ORIGINAL ARTICLE

EVALUATION OF BACTERIAL CONTAMINATION IN THE INANIMATE ENVIRONMENT SURFACES IN ACUTE CARE HOSPITALS IN KYIV, UKRAINE

DOI: 10.36740/WLek202202128

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ABSTRACT

The aim: To evaluate the quality of cleaning and disinfection of surfaces scheduled for daily cleaning and degree of bacterial contamination of hospital rooms and the patients' inanimate environment in Kyiv acute care hospitals, Ukraine.

Materials and methods: We performed a multicenter prospectively study of the quality of cleaning and disinfection of surfaces scheduled for daily cleaning in 9 acute care hospitals by use of an ultraviolet fluorescence targeting method and microbial methods.

Results: A total 9,104 environmental samples from were collected and tested. The cleaning and disinfection of surfaces were not being performed properly in most cases. Complete removal of the mark was 49.1%, partial removal was 37,5%, and mark was still visible, i.e. this area had not been processed was 13,4% when the ultraviolet fluorescence targeting method procedures were used, respectively. The predominant bacterial agents in hospital environment surfaces were: *Escherichia coli, Enterobacter* spp., *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Proteus* spp., *Citrobacter* spp., *Acinetobacter spp*., and *Enterococcus* spp. The overall proportion of extended spectrum beta-lactamase (ESBL) production among Enterobacteriaceae was 31.5% and of methicillin-resistance in *Staphylococcus aureus* (MRSA) 14.9%. Vancomycin resistance was observed in 5.2% of isolated enterococci (VRE). Resistance to third-generation cephalosporins was observed in 12.7% *E.coli* isolates and was in 11.2% *K. pneumoniae* isolates. Carbapenem resistance was identified in 24.7% of *P.aeruginosa* isolates and 59.3% of *Acinetibacter* spp. isolates.

Conclusions: In a hospital rooms, patient environmental surfaces can be a vehicle for the transmission of multidrug-resistant (MDR) bacterial agents that cause healthcare-associated infections.

KEY WORDS: healthcare-associated infections; surface contamination, cleaning, disinfection, ultraviolet fluorescence targeting method, antimicrobial resistance

Wiad Lek. 2022;75(2):482-489

INTRODUCTION

Healthcare-associated infections (HAIs) are among the most common adverse events in patient care [1]. The emergence and spread of HAIs has become a major public health threat in worldwide. HAIs have been reported to exact a tremendous toll on patients, families and systems of care, resulting in increased morbidity and mortality and increased healthcare costs.

According to literature, HAIs contribute to patient morbidity and mortality with an estimated 1.7 million infections and 99,000 deaths costing USD $28-34 billion annually in the United States alone [2]. HAIs annually account for 37,000 attributable deaths in Europe. 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 [3]. The overall prevalence of HAIs in Ukraine was 11.3%. 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 [4]. Despite major advances in infection control interventions, HAIs remain a major public health problem and patient safety threat worldwide.[5].

For several decades, environmental surfaces in hospitals were considered to play little or no role in the transmission of HAIs. However, a growing body of evidence suggests that contaminated environmental surfaces can contribute to the transmission of HAIs pathogens [6]. According to the literature, in addition to hand hygiene and reprocessing of medical products, cleaning and disinfection of surfaces is also an important issue in the prevention of germ transmission and by implication infections [7,8]. Accordingly, cleaning and disinfecting environmental surfaces in patient care areas are now recognized as important elements of infection control programs [9,10]. As a result, there is increasing interest in new technologies that can reliably decontaminate environmental surfaces in healthcare facilities. In recent years, a variety of interventions have been shown to be effective in improving cleaning and disinfection of surfaces.

Currently, in Ukrainian hospitals and other health care settings use more 500 antiseptics and disinfectants for a variety of topical and hard-surface applications. In particular, they are an essential part of infection control practices and aid in the prevention of HAIs. However, there is little understanding as to if current environmental surface disinfection practices reduce pathogen load, and subsequently HAIs in hospitals. In Ukraine, there are no studies examining how the risk of an transmission of HAI pathogens is associated with bacterial contamination of hospital rooms and the patients' inanimate environment.

