

ORIGINAL RESEARCHES

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Epidemiological features of septic nosocomial infections within various intensive care units

*Viorel Prisacari, Iana Baranetchi, Marcela Chilianu, Cristina Rarancean

Laboratory of Intrahospital Infections, Nicolae Testemitanu State University of Medicine and Pharmacy
Chisinau, the Republic of Moldova

Authors' ORCID iDs, academic degrees and contributions are available at the end of the article

*Corresponding author – Viorel Prisacari, e-mail: viorel.prisacari@usmf.md

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Abstract

Background: Septic nosocomial infections are a major public health issue. Both the risk of contracting and the specificity of nosocomial pathology directly depend upon the type of inpatient settings, as well as on the institution-specific risk factors.

Material and methods: The study used a descriptive observation method based on a cross-sectional study. The present research documented and analysed retrospectively 687 follow-up records of patients admitted to different intensive care units.

Results: The study results found that the incidence of septic nosocomial infection within various intensive care units (ICU) differs, ranging between 24.68% up to 34.8%. The structure of nosological forms was dominated by severe infections as pneumonia – 50.7%, septicemia – 12.68%, surgical site infections – 12.60%, urinary tract infections – 8.45%. The polyetiological structure of pathogens varied depending on the types of ICU. Microorganisms of the genus *Staphylococcus*, *Acinetobacter*, *Clebsiella*, *Pseudomonas* and *Enterobacter* predominated in most gram-negative (87.25%) cases, being multi-drug resistant to antibiotics. The following risk factors for the development of nosocomial septic infections were identified: the widespread use of invasive devices in the treatment process, patient's comorbidities, polytraumas, vasopressors administration, the length of hospital stay within the ICU, etc. The clinical and economic effect is also important; hence the hospital stay length of patients with nosocomial infections was 2.2-2.5 times, the hospital stay cost per patient was 4.56 times, and the mortality rate was 4.55-8.43 higher compared to patients with no purulent nosocomial infections.

Conclusions: Septic nosocomial infections are an urgent issue for ICU admission, which requires the implementation of comprehensive programs to prevent morbidity and reduce microbial antibiotic resistance.

Key words: nosocomial septic infections, intensive care units, epidemiology, etiology, risk factors.

Cite this article

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Introduction

Nosocomial infections (NI), also called healthcare-associated infections (HAIs), are a serious medical and socio-economic problem due to an increase in morbidity, the development of severe clinical forms, high mortality, and significant healthcare and economic impact [1-6].

Currently, the phenomenon of nosocomial infections is determined by several factors as the widespread use of complicated treatment methods, including the invasive ones, the multitude of infectious agents, the emergence of subpopulations of antibiotic-resistant bacteria, and the lack of vaccination [1, 7-13].

At the same time, the risk of contracting, as well as the specificity of nosocomial pathology, are directly dependent upon the type of the healthcare inpatient facility and on the specific risk factors of the institution [3, 6-8, 12].

In the hospitals of the Republic of Moldova, the real

incidence of septic nosocomial infections in intensive care units has not been studied yet.

The specificity of intensive care units (ICU) is the concentration of both patients with serious conditions and healthcare providers within a limited space, as well as the massive use of invasive diagnostic and therapeutic methods, and high levels of immunodeficiency in patients. For these reasons, patients admitted to intensive care units are at higher risk of contracting and developing nosocomial infections. According to some studies conducted within intensive care units, about 45-60% of patients have some forms of nosocomial infection, which exceeds the incidence among patients within other inpatient facilities, the mortality being of 34-48% among patients with septic nosocomial infection, thus, resulting in a significant economic burden. The development of

nosocomial pneumonia, for example, leads to an increase in the duration of treatment within the intensive care unit by 10.3 days [2, 6, 11, 12, 14].

In hospitals of the Republic of Moldova, the real incidence of nosocomial septic infections in intensive care units has not been studied yet.

Material and methods

A descriptive observation method based on a cross-sectional study was used when describing the incidence of septic-purulent nosocomial infections, epidemiological and etiological features, risk factors and socio-economic consequences. In this regard, 688 follow-up records of patients admitted to various ICUs were documented and retrospectively analysed, namely, polytraumas (A), septic infections (B), heart defects (C). The microbial strains, that are the causative agents of nosocomial septic infections, were isolated, and the antibiotic sensitivity / resistance testing was carried out in medical laboratories according to the classical methods described by Galetchi P. and others (1997), Buiuk D., Negut M. (2009), as well as via the automated system VITEC-2 Compact [15, 16].

