REVISTA DE ENFERMAGEM REFERÊNCIA
homepage: https://rr.esenfc.pt/rr/
ISSNe: 2182.2883

RESEARCH ARTICLE (ORIGINAL)

Analysis of risk factors for surgical site infection in patients undergoing major orthopedic surgery

Análise dos fatores da infeção do local cirúrgico em doentes submetidos a cirurgia ortopédica major

Análisis de los factores de infección del sitio quirúrgico en pacientes sometidos a cirugía ortopédica mayor

Daniela Alexandra Fernandes [1]
https://orcid.org/0000-0002-3598-3591

Matilde Delmina da Silva Martins [2]
https://orcid.org/0000-0003-2656-5897

[1] Northeastern Local Health Unit - Hospital Unit of Macedo de Cavaleiros - Orthopedics Department, Macedo de Cavaleiros, Portugal

[2] Polytechnic Institute of Bragança, School of Health, Bragança, Portugal

Abstract
Background: Surgical site infection affects one-third of surgical patients. Its incidence varies according to multiple factors.
Objective: To analyze risk factors for surgical site infection in patients undergoing major orthopedic surgery.
Methodology: Analytical cross-sectional study with 589 patients who underwent major orthopedic surgery between 2020 and 2021. Information on the patient, the surgery, and the compliance with bundles was collected from the Sclínico platform using a registration grid. Favorable opinion of the Ethics Committee (No. 46/2022).
Results: Twenty-three participants (3.9%) developed surgical site infections. They were mostly men (56.5%), aged 57 to 78 years (60.9%,) with a high body mass index (91.3%), hypertension (73.9%), smoking habits (14.09%), heart failure (9.3%), and tremor (33.3%). A statistically significant association was found between surgical site infection and smoking, heart failure, tremor, duration of surgery, postoperative time, and type of surgery.
Conclusion: The frequency of infection was significant in patients with smoking habits, heart failure, tremor, and longer surgical and hospitalization times. We recommend reducing smoking, controlling heart failure, and decreasing surgical and hospitalization times.

Keywords: surgical wound infection; risk factors; orthopedics; nursing

Resumo
Enquadramento: A infeção do local cirúrgico afeta um terço dos doentes cirúrgicos e a incidência varia consoante múltiplos fatores.
Objetivo: Analisar os fatores associados à infeção do local cirúrgico na cirurgia ortopédica major.
Metodologia: Estudo transversal analítico, realizado em 589 doentes submetidos a cirurgia ortopédica major entre 2020 e 2021. Recolheu-se informação constante do Sclínico, através de grelha de registo, sobre o doente, cirurgia e cumprimento de bundles. Aprovação da Comissão de Ética (N.º 46/2022).
Resultados: A frequência de infeção foi (3,9%), maioritariamente do sexo masculino (56,5%), entre os 57 e 78 anos (60,9%,) índice de massa corporal elevado (91,3%), hipertensão arterial (73,9%), tabagismo (14,09%), insuficiência cardíaca (9,3%) e tremor (33,3%). Verifica-se associação, estatisticamente significativa, entre infeção do local cirúrgico e tabagismo, insuficiência cardíaca, tremor, duração da cirurgia, tempo pós-operatório e tipo de cirurgia.
Conclusão: A frequência de infeção foi significativa para os fumadores com insuficiência cardíaca, tremor, maiores tempos cirúrgicos e de internamento. Sugere-se a redução tabágica, controlo da insuficiência cardíaca e diminuição dos tempos cirúrgicos e de internamento.

Palavras-chave: infeção da ferida cirúrgica; fatores de risco; ortopedia; enfermagem

Resumen
Marco contextual: La infección del sitio quirúrgico afecta a un tercio de los pacientes quirúrgicos y su incidencia varía en función de múltiples factores.
Objetivo: Analizar los factores asociados a la infección del sitio quirúrgico en una cirugía ortopédica mayor.
Metodología: Estudio transversal analítico realizado en 589 pacientes sometidos a cirugía ortopédica mayor entre 2020 y 2021. La información sobre el paciente, la cirugía y el cumplimiento de los paquetes de medidas se recogió del Sclínico mediante una plantilla de registro. Aprobado por el Comité de Ética (N.º 46/2022).
Resultados: La frecuencia de infección fue del 3,9%, mayoritariamente masculina (56,5%), entre 57 y 78 años (60,9%,) con índice de masa corporal elevado (91,3%), hipertensión (73,9%), tabaquismo (14,09%), insuficiencia cardiaca (9,3%) y temblor (33,3%). Hubo una asociación estadísticamente significativa entre la infección del sitio quirúrgico y el tabaquismo, la insuficiencia cardíaca, el temblor, la duración de la intervención, el tiempo posoperatorio y el tipo de cirugía.
Conclusión: La frecuencia de infección fue significativa en los fumadores con insuficiencia cardiaca, temblor y tiempos quirúrgicos y de hospitalización más largos. Se propone la reducción del tabaquismo, el control de la insuficiencia cardiaca y la reducción de los tiempos quirúrgicos y de hospitalización.