THE AIM

To evaluate the quality of cleaning and disinfection of surfaces scheduled for daily cleaning and degree of bacterial contamination of hospital rooms and the patients' inanimate environment in Kyiv acute care hospitals, Ukraine.

MATERIALS AND METHODS

STUDY DESIGN

We performed from January 10st, 2021 to August 31st, 2021 a multicenter prospectively study of the quality of cleaning and disinfection of surfaces scheduled for daily cleaning in 9 acute care hospitals of Kyiv city (Ukraine) by use of an ultraviolet fluorescence targeting method (UVM) and microbial (cultural) methods. All hospitals transferred information on the quality of structure. Process quality

Table I. Monitoring the quality of the cleaning and disinfection of surfaces scheduled for daily cleaning by use of an ultraviolet fluorescence targeting method (UVM) in acute care hospitals in Kyiv, Ukraine (2021)

Hospital	Number of samples	Removal of marking from surfaces with a fluorescent liquid					
		complete removal		partial removal		mark was visible	
		n	%	n	%	n	%
A	1184	645	54.5	368	31.1	171	14.4
B	1120	618	55.2	385	34.4	117	10.4
C	1040	529	50.9	362	34.8	149	14.3
D	960	504	52.5	344	35.8	112	11.7
E	1040	481	46.3	422	40.6	137	13.2
F	1056	484	45.8	434	41.1	138	13.1
G	880	428	48.6	345	39.2	107	12.2
H	912	404	44.3	381	41.8	127	13.9
I	912	377	41.3	375	41.1	160	17.5
Total	9104	4470	49.1	3416	37.5	1218	13.4

Table II. Trend the quality of cleaning and disinfection of surfaces using ultraviolet fluorescence (UVM) targeting in acute care hospitals in Kiev, Ukraine (2021)

Hospital	Number of samples	Removal of marking from surfaces with a fluorescent liquid											
		Mondays			Wednesdays			Saturdays			Sundays		
		complete removal %	partial removal %	mark was visible %	complete removal %	partial removal %	mark was visible %	complete removal %	partial removal %	mark was visible %	complete removal %	partial removal %	mark was visible %
A	1184	67.9	27.0	5.1	64.9	30.1	5.1	55.4	34.5	10.1	29.7	32.8	37.5
B	1120	67.1	28.9	3.9	65.4	31.8	2.9	53.2	42.9	3.9	35.0	33.9	31.1
C	1040	59.6	27.7	12.7	55.8	36.9	7.3	45.0	48.1	6.9	43.1	26.5	30.4
D	960	62.1	29.2	8.8	62.9	35.4	1.7	54.6	40.8	4.6	30.4	37.9	31.7
E	1040	52.7	36.9	10.4	54.2	41.5	4.2	50.8	42.3	6.9	27.3	41.5	31.2
F	1056	47.7	40.9	11.4	48.5	48.5	3.0	45.1	48.9	6.1	42.0	26.1	31.8
G	880	46.4	44.1	9.5	60.5	37.7	1.8	55.5	40.9	3.6	32.3	34.1	33.6
H	912	45.2	45.2	9.6	51.3	46.1	2.6	50.9	44.3	4.8	29.8	31.6	38.6
I	912	42.1	43.0	14.9	47.8	49.1	3.1	43.0	51.8	5.3	32.5	20.6	46.9
Total	9104	55.2	35.4	9.4	57.1	39.3	3.6	50.4	43.6	5.9	33.7	31.8	34.6

Table III. Monitoring the effect of the cleaning and disinfection of surfaces on different department/wards by ultraviolet fluorescence (UVM) targeting in acute care hospitals in Kiev, Ukraine (2021)