A retrospective descriptive analysis was carried out according to the methodology described in “General epidemiology. Fundamentals of evidence-based medicine” [17].

Results

The epidemiological analysis of the quantitative data obtained from the cross-sectional retrospective study of three types of intensive care units (tab. 1) revealed that the

development rate of nosocomial septic infections differs according to the profile of the inpatient facility, accounting for 24.6%, or 246.0‰ for “Polytrauma” ICU; 28.12%, or 281.2 ‰ – in “Sepsis” ICU; 34.1%, or 348.1 ‰ for “Heart Defects” ICU, the mean value being of 28.94% or 289.4 ‰.

Table 1. The incidence of septic infections within different types of intensive care units

ICU	Indices					
	No patients	Including septic infections			Mas	
		Abs	%	‰	%	‰
A	162	40	24.60	246.0	28.94	289.4
B	288	81	28.12	281.0		
C	158	55	34.81	348.1		

The structure of nosological forms was dominated by severe septic pathologies, such as pneumonia and bronchopneumonia – 44.74%, septicemia – 11.66%, urinary tract infections (UTIs) – 16.47%, and surgical site infections – 27.2% of cases (fig. 1).

At the same time, depending on the type of the inpatient care facility, a clear predominance of pneumonia and bronchopneumonia was revealed in the “Heart Defects” ICU – 57.74%, septicemia in the “Sepsis” ICU – 18.75%, urinary tract infections and wound infections – in the “Polytrauma” ICU – 23.1% and 41.7%, respectively (fig. 1 A, B, C, Mas).

