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Improvements in Surgical Site Infection Control in Albania: Impact of Infrastructure, Sterilization Standards, and Clinical Practices

Arnavutluk'ta Cerrahi Alan Enfeksiyonunun Kontrolünde İyileştirmeler: Altyapı, Sterilizasyon Standartları ve Klinik Uygulamaların Etkisi

✉ Ardit Kacani¹, ✉ Krenar Lilaj², ✉ Vjollca Duro³, ✉ Emigleo Sulku⁴, ✉ Fjoralba Mulgeci⁴, ✉ Sara Ferizaj⁴, ✉ Irişi Sure⁴, ✉ Lejdis Zeneli⁴, ✉ Edmond Puca^{5*}

¹University Hospital Center “Mother Theresa”, Department of General and Digestive Surgery, Tirana, Albania

²University Hospital Center “Mother Theresa”, Department of Anaesthesia and Reanimation, Tirana, Albania

³University Hospital Center “Mother Theresa”, Laboratory Service, Tirana, Albania

⁴University of Medicine, Faculty of Medicine, Tirana, Albania

⁵University Hospital Center “Mother Theresa”, Service of Infectious Diseases, Tirana, Albania

Abstract

Introduction: Surgical site infections (SSIs) are a major cause of postoperative morbidity, prolonged hospitalization, and increased healthcare costs worldwide. In Albania, SSI rates have historically been high; however, recent infrastructural and organizational reforms in tertiary hospitals have led to measurable progress. This study evaluated the effects of infrastructure modernization, centralization of sterilization services, and the introduction of disposable materials and laparoscopic techniques on SSI incidence at the University Hospital Center “Mother Teresa” in Albania.

Materials and Methods: A prospective observational study was conducted in the Department of General and Digestive Surgery from October 2023 to October 2024. Data were collected on patient demographics (age, sex), surgical characteristics (upper or lower gastrointestinal; elective or emergency), comorbidities (hypertension, diabetes mellitus, malignancy), and SSI occurrence. Microbiological analyses included pathogen identification and antimicrobial susceptibility testing (AST) in accordance with the 2024 European Committee on AST guidelines.

Results: Among 1,179 patients (51.2% male; mean age, 57.8 years), 5.4% developed SSIs after abdominal surgery. Infection rates were significantly higher in lower gastrointestinal procedures (57.8%) than in upper gastrointestinal procedures (42.2%). Patients aged ≥ 50 years exhibited a greater risk of SSI ($p = 0.01$), as did those with comorbidities ($p = 0.0007$) and diabetes mellitus ($p = 0.0006$). Mean hospital stay was markedly longer among infected patients (4.4 vs. 2.0 days; $p < 0.0001$). *Escherichia coli* (39%) and *Enterococcus faecalis* (22%) were the most common isolates, demonstrating notable resistance to ciprofloxacin (34%) and trimethoprim-sulfamethoxazole (31%). Reductions in infection rates were closely linked to enhanced operating room ventilation, improved sterilization practices, and the use of single-use materials.

Conclusion: Albania has achieved substantial progress in SSI prevention through targeted infrastructural and procedural reforms. Nonetheless, persistent challenges—particularly antimicrobial resistance and the lack of a national SSI surveillance system—underscore the need for a coordinated, multidisciplinary strategy. Strengthening antimicrobial stewardship, standardizing perioperative protocols, and expanding the use of minimally invasive surgery are key priorities for sustaining improvements.

Keywords: Surgical site infection, Albania, abdominal surgery, hospital infrastructure, antimicrobial resistance, infection control

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Address for Correspondence/Yazışma Adresi: Edmond Puca MD, University Hospital Centre “Mother Theresa”, Service of Infectious Diseases, Tirana, Albania

E-mail: edmond_puca@yahoo.com **ORCID ID:** orcid.org/0000-0002-0621-4865

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Öz

Giriş: Cerrahi alan enfeksiyonları (CAE), dünya çapında ameliyat sonrası morbidite, uzun süreli hastanede kalış ve artan sağlık hizmetleri maliyetlerinin başlıca nedenidir. Arnavutluk'ta CAE oranları tarihsel olarak yüksek olmuştur; ancak, üçüncü basamak hastanelerdeki son altyapısal ve organizasyonel reformlar ölçülebilir bir ilerleme sağlamıştır. Bu çalışmada, Arnavutluk'taki “Rahibe Teresa” Üniversite Hastanesi Merkezi'nde altyapı modernizasyonu, sterilizasyon hizmetlerinin merkezileştirilmesi ve tek kullanımlık malzemeler ile laparoskopik tekniklerin kullanılmaya başlanmasıyla CAE insidansı üzerindeki etkileri değerlendirilmiştir.

