

Original article

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Trends of Surgical Site Infection at the Orthopedics and Traumatology Clinic of the University Clinical Center Of Niš

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Hospital-acquired surgical site infections (SSIs) are one of the main causes of postoperative complications. Surgical site infections in orthopedics include bone infections which are particularly challenging for treatment. Objective: Monitoring of trends in SSIs after orthopedic surgeries in University Clinical Center Nis, providing updated epidemiology data on SSIs by multi resistant strains of pathogens and improving measures of prevention and suppression of hospital infections. Materials and methods: A descriptive study was used as a research model. It included all patients who had orthopedic interventions at the UCC Nis from 2015 to 2024. The annual rates for the observed period, as well as the linear trend, were calculated. The data were statistically processed in the IBM SPSS v27.0 program. Chi square test was used to determine the statistical significance of the data, at the $p < 0.05$ level. Results: The number of hospitalized patients and average length of stay varied significantly, with a notable decline in surgical site infections observed after 2019 despite increased patient volume in later

years. A statistically significant association was found between the type of causative agent and the year of infection ($p < 0.05$), with MRSA being predominant in 2015, Acinetobacter sp. in 2016 and 2017, and Serratia sp. in 2022 and 2024. Conclusion: Our findings indicate a significant decline in SSIs after 2019, even though the number of patients continued to rise in subsequent years. Acinetobacter sp. and Serratia sp. were the most common pathogens in orthopedic SSIs. Prevention should focus on education and timely reporting of hospital-acquired infections.

Keywords: Surgical site infection, Orthopedic surgery, Surveillance system

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Trend učestalosti infekcija operativnog mesta na Klinici za ortopediju i traumatologiju Univerzitetskog kliničkog centra Niš

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Sažetak

Uvod: Bolničke infekcije operativnog mesta (IOM) su jedan od glavnih uzroka postoperativnih komplikacija. Infekcije hirurškog mesta u ortopediji uključuju infekcije kosti koje su posebno izazovne za lečenje. Cilj: Praćenje trendova IOM nakon ortopedskih operacija u Univerzitetskom kliničkom centru Niš, ažuriranje epidemioloških podataka o IOM izazvanim multirezistentnim sojevima i poboljšanje mera prevencije i suzbijanja bolničkih infekcija. Materijali i metode: Sprovedena je deskriptivna studija koja je obuhvatila sve pacijente koji su imali ortopedske intervencije u UKC Niš od 2015. do 2024. godine. Izračunate su stope incidencije za posmatrani period, kao i linearni trend. Podaci su statistički obrađeni u programu IBM SPSS v27.0. Hi-kvadrat test je korišćen za određivanje statističke značajnosti podataka, na nivou $p < 0,05$. Rezultati: Broj hospitalizovanih pacijenata i prosečna dužina boravka varirali su, sa

značajnim padom IOM nakon 2019. godine, uprkos povećanom broju pacijenata u kasnijim godinama. Utvrđena je statistički značajna povezanost između vrste uzročnika i godine infekcije ($p < 0,05$), pri čemu je MRSA bio dominantan 2015. godine, *Acinetobacter sp.* 2016. i 2017. godine, a *Serratia sp.* 2022. i 2024. godine. Zaključak: Naši nalazi ukazuju na značajan pad infekcija operativnog mesta nakon 2019. godine, iako je broj pacijenata nastavio da raste u narednim godinama. *Acinetobacter sp.* i *Serratia sp.* bili su najčešći uzročnici infekcija operativnog mesta. Prevencija treba da se fokusira na edukaciju i blagovremeno prijavljivanje bolničkih infekcija.

