ORIGINAL ARTICLE

CONTENTS

Healthcare-associated infections after neurosurgical procedures in Ukraine: a multicentre study (2020-2022)

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ABSTRACT

Aim: To investigate the epidemiology, microbiology, and risk factors for healthcare-associated infections (HAIs) after a neurosurgical procedure in Ukraine.

Materials and Methods: Prospective multicentre surveillance was conducted from January 2020 to December 2022 in 10 regional hospitals of Ukraine. Definitions of HAIs were adapted from the Centers for Disease Control and Prevention's National Healthcare Safety Network.

Results: Of 8,623 neurosurgical patients, 1,579 (18.3%) HAIs were observed. The most frequently of HAI types were pneumonia (38.4%), surgical site infection (34.2%), urinary tract infection (18.1%) and bloodstream infection (9.3%). Death during hospitalization was reported in 11.3% of HAI cases. There was an association between HAIs after neurosurgical procedures and patients with diabetes mellitus, end-stage renal disease undergoing dialysis, and leukaemia. The strongest independent associations were observed for intubation, urinary catheters, and vascular catheters. Klebsiella pneumoniae were most commonly reported, accounting for 25.1% of all organisms, followed by Escherichia coli (17.6%), *Staphylococcus aureus* (9.9%), *Pseudomonas aeruginosa* (8.9%), *Acinetobacter baumannii* (8.5%), coagulase-negative staphylococci (6.8%), and Streptococcus spp. (5.5%). In total, 76.3% isolates from neurosurgical patients were MDROs. Antimicrobial resistance in Ukraine varies greatly by bacterial species, antimicrobial group, and region.

Conclusions: Healthcare-associated infections are a cause for mortality and morbidity among neurosurgical patients. This is due to increase emergence of antimicrobial-resistant pathogens. Routinely collected surveillance data are of great value as a basis for studying the consequences of HAIs.

KEY WORDS: Neurosurgery, healthcare-associated infection, prevalence, risk factors, mortality, antimicrobial resistance, Ukraine

Wiad Lek. 2024;77(1):17-24. doi: 10.36740/WLek202401102 DOI

INTRODUCTION

Healthcare-associated infection (HAI) continues to be a significant problem, particularly after neurosurgery, where infection can result in rehospitalization, multiple operative procedures, and aggressive antibiotic therapy. HAIs after intracranial neurosurgery procedures remains a significant worldwide problem, resulting in substantial morbidity/mortality if not combatted quickly and energetically. These infections presented in the most dangerous and sometimes life-threatening forms of infection, such as pneumonia, bloodstream infection, and urinary tract infection. The prevention of these infections is correlated with high treatment costs and longer hospitalization times [1].

Most of these infections are caused by opportunistic organisms, such as gram-positive *Staphylococcus* species and *Enterococcus* spp., and gram-negative bacilli [2, 3]. Further, an increasing number of infections are caused by organisms that are resistant to multiple antibiotics [2, 3]. A few studies the use of the prophylactic antibiotics has been shown to significantly decrease the incidence of meningitis after neurosurgery, its effect on extra-neurosurgical-site infections has not been documented.

Understanding the incidence and pathophysiology of HAIs is the key to their prevention. Their impact on the patient's subjective well-being is always negative and significant, and their management requires considerable expenses for the health care systems. A previous study found that patients who developed a SSI were twice as likely to die, 1.6 times as likely to require intensive care treatment, and more than five times as likely to be readmitted to the hospital. As shown in a survey of healthcare associated infections (HAIs) by the European Centre for Disease Prevention and Control, SSIs were the second most common reason, accounting for 19.6% of all HAI between 2011 and 2012 [4].

In neurosurgery in general, large-scale studies reporting robust HAI estimates are currently lacking and a wide range of SSI rates between 1-8% for cranial procedures and 0.5-18.8% for spinal procedures have been reported [5-7]. Other study shown that pooled proportion of SSI was 10.4% when an immediate cranioplasty was done and 16.1% when delayed cranioplasty was done [8].

Although the danger of HAI is universally recognized, the reported incidence of HAIs after neurosurgery procedures remains variable. Today, in Ukraine there are only few reports on the incidence of HAIs in neurosurgery. We have previously reported HAI in Ukraine were ranging from 19.4% to 20.9% [3, 9, 10]. The impact of risk factors and adverse outcome on this reported variability has not been previously investigated.

