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Healthcare-associated infections in an orthopaedic setting: a multidisciplinary approach

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Summary

Healthcare-associated infections (HAIs) are a significant problem in healthcare facilities, resulting in longer hospital stays, additional costs and inconvenience for patients. Surgical site infections are one of the most common types of HAIs. In this context, orthopaedics appears to be the surgical area that is most involved in claims for HAIs. This narrative review explores the landscape of HAIs, their prevalence, associated adverse events, preventive measures and overall impact by providing an overview of infections in elective orthopaedic surgery. In summary, a significant proportion of surgical site infections can be prevented by a comprehensive, multidisciplinary approach.

Key words: surgical site infections, infection prevention and control, antimicrobial stewardship

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Introduction

Healthcare-associated infections (HAIs) present a significant challenge in contemporary healthcare settings, with repercussions on patient health and economic and public health considerations.
This narrative review explores the landscape of HAIs, their prevalence, associated adverse events, preventive measures, and global impact. In particular, it provides an overview of surgical site infections and infections in orthopaedic surgery and summarises the most effective measures to prevent them according to literature.
HAIs are infections that manifest during healthcare, predominantly within hospital or healthcare facility settings, and emerging 48 hours or more after hospital admission or within 30 days post-healthcare receipt [1].
Adverse events affecting hospitalised patients, notably adverse drug events, HAIs, and surgical complications, constitute pivotal areas of concern. Adverse outcomes include prolonged hospital stays, increased healthcare costs and considerable patient distress. Common HAI types encompass respiratory tract infections, surgical site infections, urinary tract infections, bloodstream infections, and gastrointestinal infections [2].
The European Union and European Economic Area report an estimated 3.5 million cases of HAI annually, contributing to over 90,000 deaths and substantial disa-

bility-adjusted life years (DALYs) [1]. The protection of patient safety and the constant monitoring of litigation, adverse events and sentinel events are essential elements of clinical risk management and are aimed at promoting, on the one hand, ever higher levels of quality of care and, on the other, containing insurance risks for healthcare organisations and individual professionals [3].

Therefore, improvement of prevention of HAIs and control programmes requires the timely analysis of the clinical effects and healthcare costs associated with these infections (claims and incident reporting), in order to intercept the most critical areas and define the most suitable strategies to increase patient safety and reduce the costs inherent to medical malpractice.

According to Marsh's 2022 MedMal report [4] on a sample of public and private healthcare companies, HAIs are a growing phenomenon (9% of the total cost of claims, up from 4.7% in 2012) and lead to some of the highest costs per case and some of the longest closure times. The hospital departments most affected by claims arising from HAIs belong to the surgical area (almost a third of the total): first and foremost, Orthopaedics and Traumatology, followed by General Surgery and Cardiac Surgery.

This analysis of the claims shows that in 19% of cases, HAIs lead to death, while in 81% they lead to a disability that compromises the quality of life. Among the different HAIs detected, post-surgical infections prevail in all hospital wards (47% of the total, including surgical wound infections) and particularly in Orthopaedics and Traumatology (76.5%).

Surgical Site Infections (SSIs)

Surgical site infections (SSIs) are one of the most common HAIs. They are linked to longer hospital stays, additional surgeries, intensive care, and increased rates of morbidity and mortality. According to data from the European Surveillance conducted by the ECDC between 2018 and 2020, the incidence of SSIs varies depending on the type of surgical procedure. For example, knee replacement surgery has a low incidence of SSIs of 0.6%, while open colon surgery has a higher incidence of 9.5% [5].

The responsible pathogen agents depend on the type of surgery. *Staphylococcus aureus*, coagulase negative *Staphylococci*, *Enterococcus spp*. and *Escherichia coli* are the most commonly isolated microorganisms. In addition, an increasing number of SSIs are caused by antibiotic-resistant pathogens such as methicillin-resistant *S. aureus* (MRSA) or *Candida albicans* [6].

Antimicrobial resistance in healthcare-associated infections

HAIs wield a substantial impact on global public health, constituting 71% of cases involving antibiotic-resistant bacteria, including those resistant to last-resort antibiotics [1]. This phenomenon is a major threat to public health globally; increased consumption of antimicrobial drugs, by both humans and animals, and improper prescribing of antimicrobial therapy can contribute to the development and selection of resistant germs. The result of this situation has been a reduced number of treatment options for patients and a consequent increase in morbidity and mortality [7].