Ključne reči: Infekcije operativnog mesta, Ortopedska hirurgija, Sistem nadzora

Introduction

Surgical Site Infections (SSIs) are one of the main causes of postoperative complications. According to the latest regulations, health care-associated infection (HAI) is infection that occurs within 30 days of the operation if no implant has been installed (a foreign body that is installed during the operation and remains permanently in the patient's body, e.g. artificial heart valves, heterologous vascular graft, mechanical heart, joint prostheses) or during 90 days if the implant is placed and the patient has leakage of pus from the incision or dehiscence of the wound with following signs or symptoms: elevated body temperature ($>38^{\circ}\text{C}$), localized pain or sensitivity to touch (1). SSI is responsible for increased mortality, long hospitalization period, and a high economic burden (2, 3). According to the past reports, the incidence rate of SSI is globally about 10–20% (4). According to the European Center for Disease prevention and Control (ECDC), the percentage of SSI varies from 0.5 to 9.0%, depending on the type of procedure (5). Due to the nature of orthopedic surgeries and characteristics of patients (older patients especially in arthroplasty surgeries, with variety of conditions and disorders) the risk of surgical site infection is higher compared to other procedures. These infections are commonly caused by Gram-negative bacteria or *Staphylococcus aureus*. Most of these bacteria can form a biofilm on artificial surfaces (such as prostheses, screws, plates) which makes them resistant to the immune system and antibiotics. There is also a risk of fistula formation, tissue necrosis and implant loss. Methicillin-resistant *Staphylococcus aureus* (MRSA) often causes more aggressive infections with purulent secretions and can progress quickly. Bone infection (osteomyelitis) can be the result of deep wounds that are not treated adequately (6).

Modern surgery had been developing in Europe for centuries, and 150 years ago, surgical site infections were so common that suppuration of the wound was considered a positive response to injury, even though two-thirds of limb amputations were fatal due to infection (7).

This topic was chosen due to the increasing number of surgical site infections (SSIs) observed in orthopedic practice. Although SSIs significantly impact patient outcomes, prolong hospital stays and increase healthcare costs, there is still a lack of comprehensive research focused specifically on orthopedic cases. The complexity of orthopedic procedures, the frequent use of implants, and the rising

issue of antibiotic resistance make this area particularly vulnerable - yet underexplored. By addressing this topic, the aim is to highlight the importance of early detection, prevention strategies, and the need for further studies that could contribute to better clinical outcomes and improved standards of care in orthopedic surgery.

1. Objective

The main objective of the study was to explore the epidemiological situation of hospital-acquired infections of surgical site after orthopedic surgeries in the University Clinical Center Nis from 2015 to 2024.

Additional objective was to determine the basic epidemiological characteristics and updating epidemiology data on SSIs by multi-resistant strains of pathogens would provide the elements for improving measures of prevention and suppression of hospital infections in University Clinical Center Nis.

2. Materials and methods

A descriptive study was used as a research model and the data were retrospectively analyzed for the 10-year period. It included all patients who had orthopedic interventions at the University Clinical Center Nis (UCC Nis) from 2015 to 2024.

The study included data from the documentation of the Institute of Public Health Nis, Centre of Prevention and Disease Control, as well as reports from the Department of Sanitary and Epidemiological Surveillance of the University Clinical Center Nis, namely: Reports on the trend of nosocomial infections in the University Clinical Centre Nis in the period from 2015 to 2024; Nosocomial infection reporting forms and Reports of hospitalized patients of the University Clinical Center Nis. The annual rates and average prevalence for the observed period, as well as the linear trend, were calculated. All the collected data were entered into a database specially created for this research.

All data were statistically processed using Microsoft office (Word and Excel version 2019) and IBM SPSS ver. 27.0 program. Chi square and Fisher's test were used to determine the statistical significance of the data, at the $p < 0.05$ level.

Ethical approval for this study was obtained from the Ethics Committee of the University Clinical Center Nis (Approval No. 26249/10, issued on September 3, 2025).

3. Results

During the period 2015 to 2024, total of 19474 patients were hospitalized at the Clinic of Orthopedic surgery and Traumatology of the University Clinical Center Nis. The total number of reported surgical site infections was 45, more precisely 35 persons had a hospital-acquired surgical site infection (25 patients had SSI caused by one causative agent and 10 patients had SSI caused by two different pathogen agents).