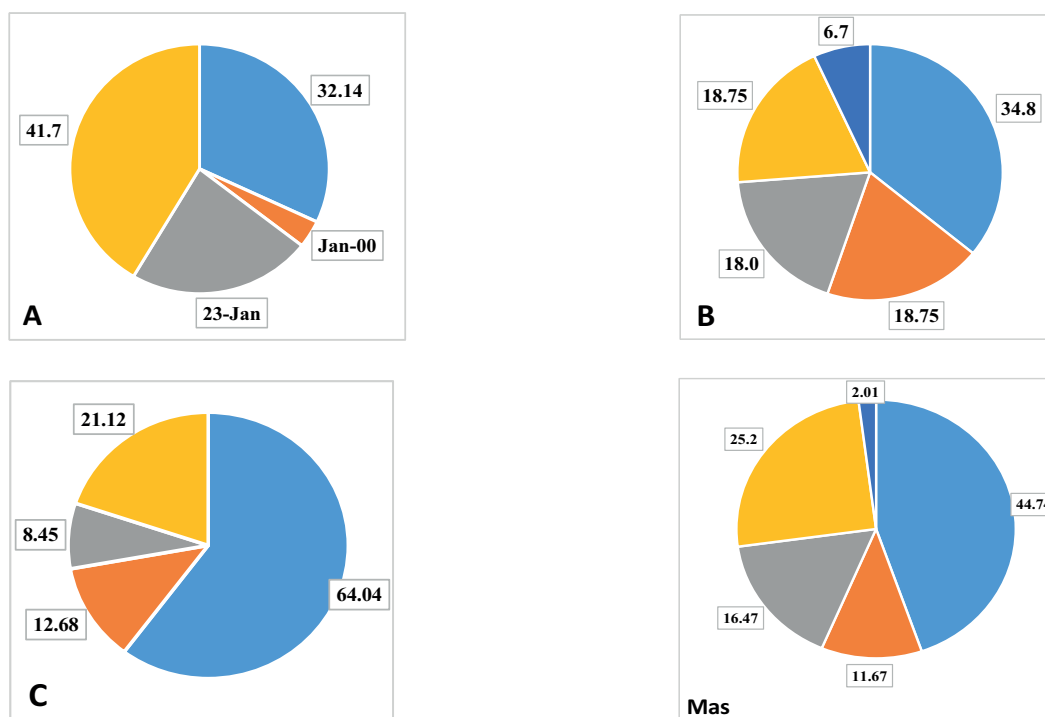


Fig. 1A, B, C, Mas. Distribution of nosological forms

■ Pneumonia and bronchopneumonia ■ Septicemia ■ UTI ■ Wound infection ■ Others

Following the analysis findings of the pathogen spectrum of septic infections in the examined ICU patients, it was found that their structure is very diverse. For example, 18 types of microorganisms were the causative agents for septic infections within the “Polytrauma” ICU. The structure of pathogens was dominated by: *Kl. Pneumoniae* – 19.9%, *Acinetobacter spp* – 16.66%, *P. aeruginosa* – 14.5%, *Staphylococcus* strains – 17.7%, *E. faecalis* – 10.4% and *P. mirabilis* – 4.2%. The study of the antibiograms showed that the strains isolated from patients with septic infections were highly resistant to antibiotics in 68.19% of samples, had an intermediate resistance in 5.12% of samples and only 26.5% of samples were susceptible to antibiotics. High resistance to aminoglycosides – 71.16%, penicillins – 81.39%, cephalosporins – 88.18%, quinolones – 75.38% and carbapenems – 56.37% was revealed. As to the types of antibiotics, the strains were highly resistant to gentamicin – 77.5%, ampicillin – 77.16%, ceftazidime – 87.5%, ceftriaxone – 87.5%, cefepime – 88.23%, ciprofloxacin – 83.95 %, levofloxacin – 75.38%, and impinem – 70.9%, which are widely used in medical practice. In addition, it has been revealed that the microbial isolates exhibited multi-drug resistance to antibiotics. High multi-drug resistance was found in the following prevailing pathogens: *Kl. pneumoniae* – 78.95%, *Acinetobacter spp* – 81.25%, *P. aeruginosa* – 92.86% and *S. epidermidis* – 81.81%. It is also noteworthy that strains of *Staphylococcus* were methicillin-resistant in 52.0% of cases.

Microorganisms of the genus *Staphylococcus* (*aureus*, *epidermidis* and *haemolyticus*) dominated in the “Heart defects” ICU, accounting for 23.4% of the total number of strains isolated from patients with septic infections, followed by *Kl. pneumoniae* – 18.2%, *E. faecalis* – 18.2%, *P. aeruginosa* – 9.1%, *A. baumani* – 6.5% and *E. cloacae* – 5.2%. At the same time, it was found that *Candida* fungi (*albicans*, *krusei*, and *glabrata*), being determined in 7.8% of patients, played an important role as pathogens of nosocomial septic infections within the “Heart Defects”

ICU. The remaining 11.6% of microbial strains identified in the sources of septic-purulent infections belong to other types of microorganisms. Of the total number of isolated strains, 69.35% were multi-drug resistant to antibiotics: *Kl. pneumoniae* – 78.0%, *Staphylococcus spp* – 56.6%, *Acinetobacter spp* – 87.25%, *P. aeruginosa* – 84.4%, *E. faecalis* – 53.0%, and *E. coli* – 88.9%. The microbial strains showed high resistance to aminoglycosides – 66.77%, penicillins – 81.25%, cephalosporins – 82.87%, quinolones – 70.59%, carbapenems – 48.55%, and depending on the types of antibiotics: to gentamicin – 77.50%, cefoperazone – 94.74%, tobramycin – 79.49%, ticarcillin – 91.67%, piperacillin – 89.19%, cefoperazone – 94.74%, ceftazidime – 87.88%, cefazolin – 85.71%, ceftriaxone – 88.24%, cefuroxime – 78.95%, cefepime – 66.67%, moxifloxacin – 84.0%, levofloxacin – 85.29%, meropenem – 53.66%, and vancomycin – 25.0%.

There were 24 types of microorganisms from septic ICU patients, among which *Kl. pneumoniae* – 28.3%, *P. mirabilis* – 15.09%, *P. aeruginosa* – 11.32%, *E. coli* – 9.04%, *E. faecalis* – 8.49%, *Staphylococcus spp* – 7.54%, and *A. baumannii* – 6.06%.