Department/wards	Number of samples	Removal of marking from surfaces with a fluorescent liquid					
		complete removal		partial removal		mark was visible	
		n	%	n	%	n	%
General surgery	680	388	57.1	238	35.0	54	7.9
Digestive tract surgery	320	148	46.3	96	30.0	76	23.8
Cardiovascular surgery	360	210	58.3	138	38.3	12	3.3
Ear/nose/throat surgery	480	240	50.0	170	35.4	70	14.6
Orthopedic surgery	560	298	53.2	176	31.4	86	15.4
Neurosurgery	680	360	52.9	266	39.1	54	7.9
Urology	660	345	52.3	221	33.5	94	14.2
Burns care	460	300	65.2	104	22.6	56	12.2
Haematology	410	233	56.8	157	38.3	20	4.9
Pneumology	470	240	51.1	180	38.3	50	10.6
Obstetrics/maternity	680	360	52.9	264	38.8	56	8.2
Gynaecology	680	320	47.1	292	42.9	68	10.0
Paediatrics general	680	280	41.2	304	44.7	86	12.6
Medical ICU	420	140	33.3	189	45.0	91	21.7
Surgical ICU	420	157	37.4	159	37.9	104	37.9
Paediatric ICU	420	170	40.5	182	43.3	68	43.3
Neonatal ICU	364	141	38.7	125	34.3	98	34.3
Mixed and other ICU	360	140	38.9	145	40.3	75	40.3
Total	9104	4470	49.1	3416	37.5	1218	13.4

was obtained through direct observation during cleaning and disinfection of rooms and their plumbing units. All participating hospitals were required to have a clinical microbiology laboratory with the capacity to process cultures and at least one intensive care unit (ICU).The study was conducted in hospital wards, operating theatres and intensive care units.

DATA COLLECTION

In our study, as part of a questionnaire-based survey, data was obtained regarding the staff training and quality control, the interface of the responsibilities of house cleaning and nursing personnel, the work instructions (standard operating procedures (SOP)), the cleaning performance on weekends and holidays.

We took samples on Mondays, Wednesdays, Saturdays, and Sundays for one month and took samples from near- and extended patient areas. Infection control practitioners of the respective hospitals had marked definite points in fluorescent ink, according to the CDC recommendation [11]. On the day of the control visit, reprocessing of at least 5 four-bed rooms and bathrooms was monitored in every hospital. In during the control visit infection control practitioners, if and how these points had been removed by cleaning was determined using an ultraviolet flashlight. Cleaning performance was measured by complete removal of UVM, i.e. marking surfaces with a fluorescent liquid and testing if this mark has been sufficiently removed by cleaning and removed of bacterial contamination of hospital rooms and the patients' inanimate environmental surfaces. Complete removal of the mark was scored as two points, partial removal was given one point, and zero points were awarded if the mark was still visible, i.e. this area had not been processed.

MICROBIAL METHODS

Microbiological samples were taken from the surfaces of near- and extended patient areas. In each hospital, two infection control practitioners carried out the sampling. To sample a large surface, we used RODAC plate, 55 mm in diameter. A RODAC plate, 55 mm in diameter, was pressed on the surface to be tested, and then incubated at 36°C for 48 h. Microbial isolates were identified using standard microbiological techniques. Antibiotic susceptibility testing was performed by using the disk diffusion method according to the recommendations of the European Committee on Antimicrobial Susceptibility

Table IV. Monitoring the effect of the cleaning and disinfection of surfaces on different items in hospital room by ultraviolet fluorescence (UVM) targeting in acute care hospitals in Kiev, Ukraine (2021)