Table 1 shows total number of hospitalized patients, average length of hospitalization and number of hospital-acquired surgical site infections throughout the years.

Table 1. Total number of hospitalized patients, duration of hospitalization (in days), average length of treatment (in days) and number of isolated bacteria annually at the Clinic of Orthopedic surgery and Traumatology

2015	Total number of hospitalized patients	2050	2020	Total number of hospitalized patients	1374
	Duration of hospitalization (days)	15558		Duration of hospitalization (days)	8226
	Average length of treatment (days)	8		Average length of treatment (days)	6
	Number of SSI	8		Number of SSI	0
2016	Total number of hospitalized patients	1964	2021	Total number of hospitalized patients	1488
	Duration of hospitalization (days)	16007		Duration of hospitalization (days)	8915
	Average length of treatment (days)	8		Average length of treatment (days)	6
	Number of SSI	7		Number of SSI	0
2017	Total number of hospitalized patients	1967	2022	Total number of hospitalized patients	1668
	Duration of hospitalization (days)	15817		Duration of hospitalization (days)	11758
	Average length of treatment (days)	8		Average length of treatment (days)	7
	Number of SSI	11		Number of SSI	4
2018	Total number of hospitalized patients	1545	2023	Total number of hospitalized patients	3071
	Duration of hospitalization (days)	16716		Duration of hospitalization (days)	15178
	Average length of treatment (days)	11		Average length of treatment (days)	5
	Number of SSI	10		Number of SSI	1
2019	Total number of hospitalized patients	2055	2024	Total number of hospitalized patients	2292
	Duration of hospitalization (days)	15903		Duration of hospitalization (days)	15900
	Average length of treatment (days)	8		Average length of treatment (days)	7
	Number of SSI	0		Number of SSI	2

In Table 1, we see that the number of hospitalized patients ranged from a low of 1,488 in 2021 to a high of 3,071 in 2023. The total duration of hospitalization generally fluctuated in line with patient volume, peaking at 15,903 days in 2019, and dropping significantly during the pandemic years (2020 - 2021). The average length of treatment decreased over the years, from a consistent 8 days (2015 - 2019) to only 5 days in 2023. The highest number of SSIs occurred in 2017 (11 cases) and 2015 (8 cases). From 2019 onward, a noticeable decline in SSI cases is observed: 2019, 2020, 2021 and 2024 all reported zero SSIs. Only 1 case was reported in 2023, despite the highest number of hospitalizations that year.

Figure 1 shows the distribution of patients with HAI by gender in the period from 2015 to 2024.

Figure 2. Patients with surgical site infection at the Clinic of Orthopedic surgery and Traumatology - distribution by age

Figure 2 shows that most patients were aged 71 to 80 years. The youngest patient was 26 and the oldest was 80 years old. Fisher's test: $p > 0.05$, There was no statistically significant relationship between the age of patients and year of infection (Fisher's test: $p > 0.05$, Fisher=45.142, $p = 0.180$).

Figure 3 depicts the most common causative agents of infection.