Gereç ve Yöntem: Ekim 2023 ile Ekim 2024 tarihleri arasında Genel ve Sindirim Sistemi Cerrahisi Anabilim Dalı'nda prospektif bir gözlemsel çalışma yürütüldü. Hastaların demografik özellikleri (yaş, cinsiyet), cerrahi özellikleri (üst veya alt gastrointestinal; elektif veya acil), eşlik eden hastalıklar (hipertansiyon, diabetes mellitus, malignite) ve CAE oluşumu hakkında veriler toplandı. Mikrobiyolojik analizler, 2024 Avrupa Antimikrobiyal Duyarlılık Testi (ADT) yönergelerine uygun olarak patojen tanımlama ve ADT içeriyordu.

Bulgular: Bin yüz yetmiş dokuz hastanın (%51,2'si erkek; ortalama yaş 57,8) %5,4'ünde abdominal cerrahi sonrası CAE gelişti. Enfeksiyon oranları alt gastrointestinal prosedürlerde (%57,8), üst gastrointestinal prosedürlere (%42,2) göre anlamlı derecede daha yüksekti. ≥ 50 yaş hastalarda CAE riski daha yüksekti ($p = 0,01$), eşlik eden hastalıkları ($p = 0,0007$) ve diyabeti ($p = 0,0006$) olanlarda da aynı risk mevcuttu. Enfekte hastalarda ortalama hastanede kalış süresi belirgin şekilde daha uzundu (4,4'e karşı 2,0 gün; $p < 0,0001$). *Escherichia coli* (%39) ve *Enterococcus faecalis* (%22) en sık görülen izolatlar olup, siprofloksasine (%34) ve trimetoprim-sülfametoksazol (%31) karşı belirgin direnç göstermekteydi. Enfeksiyon oranlarındaki azalmalar, gelişmiş ameliyathane ventilasyonu, iyileştirilmiş sterilizasyon uygulamaları ve tek kullanımlık malzemelerin kullanımıyla yakından bağlantılıydı.

Sonuç: Arnavutluk, hedefli altyapı ve prosedür reformları sayesinde CAE önlenmesinde önemli ilerleme kaydetmiştir. Bununla birlikte, özellikle antimikrobiyal direnç ve ulusal bir CAE gözetim sisteminin olmaması gibi devam eden zorluklar, koordineli ve çok disiplinli bir stratejiye olan ihtiyacı altını çizmektedir. Antimikrobiyal yönetimin güçlendirilmesi, perioperatif protokollerin standartlaştırılması ve minimal invaziv cerrahinin kullanımının yaygınlaştırılması, iyileştirmelerin sürdürülmesi için temel önceliklerdir.

Anahtar Kelimeler: Cerrahi alan enfeksiyonu, Arnavutluk, karın cerrahisi, hastane altyapısı, antimikrobiyal direnç, enfeksiyon kontrolü

Introduction

Healthcare-associated infections (HAIs) remain a persistent and critical challenge in modern surgical care. Also known as hospital-acquired or nosocomial infections, HAIs pose a substantial threat to patient safety and quality of care. Although largely preventable through evidence-based infection control strategies, they continue to occur with alarming frequency. HAIs are associated with extended hospital stays, adverse clinical outcomes, long-term disability, rising antimicrobial resistance (AMR), increased healthcare costs, and preventable deaths. Globally, they contribute significantly to both morbidity and mortality, representing a major burden for healthcare systems.

Among HAIs, surgical site infections (SSIs) account for approximately 16%–20% of all cases and exert profound effects on patient outcomes, including delayed wound healing, prolonged hospitalization, increased readmission rates, and elevated mortality^[1–4]. The global prevalence of HAIs in acute care hospitals is estimated at 7.1%, but the burden is substantially higher in low- and middle-income countries (LMICs)^[5,6]. In these settings, the financial consequences are particularly severe because patients frequently shoulder the majority of healthcare expenses. Developing an SSI can increase household expenditures by more than 10% of annual income, imposing a considerable economic strain^[7].

In Albania, earlier reports documented SSI prevalence rates of up to 13.3%, underscoring long-standing infrastructural and procedural gaps in infection control^[8,9]. Over the past

decade, however, major reforms have been implemented at the University Hospital Center “Mother Teresa,” including the renovation of surgical theaters, centralization of sterilization services, introduction of disposable surgical materials, and acquisition of laparoscopic systems. Recent prospective data indicate that these reforms have reduced the SSI incidence following abdominal surgery to 5.4%.