AIM

The aim of the study was to investigate the epidemiology, microbiology, and risk factors for HAIs after a neurosurgical procedure in Ukraine.

MATERIALS AND METHODS

STUDY DESIGN, SETTING AND POPULATION

This multicentre prospective observational study was performed over a 36-month period (January, 2020 to December 2022) in 10 Ukrainian regional hospitals for adult patients, which are similar in terms of medical equipment, personnel, laboratory facilities. Within the structures of all hospitals, there are microbiological laboratories. These hospitals are not related administratively, and receive elective and emergency patients. Patients who were aged 18 years or older and underwent elective or emergency neurosurgical procedure, who stayed for more than 48 h in hospital, and survived at least 7 days after surgery were included in the study. Patients highly suspicious of central nervous infection prior to the procedure including subdural empyema, cerebral abscess, or infected pathological disease, and patients who passed away within 48 hours after the operation were excluded.

DEFINITION

In this study an HAI was defined as an infection arising >48 h after admission to hospital and not present or incubating on admission, unless the patient had been discharged from hospital within a defined period. The criteria for specific HAI site were adapted from the Centers for Disease Control and Prevention's (CDC) and National Healthcare Safety Network's (NHSN) case definitions. An incident HAI was defined by microbiologically confirmed CDC/NHSN HAI epidemiological case definitions. 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 in Ukrainian hospitals.

DATA COLLECTION

We developed a special questionnaire that collected data from medical records, including gender, age (years), discharges or deaths of patients, microbiological and radiographic investigations, invasive procedures, comorbidities, procedure/treatment, day of admission to the ICU, surgical interventions, previous hospitalization within one year after the current hospitalization, antibiotics usage, and culture and sensitivity of the clinical isolates. All participating hospitals had hospital infection control teams. The surveillance of HAIs in hospitals was based mainly on analysis of microbiological reports, databases on patients and telephone communication between the epidemiological nurse and the neurosurgery unit. The HAI monitoring in hospitals was an outcome of daily personal communication between the infection prevention and control nurse and patients in the neurosurgery unit and assessment of their health status based on clinical symptoms presented by the patient, epidemiological definitions by CDC/NHSN, microbiological and other diagnostic tests. Follow-up of each patient was continued for one month, and for some infections for up to 90 days.

ETHICS

Scientific workup of the data was approved by the institutional review board of the Shupyk National Healthcare University of Ukraine. The data used for the present analysis had been previously anonymized.

MICROBIOLOGICAL METHODS

In this study for the microbiological diagnosis of different HAI cases, appropriate clinical material (blood, swabs, urine samples and others) was collected following doctor's orders. Only the first isolate from each patient was selected for microbiological analysis, excluding subsequent cultures from the same patient and HAI case. Species identification was performed with standard microbial methods. Antibiotic susceptibility testing of bacteria was determined by Kirby-Bauer disc diffusion test according to the protocol of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (http://eucast.org). An isolate is considered resistant to an antimicrobial agent when tested and interpreted as R in accordance with the EUCAST clinical breakpoint criteria used by the local laboratory. When combining results

Table 1. Distribution of healthcare-associated infections (HAIs) after neurosurgical procedures in regional (tertiary care) hospitals, Ukraine, 2020-2022

Regional hospitals	Type of HAI								Total (n=1579)	
	PNEU (n=606)		SSI (n=540)		UTI (n=286)		BSI (n=147)			
	n	%	n	%	n	%	n	%	n	%
1	69	11.4	51	9.4	31	10.8	14	9.5	165	10.4
2	47	7.8	31	5.7	15	5.2	9	6.1	102	6.5
3	38	6.3	58	10.7	28	9.8	19	12.9	143	9.1
4	29	4.8	36	6.7	24	8.4	12	8.2	101	6.4
5	38	6.3	27	5.0	18	6.3	11	7.5	94	6.0
6	68	11.2	52	9.6	27	9.4	14	9.5	161	10.2
7	31	5.1	44	8.1	31	10.8	18	12.2	124	7.9
8	34	5.6	33	6.1	22	7.7	17	11.6	106	6.7
9	126	20.8	106	19.6	59	20.6	21	14.3	312	19.8
10	126	20.8	102	18.9	31	10.8	12	14.3	271	17.2

HAI, healthcare-associated infection; PNEU, pneumonia; SSI, surgical site infection; UTI, urinary tract infection; BSI, bloodstream infection.