Bacterial antimicrobial resistance was estimated to be directly accountable for 1.27 million global deaths in 2019 and to have contributed to 4.95 million deaths [8].

EARS-Net data indicate that in 2020, more than 800,000 infections in the EU/EEA were due to antibiotic-resistant bacteria and that more than 35,000 people died as a direct consequence of these infections [9].

In addition to deaths and disabilities, antimicrobial resistance carries significant economic burden. According to the World Bank, antimicrobial resistance could result in an additional health cost of USD 1 trillion by 2050 and a loss of gross domestic product of between USD 1 trillion and USD 3.4 trillion per year by 2030 [10,11].

Resistance of bacterial pathogens to antibiotics can be intrinsic, if always expressed in the species, or induced if genes are naturally present in the bacteria but only expressed at resistance levels upon exposure to an antibiotic [12].

The main six pathogens for resistance-related deaths are: *Escherichia coli*, followed by *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Streptococcus pneumoniae*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa* [13].

A report published in 2022 [14] jointly by the European Centre for Disease Prevention and Control (ECDC) and the WHO Regional Office for Europe suggests that rates of antimicrobial resistance for bacterial species-group combinations under surveillance are still elevated in Europe. In particular, it reports carbapenem resistance in *Escherichia coli* and *Klebsiella pneumoniae* and vancomycin resistance in *Enterococcus faecium*, with considerable growth in the years 2016 to 2020. The high rates of resistance to third generation cephalosporins and carbapenems in *K. pneumoniae* and of carbapenems-resistant *Acinetobacter* and *Pseudomonas aeruginosa* in several countries of the European Region are also cause for concern.

Surgical site infections in elective orthopaedic surgery

Elective orthopaedic surgery is generally considered to be a "clean" surgery and, therefore, associated with a low rate of infection [15,16]; however, orthopaedics appears to be the surgical area most involved in claims of HAIs. HAIs have important consequences not only on the health of patients and the quality of care provided, but also have strong economic impact due to the related claims [4].

Several studies have investigated the association between SSIs and risk factors related to the patient, surgery, and hospital setting. According to a recent meta-analysis [17], the literature confirms the association between SSIs in orthopaedic surgery and risk factors including male sex, obesity and smoking habit. In addition, even some comorbidities can increase the risk of developing SSIs, particularly diabetes and rheumatoid arthritis, as well as therapy with steroids.

Microorganisms responsible for SSIs have developed different adaptive responses following exposure to antimicrobial agents above the mean minimum inhibitory concentration, surgical debridement stress and changes in the microenvironment [18].

Many orthopaedic infections, such as osteomyelitis and joint replacement infection, are caused by microorganisms in biofilms, developing on non-living surfaces. The microorganisms adhere to dead bone or implants [17,20].

Biofilms are colonies of microorganisms surrounded by a polymer matrix, with nutrient circulation between cells. These microorganisms form organised communities with structural and functional heterogeneity like multicellular organisms. In vitro data indicate that microorganisms in biofilms are substantially more resistant to killing by antimicrobial agents than planktonic bacteria. Furthermore, biofilm resistance to antimicrobial agents begins in the attack phase and increases as the biofilm ages. For instance, in a study of *S. epidermidis* biofilms, vancomycin showed a decrease in lethal action when the biofilm aged from 6 hours to 2 days [18].

Antibiotic resistance in orthopaedic infections

Staphylococci, in particular *S. aureus* and *S. epidermidis*, are the main microorganisms responsible for orthopaedic implant-related infections. As is well known, *S. aureus* has high levels of resistance to antibiotics, while *S. epidermidis* and other staphylococcal species show increasing resistance to antibiotics.

Many clinical studies on infections associated with orthopaedic implants have been conducted, with an increasing focus on antibiotic resistance and its prevalence. The most common infecting organisms in primary and revision periprosthetic joint infections are *S. aureus* and coagulase-negative Staphylococci (CNS), with many strains resistant to at least one antibiotic. In some cases, CNS resistance to methicillin and gentamicin is higher than that of *S. aureus*, raising concerns for future antibiotic prophylaxis. Antibiotic-resistant Staphylococci have also been found in orthopaedic patients with loose or failed hip replacements, even without clinical signs of infection [19].