This study aims to evaluate the extent to which infrastructural modernization, improved sterilization standards, and updated clinical practices have contributed to this decline. Unlike previous investigations that primarily addressed clinical or epidemiological aspects, the present analysis highlights hospital modernization as a pivotal determinant in the prevention and control of SSIs in Albania.

Materials and Methods

Inclusion and Exclusion Criteria

All adult patients (≥ 14 years) who underwent abdominal surgery—either elective or emergency—at the Department of General and Digestive Surgery, University Hospital Center “Mother Teresa,” Albania, between October 2023 and October 2024 were included. Abdominal procedures were classified as upper gastrointestinal, lower gastrointestinal, hepatobiliary, or hernia-related surgeries. Laparoscopic procedures were analyzed as a separate subgroup to assess their increasing utilization during the study period. Reoperations within the same hospitalization were included when associated with postoperative complications.

Patients admitted solely for diagnostic procedures, minor interventions (e.g., biopsies, wound revisions), or transferred postoperatively from other hospitals were excluded. Pediatric, thoracic, cardiac, trauma, and neurosurgical procedures were also excluded.

Study Design and Context

This research employed a hybrid design combining a narrative review of previously published national data with a prospective observational analysis. The prospective component included all abdominal surgery patients treated between October 2023 and October 2024 at the University Hospital Center “Mother Teresa.”

Comparative analyses between pre- and post-reconstruction periods were based on institutional records obtained before (2015–2019) and after (2023–2024) modernization of operating theaters and central sterilization units. Published hospital reports and earlier prevalence surveys represented the pre-reconstruction baseline, whereas current data from the prospective survey characterized the post-reconstruction phase.

Descriptive statistics were used to compare SSI incidence, patient demographics, risk factors, and microbiological patterns across the two periods. The study emphasized systemic infrastructural and procedural improvements rather than individual patient-level matching.

The 2023–2024 prospective survey included 1,179 patients and assessed SSI incidence, associated risk factors, microbiological profiles, and AMR trends. Additionally, literature on SSI epidemiology in Europe and LMICs was reviewed to provide contextual background.

Data Extraction and Thematic Analysis

Data were analyzed under three domains:

- Infrastructure and organization: Upgrades in operating rooms, sterilization processes, use of disposable materials, and patient ward improvements.
- Clinical epidemiology: SSI incidence, patient demographics, comorbidities, and surgical categories.
- Microbiology and AMR: Pathogen distribution and antimicrobial susceptibility profiles.

Microbiological Sampling and Analysis

For patients clinically suspected of SSIs, wound specimens were collected aseptically. In superficial incisional infections, sterile cotton swabs were used after cleaning the wound with saline to eliminate surface contaminants. For deep or purulent infections, aspirates or tissue biopsies were collected to enhance diagnostic accuracy. All specimens were transported promptly to the Microbiology Laboratory of the University Hospital Center “Mother Teresa” and processed within 2 h of collection.

Microbial Identification and Antimicrobial Susceptibility Testing (AST)

Bacterial isolates were cultured on blood and MacConkey agar, followed by biochemical identification using conventional methods and the VITEK® 2 Compact system (bioMérieux, France). AST was performed according to the 2024 European Committee on AST (EUCAST) guidelines, using the automated VITEK® 2 platform. Breakpoints were interpreted per EUCAST standards. Resistance data were analyzed for each organism individually, and antibiotic names are reported as generic compounds.

Infrastructure and Organizational Upgrades

Comparison of conditions before and after departmental renovation revealed substantial improvements:

Before renovation:

- Operating theaters lacked adequate ventilation and temperature regulation.
- Sterilization was decentralized, performed independently by each department with variable standards.
- Reusable cloth drapes and gowns were employed, heightening infection risk.
- Laparoscopic instruments were unavailable.
- Wards were overcrowded (up to four patients per room) and lacked proper ventilation systems.

After renovation:

- Modern operating theaters with biofiltration and climate control systems were constructed.
- Sterilization was centralized under a specialized, trained team.
- Disposable gowns and drapes replaced reusable materials.
- Laparoscopic instruments became standard for minimally invasive surgery.

Table 1. Clinical and demographic characteristics of patients with SSIs.

Patients with SSIs	Number	Percentage
Female	27	42.19%
Male	37	57.81%
Lower gastrointestinal surgery	37	57.81%
Upper gastrointestinal surgery	27	42.19%
Comorbidities	45	70.31%
Arterial hypertension	41	64.06%
Diabetes mellitus	18	28.12%
Cancer	21	32.81%

SSIs, surgical site infections.

- Patient wards were renovated, featuring reduced bed density and air-conditioning systems.