Table 2. Trend of the most frequently recorded types of healthcare-associated infections (HAIs) after neurosurgical procedures in regional (tertiary care) hospitals, Ukraine, 2020-2022

Type of HAI	2020	2021	2022	Total (2020-2022)		Trend 2020-2022
	%	%	%	No. (%)	95% CI	
Pneumonia	36.8	37.1	37.7	606 (38.4)	37.2-39.6	↑
Surgical site infection	33.7	33.9	34.6	540 (34.2)	33.0-35.4	↑
Urinary tract infection	18.1	18.9	18.9	286 (18.1)	17.1-19.1	↑
Bloodstream infection	11.4	10.1	8.8	147 (9.3)	8.6-10.0	↓

for antimicrobial agents representing an antimicrobial group, the outcome is based on the most resistant result.

STATISTICAL ANALYSIS

In this study IBM SPSS (SPSS-Statistical Package for the Social Sciences, STATISTICS 24, Armonk, NY, USA) and Microsoft Excel were used in the statistical analysis of the collected material. Statistical analysis presents descriptive statistics for the characteristics of patients, and types of HAI.

The analysis of differences between the analyzed departments was performed using Pearson's chi-square. Univariate and multivariate analyses were conducted with SPSS 16 software. Logistic regression allowed for the estimation of the effect size of certain predictors of HAI. The level of significance was $p < 0.05$.

RESULTS

PREVALENCE OF HAI

In the surveillance period, a total of 8623 neurosurgical procedures were performed in hospitalized patients. In this cohort, we detected 1579 healthcare-associated infections (HAIs), but in each hospital, the rates were different (Table 1). Of the total HAI cases, 14.8% were detected after hospital discharge. The prevalence of HAI among patients after neurosurgical procedures in Ukrainian hospitals was 18.3% (95% CI: 17.9-18.7). The most frequently recorded types of HAIs were: pneumonia (PNEU), 38.4% (95% CI:37.2-39.6); surgical site infection (SSI), 34.2% (33.0-35.4); urinary tract infection (UTI), 18.1% (95% CI:17.1-19.1); and bloodstream infection (BSI), 9.3% (95% CI:8.6-10.0). Of all HAIs, 9.4% (PNEU) were defined as part of an outbreak. The most frequent specific types of HAI among operated patients are reported in Table 1. There was an increase in the rate of HAI during the study period ($P < 0.0001$), largely associated with increased rates of PNEU, SSI, UTI, SSI, and BSI (Table 2). The prevalence of HAI among patients after neurosurgical procedures varied widely within Ukraine, from <10% in two (20.0%) of 10 regional hospitals to ≥15% in eight (80.0%), mostly in southern, eastern, and central Ukraine. An increase in the incidence of HAI was observed in 8 (80.0%) out of 10 regional hospitals, mostly in southern, eastern, and central Ukraine.

RISK FACTORS FOR HAI

An overview of the analysed patient characteristics and risk factors for HAI are shown in Table 3. The risk factors in

Table 3. Patient characteristics and risk factors for healthcare-associated infection (HAI) after neurosurgical procedures in regional (tertiary care) hospitals, Ukraine, 2020-2022

Variables	HAI				P value
	No		Yes		
	n	%	n	%	
All	7,044	81.7	1,579	18.3	0.05
Gender					0.49
Male	4,543	64.5	1,080	68.4	
Female	2,501	35.5	499	31.6	
Age (years)					0.001
18-34	339	6.9	76	4.8	
35-44	444	8.4	100	6.3	
45-54	275	9.4	62	3.9	
55-64	698	22.8	156	9.9	
65-74	1,142	19.6	256	16.2	
75-84	1,909	16.5	428	27.1	
≥85	2,237	16.3	501	31.8	
Admission type					0.083
Emergency or Urgent	4,162	59.1	687	43.5	
Elective	2,882	40.9	892	56.5	
Length of stay in ICU >5 (days)	7,366	31.8	1,257	77.6	<0.001
McCabe score					<0.001
Non-fatal	2,590	36.8	134	8.5	
Ultimately fatal	2,431	34.5	299	18.9	
Rapidly fatal	1,230	17.4	529	33.5	
Missing	793	11.3	617	39.1	
Duration of operative procedure (hrs)					0.034
≤4	4,673	66.3	532	33.7	
>4	2,371	33.7	1,047	66.3	
Comorbidities					
Diabetes mellitus	1,067	15.1	499	31.6	0.009
End-stage renal disease with dialysis	766	10.9	354	22.4	0.009
Peripheral vascular disease	2,056	29.2	0	0.0	0.24
Cerebrovascular accident	588	8.3	103	6.5	0.31
Peptic ulcer disease	483	6.9	84	5.3	0.85
Myocardial infarction	569	8.1	82	5.2	0.91
Congestive cardiac failure	501	7.1	84	5.3	0.43
Liver disease	357	5.1	61	3.9	0.42
Leukaemia	647	9.3	312	19.8	0.009
Procedure/treatment					
Mechanical ventilation	5,148	73.1	1,558	98.7	<0.001
Central venous catheter	4,638	65.8	1,204	76.3	0.05
Peripheral vascular catheter	4,552	64.6	1,132	71.7	0.19
Urinary catheter	4,321	61.3	1,455	92.1	<0.001
Transfusion	2,074	29.4	728	46.1	0.02
Sedation	5,641	80.1	1,449	91.8	0.02