It is noteworthy that gram-negative microorganisms (*Kl. pneumoniae*, *A. baumannii*, *P. aeruginosa*, *E. coli*, *P. mirabilis*), which account for 87.25% of the total number of isolated strains, prevailed as causative agents of septic infections in all the intensive care units under study (fig. 2).

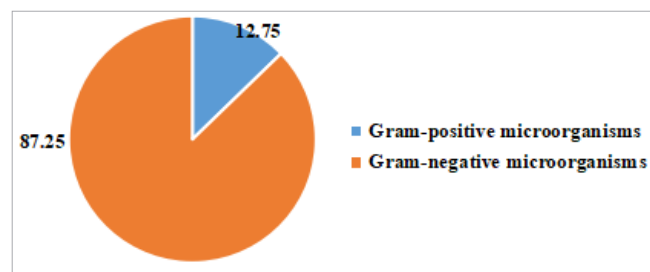


Fig. 2. The prevalence of gram-positive and gram-negative microorganisms in the etiological structure of septic infections within intensive care units

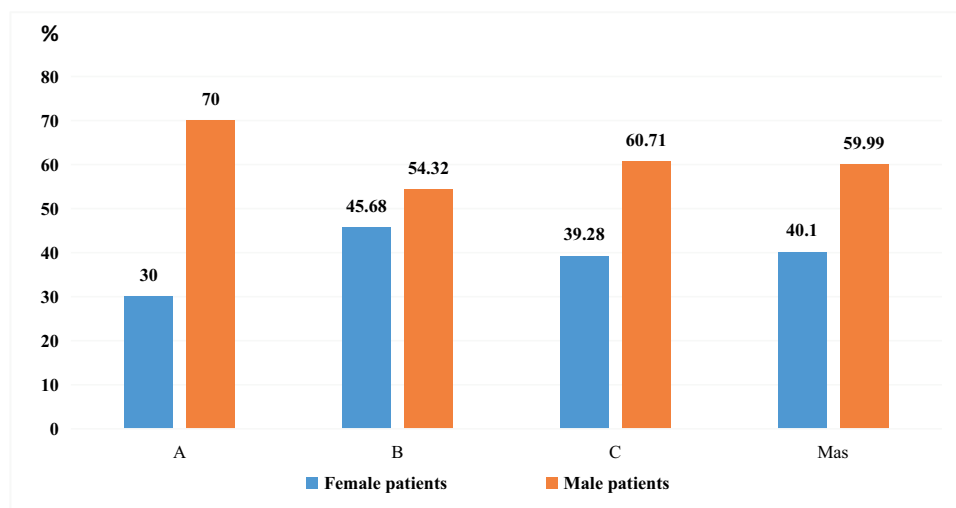


Fig. 3. The occurrence of septic infections depending on patient's gender

The risk of developing nosocomial septic infections was higher in men, whose overall prevalence was 59.9% from the total number of patients compared to 40.1% in women, being common for all ICU types included in the study (fig. 3).

Obviously, people aged ≥ 60 years (48.4%) predominated among patients with septic infections, except for the “Heart Defects” ICU, where young people, up to one year old, predominated with a frequency of 33.33% of the total number diseases, as well as patients of working age viz. 20-39 years old admitted within the “Polytrauma” ICU, showing an occurrence of 37.5% of the total number of diseases (tab. 2).

The main risk factors for developing septic infections in patients admitted to “Polytrauma” ICU included the massive polytraumas found in 50.40% of patients, characterized by the presence of multiple wounds, including the open ones in primary sources – 78.50%, hence the prevalence of wound infections; emergency admission, being registered

in 76.90%; horizontal patient position – 95.23%; artificial lung ventilation – 76.20%; vascular catheterization used in 96.60% of patients, including 68.29% – more than 48 hours; urinary catheterization – 90.47%, including 80.43% of patients – more than 48 hours; vasopressor administration – 80.95% (fig. 4A).

In the septic ICU, the use of a vascular catheter was found in 83.95% of patients with septic infections, including 63.33% of patients with ≥ 48 hours; urethral catheter – in 77.77% of patients, including 57.14% ≥ 48 hours, and 67.9% of patients were mechanically ventilated (fig. 4B).

