the potential of developing a global national surveillance system. Routinely collected prevalence surveillance data, integrated with a patient administrative system, are of great value as a basis for studying the long-term consequences of HAIs. Burden estimates obtained in this study will be valuable in future evaluations of the cost-effectiveness of infection prevention programs.

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