HAI, healthcare-associated infection; ICU, intensive care unit.

Table 4. Distribution of pathogens (n=3872) isolated from neurosurgical patients (n=1579) with healthcare infections (HAIs) in Ukraine (2020-2022)

Types of micro-organisms	Type of HAI								Total no. (%) of isolates	95% CI
	PNEU		SSI		UTI		BSI			
	n	%	n	%	n	%	n	%		
Gram-positive cocci	203	19.9	274	26.8	308	30.1	237	23.2	1022 (26.4)	25.7 – 27.1
Staphylococcus aureus	82	21.5	147	38.5	56	14.7	97	25.4	382 (9.9)	9.4 – 10.4
CoNS	17	6.4	74	27.9	91	34.3	83	31.3	265 (6.8)	6.4 – 7.2
Staphylococcus haemolyticus	9	15.5	14	24.1	17	29.3	18	31.0	58 (1.5)	1.3 – 1.7
Streptococcus spp.	84	39.4	12	5.6	95	44.6	22	10.3	213 (5.5)	5.1 – 5.9
Enterococcus spp.	11	10.6	27	26.0	49	47.1	17	16.3	104 (2.6)	2.3 – 2.9
Gram-negative bacilli	755	27.4	699	25.4	926	33.6	362	13.2	2752 (71.1)	70.4 – 71.8
Klebsiella pneumoniae	406	41.7	97	10.0	344	35.4	126	12.9	973 (25.1)	24.4 – 25.8
Escherichia coli	46	6.8	254	37.5	297	43.8	81	11.9	678 (17.5)	16.9 – 18.1
Serratia marcescens	21	20.4	41	39.8	18	17.5	23	22.3	103 (2.7)	2.4 – 3.0
Proteus mirabilis	7	7.2	10	10.3	74	76.3	6	6.2	97 (2.5)	2.3 – 2.7
Enterobacter aerogenes	8	14.3	15	26.8	27	48.2	6	10.7	56 (1.4)	1.2 – 1.6
Enterobacter cloacae	7	8.5	28	34.1	29	35.4	18	22.0	82 (2.1)	1.9 – 2.3
Stenotrophomonas maltophilia	14	22.2	24	38.1	8	12.7	17	27.0	63 (1.6)	1.4 – 1.8
Pseudomonas aeruginosa	68	20.4	173	50.3	84	24.4	9	2.6	334 (8.9)	8.4 – 9.4
Acinetobacter baumannii	175	53.4	48	14.6	31	9.5	74	22.6	328 (8.5)	8.1 – 8.9
Other gram-negative bacteria	3	10.7	9	32.1	14	50.0	2	7.1	28 (0.7)	0.6 – 0.8
Fungi	15	15.3	9	9.2	50	51.0	24	24.5	98 (2.5)	2.3 – 2.7
Candida albicans	12	14.8	8	9.9	42	51.9	19	23.5	81(2.1)	1.9 – 2.3
Nonalbicans fungi	3	17.6	1	5.9	8	47.1	5	29.4	17 (0.4)	0.3 – 0.5

HAI, healthcare infection; PNEU, pneumonia; SSI, surgical site infection; UTI, urinary tract infection; BSIs, bloodstream infections; CoNS, coagulase-negative staphylococci; CI, confidence interval.