Environmental items in hospital room	Number of samples	Removal of marking from surfaces with a fluorescent liquid					
		complete removal		partial removal		mark was visible	
		n	%	n	%	n	%
Bed rails	560	270	48.2	261	46.6	29	5.2
Tray table	610	378	62.0	208	34.1	24	3.9
Bedside table handle	470	216	46.0	237	50.4	17	3.6
Bedside table	610	297	48.7	301	49.3	12	2.0
Chair	510	430	84.3	76	14.9	4	0.8
Room sink	430	192	44.7	224	52.1	14	3.3
Room light switch	640	173	27.0	421	65.8	46	7.2
Room inner door knob	640	176	27.5	441	68.9	23	3.6
Door handle	620	170	27.4	413	66.6	37	6.0
IV pump control	180	139	77.2	37	20.6	4	2.2
Multi-module monitor controls	460	137	29.8	167	36.3	156	33.9
Multi-module monitor touch screen	460	132	28.7	107	23.3	221	48.0
Multi-module monitor cables	614	121	19.7	207	33.7	286	46.6
Ventilator control panel	160	71	44.4	75	46.9	14	8.8
Infusion pump	140	68	48.6	65	46.4	7	5.0
Switches of intravenous pumps	140	51	36.4	71	50.7	18	12.9
Bathroom door	180	178	98.9	2	1.1	0	0
Shower	180	173	96.1	7	3.9	0	0
Basin fitting	180	169	93.9	11	6.1	0	0
Shower fitting	180	172	95.6	8	4.4	0	0
Bathroom sink	180	171	95.0	9	5.0	0	0
Bathroom light switch	180	171	95.0	9	5.0	0	0
Bathroom inner door knob	180	168	93.3	0	0	12	6
Bathroom handrails by toilet	200	91	45.5	11	5.5	98	49,0
Toilet seat	200	89	44.5	27	13.5	84	42,0
Toilet flush handle	200	67	33.5	21	10.5	112	56,0
Total	9104	4470	49.1	3416	37.5	1218	13,4

Testing (EUCAST). In our study, strains in the intermediate range were classified as resistant for data analysis.

ETHICS

The Shupyk National Healtcare University of Ukraine Ethics Committee approved this study.

STATISTICAL ANALYSIS

Descriptive statistical analysis was performed to provide median, minimum-maximum values range, and mean standard deviation. Parametric or nonparametric tests were applied on the basis of data distribution. The Wilcoxon, Mann-Whitney, and Fisher's Exact tests were run to analyze data statistically. For the statistical analysis, we used a significance level of $p < 0.05$.

RESULTS

EVALUATION BY ULTRAVIOLET FLUORESCENCE TARGETING METHOD

A total 9,104 environmental samples from were collected and tested for the evaluations of the quality of cleaning and disinfection of surfaces scheduled for daily cleaning in 9 acute care hospitals by use of an ultraviolet fluorescence targeting method (UVM). Cleaning and disinfection of surfaces were not being performed properly in most cases. Complete removal of the mark was 49.1% (4470/9104) [95% CI 48.4%, 49.9%, $p < 0.0001$], partial removal was 37,5% (3416/9104)[95% CI 36.7%, 38.3%, $p < 0.0001$], and mark was still visible, i.e. this area had not been processed was 13,4% (1218/9104)[95% CI 12.4%, 14.4%, $p < 0.0001$] when the UVM procedures were used, respectively.

Table V. Distribution of microorganisms isolated from the patients' inanimate environment surfaces in acute care hospitals in Kyiv, Ukraine (2021)

Microorganisms	All isolates (n=11723)	Percentages, %
Gram-positive cocci	1672	14.3
Staphylococcus aureus	248	2.1
Coagulase-negative staphylococci	529	4.5
Enterococcus spp.	717	6.1
Streptococcus spp.	178	1.5
Gram-negative bacilli	10051	85.7
Escherichia coli	3374	28.8
Citrobacter spp.	822	7.0
Enterobacter spp.	1401	12.0
Klebsiella pneumoniae	991	8.5
Proteus spp.	892	7.6
Serratia spp.	341	2.9
Acinetobacter spp.	788	6.7
Pseudomonas aeruginosa	1374	11.7
Stenotrophomonas maltophilia	68	0.6
Total	11723	100.0

Cleaning performance varied significantly between the 9 acute care hospitals. Results of monitoring the quality of the cleaning and disinfection of surfaces scheduled for daily cleaning by use of an ultraviolet fluorescence targeting method (UVM) in acute care hospitals are presented in Table I.

There were significant differences in the quality of cleaning and disinfecting environmental surfaces in hospitals on Mondays, Wednesdays, Saturdays, and Sundays. The best results of cleaning the patients' inanimate environment surfaces were achieved in Mondays and Wednesdays, the worst results in Saturdays, and Sundays (Table II). The best results of were achieved in Burns care, Cardiovascular surgery, General surgery, and Haematology departments, the worst results in intensive care units. Results of monitoring the effect of the cleaning and disinfection of surfaces on different department/wards by ultraviolet fluorescence (UVM) targeting in acute care hospitals are presented in Table III.