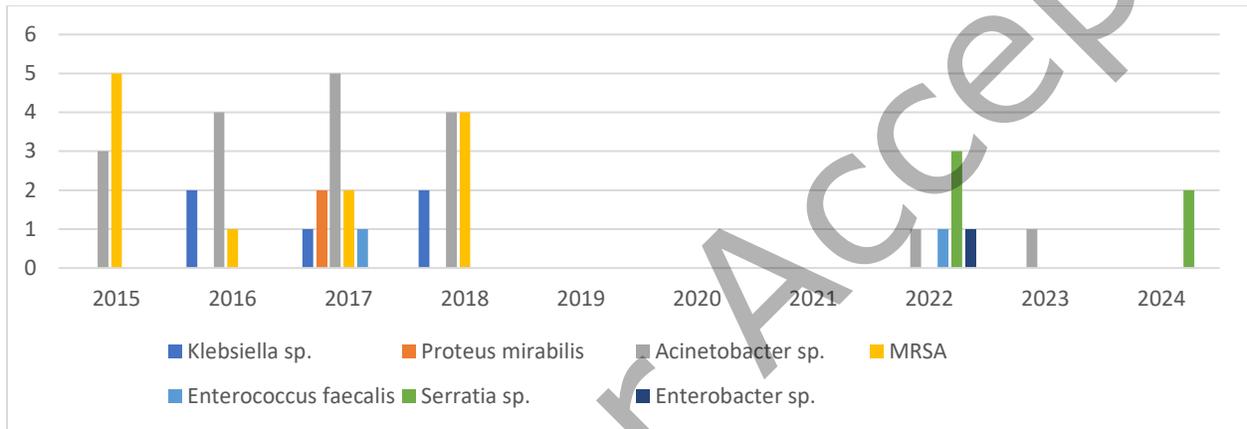


Figure 3. Pathogen agents that caused surgical site infections at the Clinic of Orthopedic surgery and Traumatology

In fig 3 we see that the most common pathogen agents were methicillin-resistant *S. aureus* in 2015 and *Acinetobacter sp.* in 2016, 2017 and 2018. In recent years there has been an increase in infections caused by *Serratia sp.* (2022 and 2024).

In table 2 is distribution of hospital-acquired infections by causative agents.

Table 2. Hospital associated infections by causative agent in 10-year period

		Year							Total	
		2015	2016	2017	2018	2022	2023	2024		
Bacteria	<i>Klebsiella sp.</i>	Count	0	2	1	2	0	0	0	5
		% of Total	0.0%	4.4%	2.2%	4.4%	0.0%	0.0%	0.0%	11.1%
	<i>Proteus mirabilis</i>	Count	0	0	2	0	0	0	0	2
		% of Total	0.0%	0.0%	4.4%	0.0%	0.0%	0.0%	0.0%	4.4%
	<i>Acinetobacter sp.</i>	Count	3	4	5	4	1	1	0	18
		% of Total	6.7%	8.9%	11.1%	8.9%	2.2%	2.2%	0.0%	40.0%
	MRSA	Count	5	1	2	4	0	0	0	12
		% of Total	11.1%	2.2%	4.4%	8.9%	0.0%	0.0%	0.0%	26.7%
	<i>Enterococcus faecalis</i>	Count	0	0	1	0	1	0	0	2
		% of Total	0.0%	0.0%	2.2%	0.0%	2.2%	0.0%	0.0%	4.4%
	<i>Serratia sp.</i>	Count	0	0	0	0	3	0	2	5
		% of Total	0.0%	0.0%	0.0%	0.0%	6.7%	0.0%	4.4%	11.1%
	<i>Enterobacter sp.</i>	Count	0	0	0	0	1	0	0	1
		% of Total	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	2.2%
Total		Count	8	7	11	10	6	1	2	45
		% of Total	17.8%	15.6%	24.4%	22.2%	13.3%	2.2%	4.4%	100.0%

Table 2 outlines the causative agents responsible for hospital-acquired infections. Using Fisher's test $p < 0.05$, we notice there was a statistically significant association between the type of bacteria and year of infection (*Serratia sp.* was significantly more common in 2022 and 2024 compared to other bacteria whereas *Acinetobacter sp.* was more common in 2016 and 2017 compared to other bacteria; MRSA was significantly more common in 2015 compared to other bacteria (Fisher=47.268, $p=0.013$).

4. Discussion

Hospital-acquired infections (HAIs) emerged as a significant issue with the development of institutional hospital care. Initially, there was limited understanding of the causes and transmission

routes of infections, and virtually no knowledge of effective disinfection, sterilization, or aseptic practices. Over time, as hospitals became central to modern healthcare, HAIs evolved into a major public health concern, contributing to increased morbidity, prolonged hospital stays, and higher healthcare costs worldwide (7).