Palabras clave: infección de la herida quirúrgica; factores de riesgo; ortopedia; enfermería

Corresponding author
Daniela Alexandra Fernandes
E-mail: alexandradf8@gmail.com

Received: 03.11.22
Accepted: 29.05.23

How to cite this article: Fernandes, D. A., & Martins, D. S. (2023). Analysis of risk factors for surgical site infection in patients undergoing major orthopedic surgery. *Revista de Enfermagem Referência*, *6*(2), e22101. https://doi.org/10.12707/RVI22101

Introduction

Healthcare-associated infections (HAIs) are infections that occur during healthcare procedures. They play a key role in infection control and have a significant impact on morbidity, length of stay, mortality, and antibiotic resistance (Ferreira et al., 2022). In Portugal, hospital infection rates are higher than the European average, and surgical site infections (SSIs) are prevalent (European Center for Diseases Control and Prevention [ECDC], 2017). In 2019, the world began a battle against a complex, highly contagious, and difficult-to-control virus: the coronavirus responsible for COVID-19. The pandemic raised awareness of the importance of infection prevention behaviors and transmission of infectious agents (Ferreira et al., 2022). The tools initially available to health professionals were preventive measures to avoid infection (Ferreira et al., 2022). These preventive measures are the standard precautions for infection control (SPIC) already described by the Directorate-General for Health (Direção-Geral da Saúde [DGS], 2013). The pandemic has reshaped the world and the mindset, raising raised awareness of the importance of adhering to SPIC to prevent and control infections, even in a surgical setting with high adherence to SPIC and safe surgical bundles (DGS, 2018; Ferreira et al., 2022). On the other hand, the pandemic period led to a significant decrease in epidemiologic surveillance records of HAIs, including SSIs, due to the global commitment to combat COVID-19 (DGS, 2022b).

Although old, the ECDC's definition of SSI is consensual in the literature and refers to 30 days after surgery or up to one year of implanted prosthesis (Martins & Fernandes, 2019). SSIs in orthopedic surgery stand out because they involve implanted material (Santos et al., 2017). The relevance of this study is justified by the increase in SSIs in the orthopedic department of a hospital unit in northern Portugal and the need to act and take measures to prevent new infections. Major orthopedic surgery consists of surgical procedures for total knee arthroplasty (TKA) or total hip arthroplasty (THA).

This study aimed to analyze the risk factors for SSI in major orthopedic surgery.

Background

SSIs are among the most common HAIs. They can result in pain, suffering, or the need to repeat any surgical procedure, and their complications can last for months or years (DGS, 2018). Every surgical procedure exposes body tissues that were previously considered sterile. Microorganisms potentially introduced into these tissues during the procedure can multiply in the surgical wound after closure and cause SSI. However, it can take several weeks for the infection to develop, as SSIs affect approximately one-third of surgical patients, and their incidence ranges from 2 to 15% depending on multiple factors (Stryja et al., 2020).

Microorganisms associated with SSIs can originate directly from endogenous or exogenous sources, such as the surgical team or environment, or even the instruments/implants used during the procedure. The number of microorganisms in the wound after surgery is strongly influenced by the body site involved in the surgical procedure. Surgeries performed on normally sterile tissues, such as bone or joints, are less likely to be contaminated by bacteria and therefore have lower infection rates (less than 2%; Stryja et al., 2020). The prevention of SSIs is complex and multifactorial. It requires a set of standardized measures involving the pre-, peri- and postoperative periods, including the duration of surgical antibiotic prophylaxis and compliance with SSI prevention bundles (DGS, 2022a). It is estimated that approximately half of SSIs are preventable through the use of these evidence-based strategies. Successful SSI prevention requires a combination of several preventive measures, including appropriate preoperative, perioperative, and postoperative care.

Although the epidemiological surveillance program concluded in its last report that there was a reduction in the overall incidence rate of SSIs, it also found an increase in THA and TKA (DGS, 2022). Successful SSI prevention depends on prevention measures, such as the identification of risk factors that predispose to the development of SSIs (Marques et al., 2020). Some of these factors have already been identified, including length of preoperative hospital stay, duration of surgery, American Society of Anesthesiology (ASA) classification, obesity, smoking, older age, male gender, and diabetes mellitus (Marusic et al., 2021; Souza & Serrano, 2020; Yang et al., 2020).