In addition, strains of *Staphylococcus aureus* isolated from orthopaedic implant-associated infections are more often resistant to some antibiotics than non-implant-associated isolates. Finally, elderly patients with orthopaedic implant-associated infections may present different antibiotic resistance profiles due to health impairment [20].

Responding to antimicrobial resistance

Infection prevention and control (IPC) measures and antimicrobial stewardship play an important role in preventing infections and especially in preventing infections with multidrug-resistant organisms. So-called antimicrobial stewardship defines a set of coordinated interventions aimed at promoting the appropriate use of antimicrobials and guiding the optimal choice of drug, dose, duration of therapy and route of administration [21].

Concerning IPC, the most important measure is hand hygiene compliance. The WHO recommends the 5 Hand Hygiene moments [22]:

- Moment 1 - Before touching a patient;
- Moment 2 - Before a procedure;
- Moment 3 - After a procedure or risk of exposure to body fluids;
- Moment 4 - After touching a patient;
- Moment 5 - After touching the patient's surroundings.

Furthermore, the WHO aids countries in developing and implementing antimicrobial stewardship programmes, which is one of the most cost-effective interventions to optimise the use of antimicrobial drugs, enhance patient outcomes and reduce antimicrobial resistance and HAIs.

To improve access to appropriate treatment and reduce inappropriate use of antibiotics, the WHO developed the AWaRe (Access, Watch, Reserve) classification of antibiotics. The WHO AWaRe book offers a brief, evidence-based guide on antibiotic choice, dose, route of administration and duration of treatment covering more than 30 of the most common infections among children and adults in both primary care and hospital settings [10].

Moreover, evidence-based guidelines and recommendations have been developed to reduce the selection of microbial variants [23-25]. In major orthopaedic surgery, the use of antibiotic prophylaxis is the most effective method to prevent postoperative infections.

According to the most recent Italian guidelines [25], antibiotic prophylaxis is recommended for operations requiring the implantation of open devices, such as prostheses, synthetic media and biomaterials. In other cases, the use of antibiotic prophylaxis should be individually assessed according to the invasiveness of the surgery and the characteristics of the patient. Generation I-II cephalosporins are recommended, but in cases of allergy or high incidence/risk of MRSA infection, glycopeptides or clindamycin may be used. In addition, in certain local contexts, it may be advisable to consider a combination with antibiotics that are effective against Gram-negative bacteria. An extension of antibiotic prophylaxis to perioperative prophylaxis beyond 24 hours is useless in terms of effectiveness as does not reduce the incidence of infection and is also associated with increased costs, exposes the patient to the risk of systemic toxicity and *C. difficile* colitis [26].

For other recommendations, please refer to current guidelines and local protocols.

One Health approach

Antimicrobial resistance is a challenging issue that needs both specific interventions in human health, food production, animals and the environment and a coordinated approach, known as 'One Health'.

The One Health paradigm represents an advanced approach that discerns interconnections between the health of human populations, animals, and the environment they share. This concept's significance has amplified in recent times due to shifts in various factors. For example, resistant germs, antimicrobial misuse, traverse communities, food supplies, healthcare facilities, and environmental matrices, all pose challenges in treating infections across species [27].

Conclusions

SSIs can lead to significant morbidity and mortality, as well as prolonged hospital stays, need for additional interventions and readmissions, and increased economic costs such as bed stay, physician time, nursing care, and diagnostic and therapeutic intervention [18].

However, there is evidence to suggest that the reduction of infection rates can be achieved through a combination of preventive measures and multifactorial interventions, with the potential for reduction between 35 and 55% [28]. Therefore, it is important to broaden the perspective and address the problem of SSIs through multidisciplinary approaches and different contexts. In essence, a significant percentage of SSIs can be prevented with comprehensive intervention.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

The authors contributed equally to the work.

Ethical consideration

Ethical Approval by the Institutional Ethics Committee is not required, as the data cannot be traced back to specific patients.

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