Throughout the study period, the number of hospitalized patients and average length of stay varied significantly, with a notable decline in surgical site infections observed after 2019 despite increased patient volume in later years. This trend may suggest improvements in infection prevention measures, surgical techniques, or perioperative care protocols introduced in recent years. It is also possible that changes in reporting practices or a reduced number of high-risk procedures during pandemic years played a role.

Older age has an impact on a patient's susceptibility to infection, while no significant differences were observed between genders.

A statistically significant association was found between the type of causative agent and the year of infection ($p < 0.05$), with MRSA being predominant in 2015, *Acinetobacter sp.* in 2016 and 2017, and *Serratia sp.* in 2022 and 2024.

Until 2018, all surgical clinics with intensive care units were located in the old building, where the risk of infection transmission was higher. With the opening of the new building and the simultaneous reorganization of the surgical clinics, the Anesthesia and Intensive Care Clinic became separate unit. Spatial separation of clinics contributes to easier monitoring and treatment of hospital infections.

Number of patients in the Orthopedic clinic during the study fluctuated by up to 100% (from 1545 in 2018 to 3071 in 2023) even if we exclude 2020 due to SARS-Cov-2 pandemic (number of patients that year was 1374) (Table 1). Most studies indicate that hospital overcrowding directly affects the incidence of nosocomial infections. Two studies used monthly data and found a positive correlation between the incidence of nosocomial infections and bed occupancy (8, 9). In addition, staffing shortages are more likely to occur when bed occupancy rates are high (10, 11) which is also a risk factor for transmission of bacteria.

The Clinic of Orthopedic surgery and Traumatology had the highest number of patients with hospital-acquired infections in 2017, when the average length of treatment was 11 days, i.e. 3 days longer than the usual 7-8 days (Table 1). In our experience, a higher number of hospitalized patients usually leads to a higher risk of nosocomial infections. It was observed that a higher number of days spent in the hospital increased the risk of developing infections, which was in accordance with our expectations. According to Saripella et al., the association between a longer hospital stay and an increased risk of infection can be largely explained by the prolonged length of hospitalization in patients with comorbidities and those who required invasive procedures (12). However, it is difficult to determine whether a prolonged hospital stay leads to the occurrence of nosocomial infections or whether the occurrence of nosocomial infections itself prolongs hospitalization.

There was no difference between number of male and female patients with nosocomial infections (Fig 1). In the study by Tomczyk et al., a higher incidence of nosocomial infections was observed in men than in women (13). Men represented 65.31% of the study group, while women represented 34.69%. Dividing the number of nosocomial infections by gender, as many as 75% of all nosocomial infections were diagnosed in men. This is confirmed by clinical studies that have shown that men are more prone to nosocomial infections (14). A study conducted in 2019 on a large group of patients by Aghdassi et al. (15) showed that men are also more susceptible to surgical site infections.

Infections were more common in population from 71 to 80 years old (Fig 2). Age is another important risk factor for the occurrence of hospital infections (16, 17). This is confirmed by the study by Bochicchio et al., which showed a significantly higher incidence of hospital infections in older patients (18). Other studies also confirm the significant influence of age on the occurrence of hospital infections in patients (18, 19). It has also been shown that age significantly affects the occurrence of inflammation in patients due to the presence of other risk factors, such as long hospitalization, chronic diseases, etc. (20).