In the “Heart Defects” ICU, the use of invasive devices in the treatment process (endotracheal tube for assisted lung ventilation – 38.5%, vascular catheter – 38.5%, urinary catheter – 40.2%, drainage of the chest and abdominal cavity – 39.1 and 66.7%, respectively, the use of nasogastric tube – 64.6%) was also highlighted as risk factors of developing septic infections (fig. 4C).

Table 2. Occurrence of septic infections according to the patients’ age

ICU	Indices	Patients’ age, years					Total
		≤ 1	1-19	20-39	40-59	≥ 60	
A	abs	-	-	15	7	18	40
	%	-	-	37.50	17.50	45.00	100.0
B	abs	-	1	6	18	56	81
	%	-	1.23	7.40	22.22	69.13	100.0
C	abs	25	11	5	13	21	75
	%	12.76	6.12	13.26	19.38	48.47	100.0
Total	abs	25	12	26	38	95	196
	%	12.76	6.12	13.26	19.38	48.47	100.0

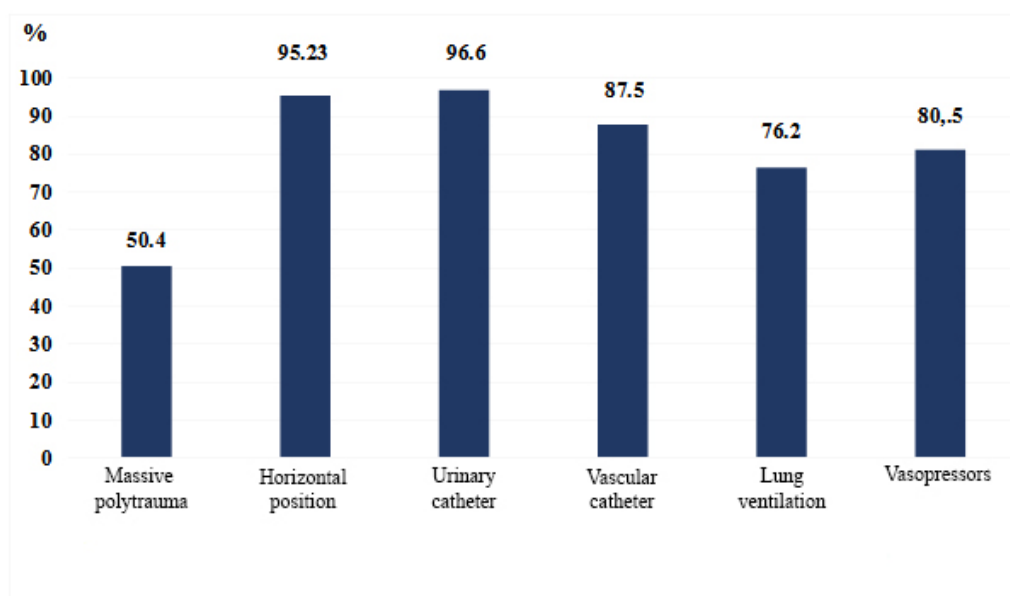


Fig. 4A. Frequency of invasive device use in critical care, type A

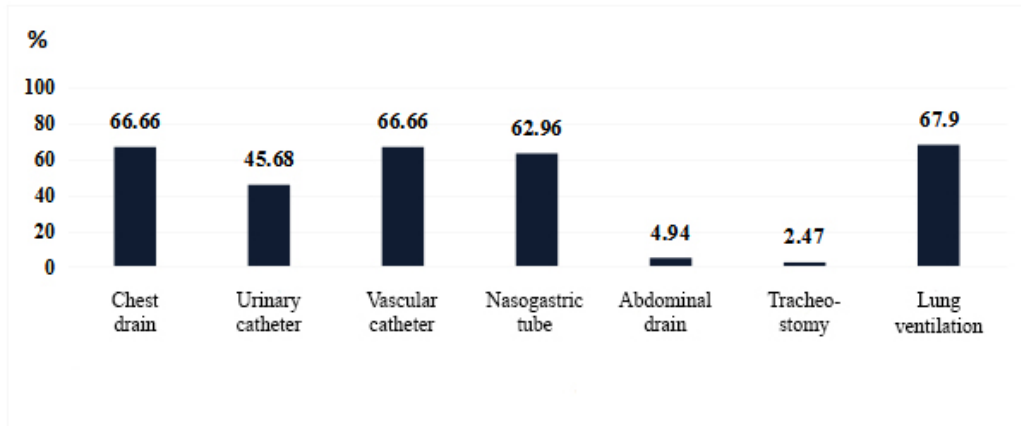