Evaluation the priority sites most frequently contaminated and touched by patients and/or healthcare workers found significant differences in the effectiveness of cleaning and disinfecting surfaces on various items in the hospital wards. The results of monitoring the effect of the cleaning and disinfection of surfaces on different items in hospital room by ultraviolet fluorescence (UVM) targeting in acute care hospitals are presented in Table IV.

EVALUATION BY MICROBIOLOGICAL METHOD

A total of 11723 strains isolated from 9104 the patients' inanimate environment surfaces. Gram-positive organisms accounted for 14.3% (1672/11723) [95% CI 14.4%, 15.2%, p <0.0001] of all strains and gram-negative organisms accounted 85.7% (10051/11723) [95% CI 85.4%, 86.1%, p <0.0001], respectively. Enterobacteriaceae were the most frequently isolated group of organisms from the patients' inanimate environment surfaces (67.6%, 95% CI 67.1%, 68.1%, p <0.0001). The predominant bacterial agents were: *E. coli* (28.8%), *Enterobacter* spp. (12%), *P. aeruginosa* (11.7%), *K.pneumoniae* (8.5%), *Proteus* spp. (7.6%), *Citrobacter* spp. (7%), *Acinetobacter* spp. (6.7%), and *Enterococcus* spp. (6.1%), followed by Coagulase-negative staphylococci (4.5%), *Serratia* spp. (2.9%), *S. aureus* (2.1%), *Streptococcus* spp. (1.5%), and *Stenotrophomonas maltophilia* (0.6%) (Table V). Evaluation the priority sites most frequently contaminated and touched by patients and/or healthcare workers found significant differences degree of bacterial agents contamination of environmental items in hospital rooms and the patients' inanimate environment (Table VI).

Because most commensally bacteria have natural gene transfer mechanisms and can be resistant to multiple antimicrobials, it is important to characterize the strains that have been isolated from environmental surfaces. Antimicrobial susceptibility tests were performed on a total of 1672 isolates of Gram-positive cocci and 10051 gram-negative organisms. The antimicrobials used in antimicrobial susceptibility testing included those commonly used as therapeutic agents in Ukraine. Varying degrees of resistance to most antimicrobials tested were found. Staphylococcal isolates showed susceptibility to most antimicrobials tested, although there were some differences depending on the environmental surfaces. No strains resistant to linezolid, teicoplanin, vancomycin, tigecycline, and fusidic acid were found. Methicillin-resistance was observed in 14.9% of *S. aureus*.

Table VI. Distribution of microorganisms isolated from the priority sites most frequently contaminated and touched by patients and/or healthcare workers in acute care hospitals in Kiev, Ukraine (2021)