The most common cause of SSI at the Clinic for Orthopedics and Traumatology was *Acinetobacter sp.* and methicillin resistant *Staphylococcus aureus* and in later years *Serratia sp.* (Fig 3; Table 2). Abbo et al. from Israel isolated *Acinetobacter sp.* in infected surgical wounds in 19.5% of patients (21), while in Sarajevo the number of *Acinetobacter sp.* infections was 26.4% according to Rebić et al. (22). Uwingabiye et al. (23) showed that patients who spent 14 or more days in the hospital

had a more than six-fold increased risk of nosocomial infections caused by *Acinetobacter baumannii*. The emergence of multi-resistant strains of *Acinetobacter baumannii* affects the spread of the same between hospitals, geographical regions and even continents; excessive use of antibiotics enhances this spread (24). Many isolates are resistant to all antimicrobials except colistin (polymyxin E) and tigecycline, and some infections are not treatable with any of the existing antimicrobial agents (25). Methicillin-resistant *Staphylococcus aureus* was the second most common pathogen (Fig 3). This bacterium is also the most common cause in a university hospital in Germany, according to Möllers et al. (26). Transmission of MRSA in the clinical setting can occur by direct and indirect contact, mainly from the nasal vestibule, which is the main reservoir for this pathogen in humans. Therefore, wearing masks should reduce the number of infections caused by this bacterium. Recent studies have highlighted that lack of adequate hand hygiene and inadequate use of personal protective equipment are the main reasons for the emergence of multidrug-resistant microorganisms (27, 28). In recent decades, *Serratia marcescens* has been established as a cause of infections difficult to treat, and several outbreaks of nosocomial infections have been reported, mostly from the USA. However, *Serratia* infections affecting bones and joints are very rare; only a few such cases have previously been reported from Europe (29). According to Karczewski et al, *Serratia* infection has been described in all major joints but it tends to primarily affect elderly with significant secondary diseases (30).

The prevalence of surgical site infections at Orthopedic clinic of UCC Nis fits into European standards. Based on the ECDC report, we note that *Staphylococcus aureus* is the most common cause of surgical site infections in the European Union, while in the UKC Nis it is in second place. The most common bacteria in our clinic, *Acinetobacter* sp. is not a common cause of SSI in the orthopedic surgeries in EU (5).

Hospital-acquired infections (HAIs), especially surgical wound infections, are complications that lead to higher mortality rates, longer hospital stays, and higher costs (31, 32). The US alone spends over \$33 billion on hospital-acquired infections annually (33). With the rapid development of invasive medical methods, the contribution of HAI to morbidity and mortality in surgery has increased significantly (34, 35). This is particularly noticeable in orthopedics, a field that relies heavily on implants (for example, internal fixators for bone fractures), wound bandages and catheters. A nine-year retrospective study of 90,551 patients undergoing elective surgery found that the surgical site infection

rate was 1.4%. Furthermore, length of hospitalization was 1.48 ± 0.04 days longer and costs were $\$8893 \pm \148 higher for patients with HAI (36, 37). Also, surgical site infections are the most common reason for revision surgeries after total knee arthroplasty (25.2%) and the third most frequent (14.8%) reason for revision of total hip arthroplasty (38, 39). It is important to investigate the financial aspect of hospital-acquired infections, including the actual costs of treatment, extended hospital stays, repeated surgical procedures, and additional interventions. A comprehensive analysis of these economic burdens could provide valuable insights for healthcare resource planning and infection prevention strategies.

Also, due to the very definition of hospital acquired infection (90 days from implant placement), a large number of these infections are not recorded. Symptoms of deep surgical site infection appear later or the patient himself is treated in a primary care facility in another city, bypassing our surveillance system.

5. Conclusion

Our findings indicate a significant decline in surgical site infections after 2019, even though the number of hospitalized patients continued to rise in subsequent years. However, further analysis would be required to determine whether these low numbers reflect actual clinical improvements or are influenced by underreporting, different patient demographics, or types of surgeries performed. Based on our results older age of the patients has an impact on the patient's resistance or sensitivity to infection. *Acinetobacter sp.* and *Serratia sp.* were the most frequently detected bacterium in orthopedic SSIs. Preventive efforts should focus on the education of healthcare workers and patients, along with enhancing the timely reporting of hospital-acquired infections.

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