Fig. 4B. Frequency of invasive device use in critical care, type B

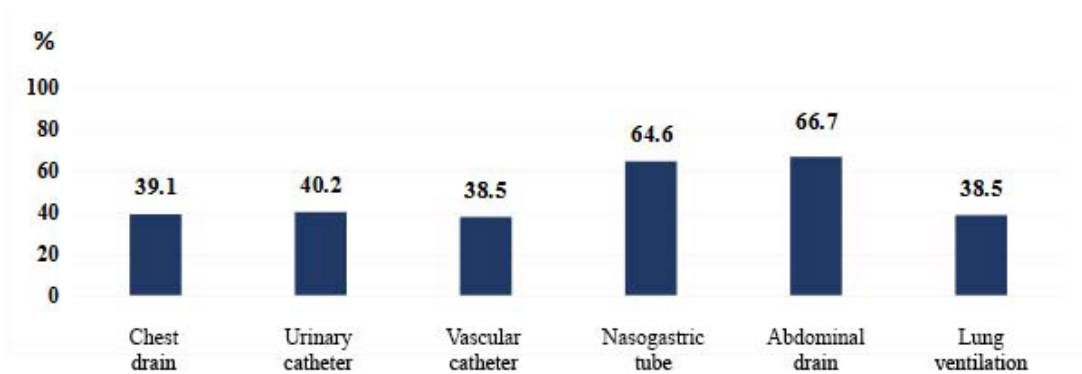


Fig. 4C. Frequency of invasive device use in critical care, type C

It has been established, for example, that endotracheal intubation of a patient showed an average increase of 23.68% for the risk of developing septic infections. At the same time, the risk got exponentially higher, the longer the duration of assisted lung ventilation was. If the duration

of mechanical ventilation was up to 24 hours, the risk of developing pneumonia was 5.56%, if it ranged between 24 and 96 hours – 23.08%, and if mechanical ventilation was over 96 hours, the risk of developing in-hospital pneumonia increased up to 56.10% (fig. 5).

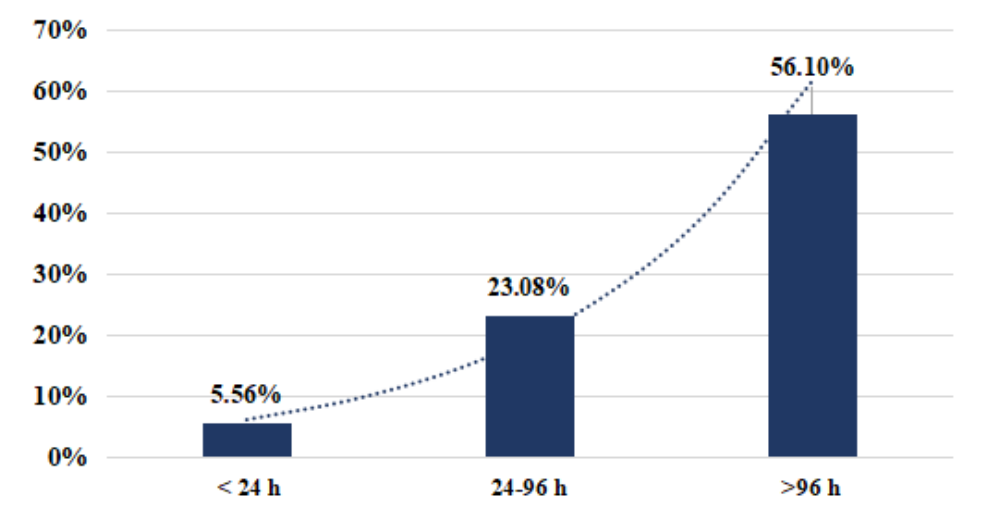


Fig. 5. Risk of developing nosocomial pneumonia depending on the duration of assisted ventilation