Ethical Approval and Informed Consent

The study complied with the ethical principles of the Declaration of Helsinki (1964) and subsequent amendments. The research protocol was approved by the Ethics Committee of the University of Medicine, Tirana, and the National Agency for Scientific Research and Innovation (approval number: 20, dated: 02.11.2023). Written informed consent was obtained from all participants prior to enrollment. All data were anonymized to ensure confidentiality.

Statistical Analysis

Data analysis was performed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean \pm standard deviation, and categorical variables as frequencies (n) and percentages (%). Associations between categorical variables were evaluated using the chi-square test, while continuous variables were compared using the Student's t-test. Univariate logistic regression was applied to identify predictors of SSI development, with results reported as odds ratios (ORs) and 95% confidence intervals. Statistical significance was set at $p \leq 0.05$.

Results

A total of 1,179 patients were included, comprising 51.23% men and 48.77% women, with a mean age of 57.8 years (range: 19–92 years). SSIs occurred in 64 patients (5.4%), all of which were classified as superficial. Although infection rates were marginally higher in males, the difference was not statistically significant (OR 1.47, $p = 0.12$) (Table 1).

Table 2. Microorganisms isolated from SSIs.

Microorganisms isolated from the SSI	Number	Percentage
<i>Escherichia coli</i>	25	39.06%
<i>Enterococcus faecalis</i>	15	23.44%
<i>Klebsiella pneumoniae</i>	6	9.37%
<i>Staphylococcus epidermidis</i>	4	6.25%
<i>Pseudomonas aeruginosa</i>	3	4.69%
<i>Staphylococcus hominis</i>	3	4.69%
<i>Enterobacter cloacae</i>	2	3.13%
<i>Staphylococcus aureus</i>	1	1.56%
<i>Staphylococcus capitis</i>	1	1.56%
<i>Staphylococcus caprae</i>	1	1.56%
<i>Streptococcus agalactiae</i>	1	1.56%
Citrobacter	1	1.56%
Corynebacterium	1	1.56%

SSIs, surgical site infections.

Lower gastrointestinal surgeries carried a greater infection risk, accounting for 58% of SSIs, compared with 42% in upper gastrointestinal procedures. Laparoscopic operations represented 21% of all surgeries and showed a significantly lower SSI rate than open procedures (2.1% vs. 6.3%; $p < 0.05$), confirming the infection-preventive advantage of minimally invasive techniques.

Patients with SSIs were significantly older than those without infection (mean age, 66.2 vs. 57.0 years; $p < 0.0001$). Age ≥ 50 years increased the infection risk nearly threefold (OR: 2.69, $p = 0.01$). Comorbidities were also strong predictors (OR: 2.71, $p = 0.0007$), particularly type 2 diabetes mellitus (OR: 2.98, $p = 0.0006$). Older patients were significantly more likely to have comorbidities (OR 19.59, $p < 0.0001$) (Table 2).

Microbiological cultures confirmed that *Escherichia coli* and *Enterococcus faecalis* were the predominant pathogens, accounting for 39% and 23% of SSIs, respectively.

Resistance patterns are summarized in Table 3. Notably, over one-third of bacterial isolates exhibited resistance to ciprofloxacin, while resistance to trimethoprim–sulfamethoxazole, cefazolin, and levofloxacin exceeded 30%. In contrast, resistance to tetracycline, nitrofurantoin, penicillin, and fosfomycin remained low ($< 5\%$). Patients who developed SSIs experienced hospital stays more than twice as long as those without infection, averaging 4.4 days versus 2.0 days ($p < 0.0001$). No deaths were directly attributable to SSIs during the study period. Overall postoperative mortality among patients undergoing abdominal surgery was 1.1% (13/1,179), and all deaths occurred in individuals with advanced malignancies or severe comorbidities rather than active SSIs. These findings indicate that improvements in infection control contributed not only to reduced morbidity but also to the maintenance of low mortality rates.

Discussion

SSIs are among the most frequent postoperative complications, contributing to increased patient morbidity, prolonged hospital

Table 3. AMR patterns among bacterial isolates from SSIs.

Antibiotic	Resistant isolates (%)
Ciprofloxacin	34%
Trimethoprim–sulfamethoxazole	31%
Cefazolin	30%
Levofloxacin	30%
Amoxicillin-clavulanate	18%
Gentamicin	12%
Tetracycline	3%
Nitrofurantoin	3%
Penicillin	3%
Fosfomycin	3%

AMR, antimicrobial resistance; SSIs, surgical site infections.

stays, and higher healthcare costs. Effective prevention and control of SSIs are widely recognized as key indicators of surgical quality and patient safety^[10–12].