Environmental items in hospital room	Microorganisms
Bed rails	*E.coli, Enterococcus spp., Citrobacter spp., Enterobacter spp., Proteus spp.*
Tray table	*S.aureus, Enterococcus spp., CNS, Enterobacter spp., Serratia spp., E.coli,*
Bedside table handle	*S.aureus, Enterococcus spp., CNS, Enterobacter spp., Serratia spp., E.coli,*
Bedside table	*S.aureus, Enterococcus spp., CNS, Enterobacter spp., Serratia spp., E.coli,*
Chair	*Enterobacter spp., Citrobacter spp., Proteus spp., CNS, E.coli,*
Room sink	*Enterobacter spp., E.coli, Citrobacter spp., P.aeruginosa, Enterococcus spp.,*
Room light switch	*S.aureus, Enterococcus spp., Streptococcus spp. E.coli, Citrobacter spp., Enterobacter spp., Serratia spp. P.aeruginosa, S. maltophilia*
Room inner door knob	*Enterococcus spp., E.coli, Citrobacter spp., Enterobacter spp., Serratia spp. P.aeruginosa, Proteus spp., S.aureus, CNS, Streptococcus spp.*
Door handle	*Enterococcus spp., E.coli, Citrobacter spp., Enterobacter spp., Serratia spp. P.aeruginosa, Proteus spp., S. maltophilia, S.aureus, Streptococcus spp.*
IV pump control	*Enterococcus spp., E.coli, Citrobacter spp., Enterobacter spp., Serratia spp. P.aeruginosa, Acinetobacter spp., K. pneumoniae, CNS, Streptococcus spp.*
Multi-module monitor controls	*Enterococcus spp., E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Acinetobacter spp., K. pneumoniae, CNS,*
Multi-module monitor touch screen	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Acinetobacter spp., K. pneumoniae, CNS. S. maltophilia, Streptococcus spp.*
Multi-module monitor cables	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Acinetobacter spp., K. pneumoniae, S. maltophilia, Proteus spp.,*
Ventilator control panel	*E.coli, Enterobacter spp., K. pneumoniae, Acinetobacter spp.*
Infusion pump	*E.coli, Enterobacter spp.*
Bathroom door	*E.coli, Citrobacter spp., Enterobacter spp., Serratia spp. P.aeruginosa*
Shower	*E.coli, Serratia spp. P.aeruginosa*
Basin fitting	*E.coli, Serratia spp.*
Shower fitting	*E.coli, Enterococcus spp., Citrobacter spp.,*
Bathroom sink	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Proteus spp., S. maltophilia*
Bathroom light switch	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Proteus spp., S. maltophilia,*
Bathroom inner door knob	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa*
Toilet seat	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Proteus spp.,*
Toilet flush handle	*E.coli, Enterobacter spp., Serratia spp. P.aeruginosa, Proteus spp.*

Regarding the genus *Enterococcus*, *E. faecalis* isolates and *E. faecium* were not sensitive to those antibiotics to which they are intrinsically resistant (cefuroxime, clindamycin, and trimethoprim-sulfamethoxazole) and 85.3% of them were resistant to erythromycin. Approximately, 20% of the *E. faecalis* isolates displayed resistance to high levels of aminoglycosides (gentamycin, tobramycin) and around 9.1% was resistant to quinolones (ciprofloxacin and levofloxacin). Vancomycin resistance was observwd in 5.2% of isolated enterococci (VRE). The overall proportion of extended spectrum beta-lactamases (ESBL) production among Enterobacteriaceae was 31.5%. The prevalence of ESBL production among *E. coli* isolates was significantly higher than in *K. pneumoniae* (36.1%, vs 16.3%, $p < 0.001$). Resistance to third-generation cephalosporins was observed in 12.7% *E.coli* isolates. No strains of *E.coli* resistant to ertapenem were found. Resistance to third-generation cephalosporins was observed in 11.2% K. pneumoniae isolates. Carbapenem resistance was identified in 24.7% of *P.aeruginosa* isolates and 59.3% of *Acinetibacter* spp. isolates.

DISCUSSION

This is the first study in Ukraine were to evaluate the quality of cleaning and disinfection of surfaces scheduled for daily cleaning and degree of bacterial contamination of hospital rooms and the patients' inanimate environment by use of an ultraviolet fluorescence targeting method (UVM) and microbial methods. In this study the cleaning and disinfection of surfaces were not being performed properly in most cases. Complete removal of the mark was 49.1%, partial removal was 37,5%, and mark was still visible, i.e. this area had not been processed was 13,4% when the UVM procedures were used, respectively. Cleaning performance varied significantly between the 9 acute care hospitals. Contamination of hospital rooms and the patients' inanimate environment surfaces by the bacterial pathogens investigated was found to be frequent and widespread occurrence. The predominant bacterial agents were: *E. coli, Enterobacter* spp., *P. aeruginosa*, *K.pneumoniae*, *Proteus* spp., *Citrobacter* spp., *Acinetobacter* spp., and *Enterococcus* spp., followed by Coagulase-negative staphylococci (CNS), *Serratia* spp., *S. aureus, Streptococcus* spp., and *Stenotrophomonas maltophilia.*