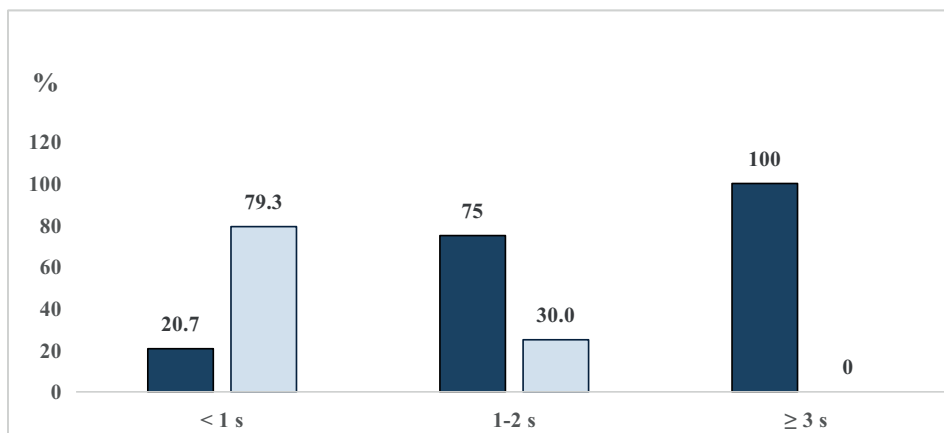


Fig. 6A. The incidence of septic infections depending on the patients' length of stay in the ICU, type A

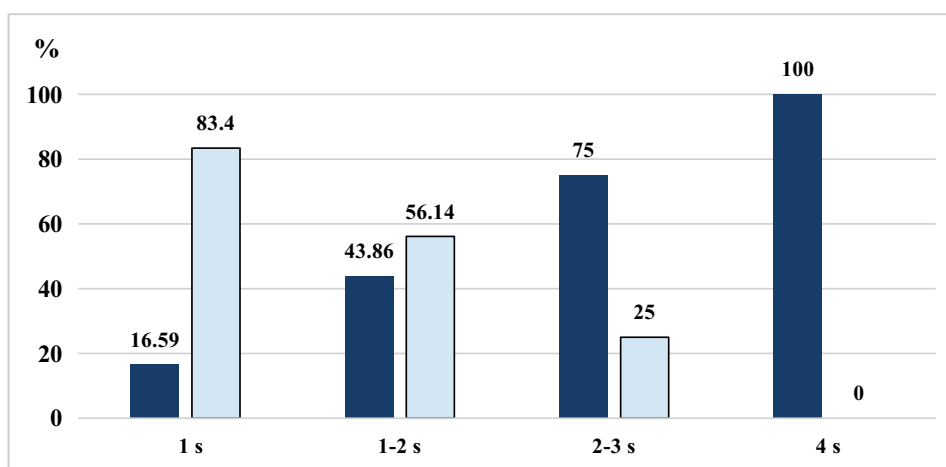


Fig. 6B. The incidence of septic infections depending on the patients' length of stay in the ICU, type B

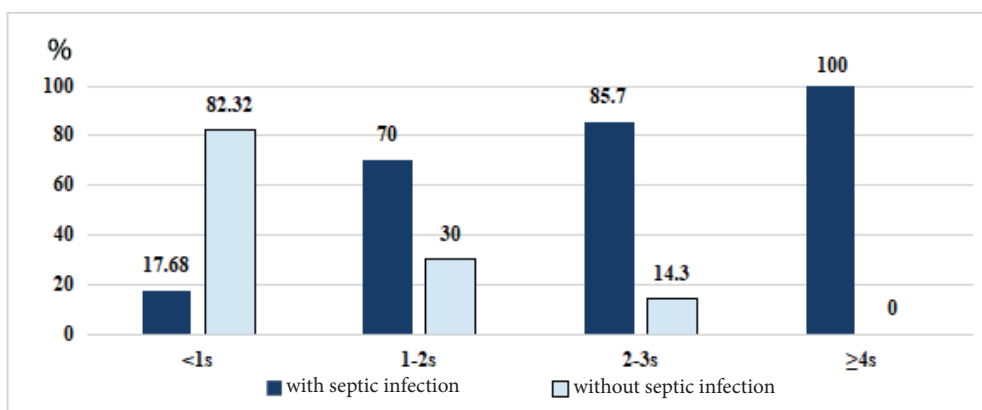


Fig. 6C. The incidence of septic infections depending on the patients' length of stay in the ICU, type C

A major risk factor of developing septic infections was the presence of comorbidities: chronic respiratory diseases – 32.35%, chronic cardiovascular diseases – 49.62%, hypertension – 45.04%, chronic kidney and liver diseases – 46.42% and 33.47%, respectively, diabetes mellitus – 23.49%, etc.