this study were significantly associated with the prevalence of HAI. By including the risk factors with P < 0.05 from the univariate analysis (Table 3) in a forward logistic regression analysis, the independent risk factors for HAI were obtained. There was an association between the prevalence of HAIs after neurosurgical procedures and patients with diabetes mellitus, end-stage renal disease undergoing dialysis, and leukaemia. The HAI incidence was highest among patients admitted to ICU, where 37.5% of patients had at least one HAI. In this study, patients with end-stage renal disease undergoing dialysis, and those with an ICU stay of more than five days were associated with a higher risk of contracting an HAI. The strongest independent associations were observed for intubation, urinary catheters, and vascular catheters (before the onset of pneumonia, UTI, and BSI, respectively). The prevalence of HAI increased with age. Most cases of pneumonia and UTI were device-associated, and cases of BSI were central-line-associated (Table 3).

INPATIENT MORTALITY FROM HAI

Of the cases of HAI identified, 14.7% died before discharge. Mortality patients with HAI increased with age for both sexes. The highest mortality risk was observed in patients with pneumonia and in patients with BSI. The highest mortality was observed in patients with PNEU (77.3%), followed by those with BSI (22.7%). In this study there were no deaths in patients with UTI and SSI. A high McCabe score was also associated with increased inpatient mortality.

PATHOGENS AND ANTIMICROBIAL RESISTANCE

In total, 3872 pathogens (Gram-negative and -positive bacteria) were isolated from 1579 neurosurgical patients with HAI. A general analysis of etiological agents of HAI showed that the most frequently isolated bacteria were *Klebsiella pneumoniae* (25.1%), followed by *Escherichia coli* (17.6%), *Staphylococcus aureus* (9.9%), *Pseudomonas aeruginosa* (8.9%), *Acinetobacter baumannii* (8.5%), coagulase-negative staphylococci (6.8%), and *Streptococcus* spp. (5.5%). A polymicrobial infection was seen in 59% of the HAI cases. PNEU were most commonly caused by *Acinetobacter* spp. (53.4%), *K. pneumoniae* (41.7%), *Streptococcus* spp. (39.4%), *Ste-*

notrophomonas maltophilia (22.2%), *S. aureus* (21.5%), and *Serratia marcescens* (20.4%). In BSI, the dominant etiological agents were CoNS (31.3%), *Staphylococcus haemolyticus* (31%), *S. maltophilia* (27%), *S. aureus* (25.4%), *Candida albicans* (23.5%), *A. baumannii* (22.6%), and *S. marcescens* (22.3%). For UTI, the agents were *C. albicans* (51.9%), *Enterobacter aerogenes* (48.2%), *Enterococcus* spp. (47.1%), *Streptococcus* spp. (44.6%), and *E. coli* (43.8%). In SSI, the most frequently isolated microorganism was *P. aeruginosa* (50.3%), *S. marcescens* (39.8%), *S. aureus* (38.5%), *S. maltophilia* (38.1%), and *E. coli* (37.5%), *E. aerogenes* (26.8%), and *Enterococcus* spp. (26%) (Table 4).

In total, 76.3% isolates from neurosurgical patients were MDROs. Most of the HAI cases were observed in patients caused by MDR strains of *K. pneumoniae* (31.9%), *A. baumannii* (31.4%), P. aeruginosa (14.3%), *S. maltophilia* (13.8), *S. aureus* (12.9%), followed by *E. coli* (9.2%), *Enterobacter* spp. (8.9%), *Enterococcus* spp. (8.7%), and *S. marcescens* (7.1%). This study showed that antimicrobial resistance in Ukrainian hospitals varies greatly by bacterial species, antimicrobial group, and region. For several bacterial species-antimicrobial group combinations, significant differences are evident. In general, lower resistance percentages were reported by Ukrainian regions in the west while higher percentages were reported in the north, south, and east of Ukraine.

DISCUSSION

The results presented in this study are based on multicentre prospective surveillance data for HAI after neurosurgical procedure in Ukraine. This study expands upon the previous reports and is the first multicentre prospective study to publish prevalence of HAI types, risk factors for HAI, inpatient mortality from HAI, and frequent pathogens and antimicrobial resistance of responsible pathogens of HAI in neurosurgical patients in Ukraine [9,10].