The increasing emergence and spread of multi-resistant bacteria in hospitals is of great concern and continues to challenge infection control and hospital epidemiology practice worldwide [12]. However, only limited data concerning the colonization of a patient with multi-resistant Gram-positive and Gram-negative strains and the subsequent spread of these strains into the hospital environment are currently available. In our study a significant part of the bacterial agents isolated from the environment surfaces were resistant to many antibiotics. The overall proportion of extended spectrum beta-lactamase (ESBL) production among Enterobacteriaceae was 31.5% and of methicillin-resistance in *S. aureus* (MRSA) 14.9%. Vancomycin resistance was observed in 5.2% of isolated enterococci (VRE). Resistance to third-generation cephalosporins was observed in 12.7% *E.coli* isolates and was in 11.2% *K. pneumoniae* isolates. Carbapenem resistance was identified in 24.7% of *P.aeruginosa* isolates and 59.3% of *Acinetibacter* spp. isolates.

According to the literature, micro-organisms in the patients' inanimate environment surfaces scheduled for daily cleaning contribute to HAI [2, 12-16]. Although there is no direct proof, there is mounting evidence that the environment of patients colonized with Gram-positive and Gram-negative bacteria serves as a potential reservoir for cross-transmission and hence, possible nosocomial infections. Patients hospitalized in rooms previously occupied by people infected with HAIs are at increased odds of HAI acquisition compared to patients whose prior room occupant was negative for HAIs.

The environmental transmission pathways of pathogens and HAIs are varied. Measures to reduce the environment as a transmission pathway for HAIs are also varied. Improved cleaning procedures, training environmental service personnel, hand hygiene, and bundled disinfection interventions reduce the concentrations of pathogens on environmental surfaces and reduce HAIs in healthcare facilities. The literature has focused on multimodal strategies in infection prevention and control. Understanding the efficacy of the individual components of multi-modal strategies may help guide bundle development and may aid in decision-making in low-resource settings. However, there has not been a rigorous systematic review of the efficacy of disinfection interventions in situ.

CONCLUSIONS

Our studies have shown that in hospital rooms, most patient environmental surfaces are contaminated with multidrug-resistant bacterial agents and can be a vehicle for the transmission of healthcare-associated infections pathogens. Cleaning and disinfection processes must be improved so that there is a reduction in environmental contamination of frequent-contact surfaces in hospitals. Transmission of infectious agents from contaminated surfaces to a patient may occur via direct contact, indirectly via the hands or gloves of healthcare personnel. Failure to properly disinfect carries risk for person-to-person transmission and transmission of environmental pathogens. To reduce transmission risk of infectious agents from contaminated surfaces to the patient, more attention should be paid to the evidence-based recommendations on the preferred methods for Handwashing, cleaning and disinfecting the healthcare environment. It is important for healthcare personnel to recognize the role of patient healthcare environment as a transmission risk of multidrug-resistant infectious agents and adhere to prevention strategies for healthcare-associated infections based on current international guidelines and the literature. Further studies are needed to confirm our data and elucidate the relative importance of the patient-care items can serve as a source or reservoir for multidrug resistant bacteria in hospitals, including causation between contamination of a pathogen with a fomite and actual HAIs, elucidation of direct and indirect transmission mechanisms via a patient-care items using advanced molecular typing, and improvement of adherence to cleaning and disinfection practice.

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We would like to thank all the nurses and physicians in Kyiv acute cfre hospitals, and members of Ukrainian association of infection control and antimicrobial resistance who contributed in this study.
This work is a fragment of a research study of the Scientific Research Laboratory of Shupyk National Healthcare University of Ukraine (Kyiv, Ukraine). Title: The scientific justification for measures to combat the resistance of microorganisms to antimicrobial drugs in Ukraine on the "One Health" approaches. State Registration Number: 0120U101440. Study period: 2020-2022. This work was funded by the Ministry of Health of Ukraine according to the plan of that research study. The authors did not receive any financial support from the manufacturers of medical instruments and drugs.

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Conflict of interest:
The Authors declare no conflict of interest

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Received: 12.08.2021
Accepted: 11.01.2022

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