In LMICs, SSIs remain a major concern due to limited access to sterile equipment, overcrowded hospitals, and suboptimal infection control practices. The incidence in these settings is often two- to fivefold higher than in high-income countries, resulting in substantial preventable morbidity and mortality^[7,13–15].

Prior to this study, national data on SSIs in Albania were scarce^[8,16]. The observed decline in SSI rates from 13.3% to 5.4% strongly correlates with recent infrastructural and organizational improvements. These include renovation of operating theaters, centralization of sterilization services, adoption of single-use surgical materials, and the integration of laparoscopic techniques. International evidence supports that ventilated, filtered operating rooms, centralized sterilization units, and disposable materials significantly reduce infection rates. Minimally invasive surgery further lowers SSI risk by reducing wound exposure^[17–21]. Our stratified analysis confirmed this protective effect, as laparoscopic procedures demonstrated substantially lower SSI rates, emphasizing the importance of expanding minimally invasive surgery programs in tertiary hospitals.

Despite these advancements, risk factors for SSI in Albania remain consistent with global trends, including advanced age, comorbidities, and diabetes mellitus. The predominance of *Escherichia coli* and *Enterococcus* species among isolates reflects the gastrointestinal origin of contamination^[22–24]. Importantly, no SSI-related deaths were observed, and overall postoperative mortality remained low (1.1%), with all deaths occurring in patients with advanced malignancies or severe comorbidities rather than active infections. These findings underscore the clinical significance of modern infection control measures and laparoscopic techniques in reducing morbidity and maintaining low mortality in LMIC surgical settings.

A significant concern is AMR. Resistance rates exceeding 30% for commonly used antibiotics—including ciprofloxacin, trimethoprim–sulfamethoxazole, cefazolin, and levofloxacin—threaten the effectiveness of both prophylactic and therapeutic regimens. In contrast, resistance to tetracycline, nitrofurantoin, penicillin, and fosfomycin remained low (< 5%). This pattern mirrors reports from the European Centre for Disease Prevention and Control documenting rising AMR trends across Europe^[25–27]. Accordingly, antimicrobial stewardship programs are as critical as infrastructural and procedural improvements in sustaining progress against SSIs.

Remaining challenges in Albania include:

- Absence of a national SSI surveillance system: Current data are limited to individual hospital reports.

- Unquantified economic burden: Although prolonged hospital stays suggest increased costs, comprehensive analyses are lacking.

- Need for continuous staff training and protocol standardization: Consistent implementation of perioperative infection control measures across hospitals is essential.

Study Limitations

This study has several limitations. First, it was conducted in a single tertiary hospital, which may restrict the generalizability of the findings to other healthcare settings in Albania. Second, only abdominal surgical procedures were evaluated, excluding thoracic, cardiac, traumatic, pediatric, and other surgical categories. Third, the comparison of pre- and post-reconstruction data relied partly on previously published institutional records rather than matched patient cohorts, which may introduce variability in reporting standards. Additionally, the study did not assess long-term postoperative outcomes beyond the hospitalization period, potentially underestimating late-onset SSIs. Finally, although antimicrobial resistance patterns were analyzed, the study did not evaluate the adequacy or adherence to antibiotic prophylaxis protocols, an important determinant of SSI prevention.

Conclusion

This study demonstrates that Albania has achieved substantial reductions in SSIs through hospital modernization, centralized sterilization services, and the adoption of disposable materials and laparoscopic techniques. The SSI incidence decreased from 13.3% to 5.4%, confirming that targeted infrastructural and organizational reforms can significantly enhance patient safety. Despite these advancements, AMR remains a major concern, underscoring the need for a national SSI surveillance system, standardized perioperative protocols, and strengthened antimicrobial stewardship programs. Sustained investment in hospital infrastructure, staff training, and infection prevention initiatives will be essential to maintain these gains and expand their impact across the national healthcare system.

Ethics Committee Approval: The study complied with the ethical principles of the Declaration of Helsinki (1964) and subsequent amendments. The research protocol was approved by the Ethics Committee of the University of Medicine, Tirana, and the National Agency for Scientific Research and Innovation (approval number: 20, dated: 02.11.2023).

Informed Consent: Written informed consent was obtained from all participants prior to enrollment. All data were anonymized to ensure confidentiality.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.K., Concept: A.K., K.L., Design: K.L., E.P., Data Collection or Processing: V.D., E.S., Analysis or Interpretation: A.K., K.L., V.D., E.S., F.M., S.F., I.S., L.Z., E.P., Literature Search: A.K., K.L., V.D., E.P., Writing: E.P.

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