This survey identified a high prevalence of HAI (18.3%) and high mortality for neurosurgical patients with HAI (14.7%). A previous study in Ukraine conducted in 2021 found that prevalence of HAI and mortality rate in neurosurgical patients were 20.9% and 11.3%, respectively [10]. In other countries prevalence of HAI in neurosurgical patients was from 3.1% to 9.1% [2, 11] and mortality was from 3.5% to 12% [12-15]. The prevalence of HAI among neurosurgical patients varied widely within Ukraine. An increase in the incidence of HAI was observed in 67.4% of regional hospitals.

In the present study the most frequent specific types of HAI in neurosurgical patients were PNEU, SSI, UTI, and BSI. Our results are consistent with those of previous studies in other countries [2,10, 11]. There was an increase in the rate of HAI among neurosurgical patients in study period, largely associated with increased rates of PNEU, SSI, and UTI (Table 2).

In this study, *K. pneumoniae, E. coli, S. aureus, P. aeruginosa, A. baumannii,* CoNS, and *Streptococcus* spp. were common HAI pathogens in neurosurgical patients. In general, the pathogens associated with HAI varied by location (PNEU, SSI, UTI, and BSI). Our study showed that the situation with antimicrobial resistance in Ukraine varies greatly by bacterial species, antimicrobial group, and region. In total, 76.3% isolates from neurosurgical patients with HAI were MDROs. Most of the HAI cases were observed in patients caused by MDR strains of *K. pneumoniae, A. baumannii*, *P. aeruginosa, S. maltophilia, S. aureus,* followed by *E. coli, Enterobacter* spp., *Enterococcus* spp., and *S. marcescens.* Our study showed that mortality among neurosurgical patients was higher among patients with HAI caused by MDROs. A previous study in Ukraine conducted in 2020-2021 found that 85.1% isolates from patients in regional hospitals were MDROs. The majority of MDRO isolates carried b-lactamase genes. [3]. In Ukrainian regional hospitals, resistance to third-generation cephalosporins and carbapenems generally was higher in *K. pneumoniae* than *E. coli*. While carbapenem resistance remained $<10\%$ for *E. coli* in most regions of Ukraine, 30% of hospitals reported *K. pneumoniae* resistance rates of $>40\%$ [3]. The proportions of MDROs among isolates from patients with HAIs, environmental surfaces and HCWs (hands, gown/gloves) were 29.2%, 16.3% and 24.2%, respectively. In 51.9% of the tested isolates, identical MDROs were found in clinical isolates, environmental samples and HCWs' hands [16].

The risk factors in present study were significantly associated with the prevalence of HAI. There was an association between the prevalence of HAIs after neurosurgical procedures and patients with diabetes mellitus, end-stage renal disease undergoing dialysis, and leukaemia. In our study the strongest independent associations were observed for intubation, urinary catheters, and vascular catheters (before the onset of pneumonia, UTI, and BSI, respectively). The prevalence of HAI increased with age. Most cases of PNEU and UTI were device-associated, and cases of BSI were central-line-associated. Results our study are consistent with those of previous studies in other countries [17-22].

STRENGTH AND LIMITATION

Strength of this study was that it was a prospective multi-centre observational cohort study, based on HAI surveillance data in neurosurgical patients and using CDC/NHSN methodology. Our study has some limitations. The study was based on a strict CDC/NHSN protocol comprising the definitions and criteria of HAIs. There was no validation of the process in the hospitals under study and no power analysis was performed when planning this study.

CONCLUSIONS

Healthcare-associated infections are a cause for high morbidity and mortality among neurosurgical patients. This is due to increase emergence of antimicrobial-resistant pathogens. The patients in the neurosurgical ward are exposed to many risk factors causing HAIs. These factors are related to operations, invasive diagnosing and monitoring of the nervous system and mechanical support of vital functions. HAIs in neurosurgical patients remain a challenge for diagnosis, treatment, and prevention. The high prevalence and resistant profile of HAIs has important implications for patient safety and emphasizes the need to strengthen collaboration between infection control teams to prevent serious complications in this setting. Routinely collected surveillance data are of great value as a basis for studying the consequences of HAIs. Gaining a better understanding of at-risk patients and development of preventative strategies will be the goal for future investigation.

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We would like to thank all members of Ukrainian association of infection control and antimicrobial resistance who contributed to the prevalence surveys.
The authors received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

RECEIVED: 10.08.2023
ACCEPTED: 28.12.2023