At the same time, the frequency of contracting and developing septic infections in the ICU is directly dependent

on the patient's treatment duration within the respective inpatient facilities (fig. 6). In case of a patient's stay for up to one week within the ICU, following rehabilitation and intensive treatment, the rate of contracting and developing septic infections was ~ 18.12%, up to 2 weeks ~ 62.95%, up to 3 weeks ~ 86.9%, and up to 4 weeks – 100.0 %. This phenomenon was characteristic of all ICU types under study (fig. 6 A, B, C).

Both clinical and economic impact, caused by septic infections in intensive care units is significant. It was found that the ICU length of stay in patients with nosocomial septic-purulent superinfections was 2.2 times, the patient's healthcare cost – 4.56 times, and the mortality rate was about 8.43 times higher compared to patients without nosocomial septic infections.

Discussion

The results of the present study on the real incidence of septic nosocomial infection, based on the model of three intensive care units confirm the specialized literature data on the relevance of the actual problem. High morbidity, severe forms of infection (pneumonia, septicemia, urinary tract infections, and surgical site infections), increased medical and socio-economic impact and require the implementation of comprehensive programs to reduce the risk of contracting and developing septic infections within the ICU.

A number of studies have shown that the microbial species that are commonly found as the causative agents of nosocomial septic-purulent infections show high multi-drug resistance to antibiotics used in hospitals, including the ICUs, which greatly complicates the therapeutic management of patients. The present study results confirm that one of the major problems facing medicine today is the high multi-drug resistance of hospital strains to antibiotics widely used in medical practice, hence a more tailored treatment, based on microbiological diagnosis and antibiogram, should be applied to patients with septic infections, especially in those admitted to intensive care units.

Conclusions

1. The incidence of nosocomial septic infections was found to be high within the ICUs under study, ranging from 248.6‰ to 348.0‰.
2. Severe forms of septic infections were predominant within various types of ICUs (pneumonia and bronchopneumonia – 44.74%, septicemia – 11.66%, urinary tract infections – 6.47%, and wound infection – 27.2%).
3. The etiological structure is clearly dominated by Gram-negative microorganisms (87.25%), including *Kl. Pneumoniae*, *A. baumannii*, *P. aeruginosa*, *E. coli*, *P. mirabilis*, which are multi-resistant to antibiotics.
4. The following predominant risk should be considered in contracting and developing septic infections: patient's advanced age and comorbidities, as well as the invasive procedures used (vascular and urinary catheterization, assisted pulmonary ventilation, thoracic and abdominal drainage, massive polytraumas, duration of intensive treatment, and vasopressor administration).
5. The clinical and economic impact in septic infections is significant due to an increase in the hospital length

of stay by 2.2 times, the healthcare cost per patient by 4.56 times, and the mortality rate by 8.43 times.

6. The current situation requires the implementation of comprehensive programs to prevent morbidity and reduce antimicrobial resistance.

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Authors' ORCID iDs and academic degrees

Viorel Prisacari, MD, PhD, Professor, Academician – <https://orcid.org/0000-0002-8694-2327>

Iana Baranețchi, MD, PhD, Scientific Researcher – <https://orcid.org/0000-0002-2899-6482>

Marcela Chilianu, MD, Scientific Researcher – <https://orcid.org/0000-0002-0250-6684>

Cristina Rarancean, MD, Scientific Researcher – <https://orcid.org/0000-0002-1598-5901>

Authors' contributions

VP conceptualized the idea and drafted the first version of the manuscript, IB, MC and CR collected the data. All the authors contributed to the study design, reviewed and approved the final manuscript.

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Ethical approval

The research has gained a positive opinion issued by the Research Ethics Committee of *Nicolae Testemitanu* State University of Medicine and Pharmacy (Protocol No 47 dated 12.04.2018).

Conflict of interests

The authors have declared no conflicts of interests.