Research question

What are the risk factors for SSIs in patients undergoing major orthopedic surgery in a hospital unit in northern Portugal?

Methodology

This is a cross-sectional analytical study. The accessible population for this study comprised a total of 589 patients who underwent major orthopedic surgery in an orthopedic inpatient service at a hospital unit in northern Portugal between 2020 and 2021, in a total of 589 patients. The sample matches the accessible population. The data were collected between April and June of 2022 using a grid with information on the patient (age, gender, personal history), the surgery (length of pre- and postoperative hospital stay, ASA classification, duration of surgery, presence of urinary catheter, tranexamic acid administration, blood transfusion), and compliance with the bundle of interventions (screening for methicillin-resistant Staphylococcus aureus [MRSA], preoperative bathing, maintenance of normothermia and normoglycemia, and prophylactic antibiotic therapy). The selected information was based on the latest scientific evidence and Standard 020/2015 of 15/12/2015 (updated on 17/11/2022) on the Bundle of Interventions for the Prevention of Surgical Site Infection

of the DGS (2022), and it was relevant to the study. The dependent variable results from the clinical diagnosis and is categorized as *yes* (if the microbiological result under analysis is positive) and *no* (if the microbiological result under analysis is negative). The independent variables are: i) Gender: Categorical variable (male and female); ii) Age: Interval discrete variable (35-45 years, 46-56 years, 57-67 years, 68-78 years, and 79-89 years); iii) Medical history (hypertension, dyslipidemia, diabetes mellitus, heart failure, kidney failure, history of acute myocardial infarction, respiratory diseases, and depression): Categorical variables (yes or no); iv) Body mass index (BMI): Interval discrete variable (< 18.5 = underweight, 18.5-24.9 = normal weight, 25-29.9 = overweight, 30-34.9 = class I obesity, 35-39.9 = class II obesity, and > 40 = class III obesity); v) Health habits (smoking and alcohol habits): Categorical variables (yes or no); vi) Length of preoperative hospital stay: Numerical variable, estimated in days; vii) Length of postoperative hospital stay: Numerical variable, estimated in days; viii) Type of surgery: Nominal variable (THA or TKA); ix) ASA classification: Nominal variable (ASA I, ASA II, ASA III or ASA IV); x) Duration of surgery: Interval discrete variable corresponding to the time in hours from incision to skin closure (0-1 hour, 1-2 hours, 2-3 hours, 3-4 hours and 4-5 hours); xi) Presence of urinary catheter: categorical variable (yes and no); xii) Tranexamic acid administration: categorical variable (yes and no); xiii) Presence of a surgical drain: categorical variable (yes and no); xiv) Postoperative blood transfusion: categorical variable (yes and no); and xv) MRSA screening: categorical variable (positive and negative).

The data required for this study were extracted from the SClínico platform by the service director, anonymized by the researcher, and then entered and analyzed using the SPSS® software, version 26.0, using the assigned coding number and respecting the anonymity and confidentiality of the data. This study was approved (No. 46/2022) by the Ethics Committee and the Board of Directors of the local health unit where it was conducted. For the descriptive analysis, the following frequency distributions and statistical measures were used: mean (*M*) and standard deviation (*SD*). Regarding the distribution of the variables, the Kolmogorov-Smirnov test was performed to understand whether the variables followed a normal distribution. The null hypothesis was rejected in all cases. Thus, the nonparametric Mann-Whitney *U*-test and Kruskal-Wallis test were used. The significance level was set at 0.05.

Results

The sample consisted of 589 participants, of whom 58.4% (n = 344) were women with a mean age of 69.54 years, 4.6% (n = 27) smoked, and 27.2% (n = 160) had alcohol habits. The most common antecedents were overweight (38.7%; n = 228), hypertension (75.2%; n = 443), and dyslipidemia (61.6%; n = 363; Table 1).

Table 1

Distribution of participants by sociodemographic characteristics, clinical factors, and risk behaviors (n = 589)

		n	%
Gender	Male	245	41.6
	Female	344	58.4
Age (years)	35–45	8	1.4
	46–56	39	6.6
	57–67	184	31.2
	68–78	260	44.1
	79–89	98	16.6
	M = 69.54 (*SD* = 9.24); Minimum = 38; Maximum = 89; Mode = 74		
BMI (kg/m²)	Underweight (< 18.5)	3	0.5
	Healthy weight (18.5–24.9)	97	16.5
	Overweight (25–29.9)	228	38.7
	Obesity Class 1 (30–34.9)	181	30.7
	Obesity Class 2 (35–39.9)	64	10.9
	Obesity Class 3 (> 40)	11	1.9
	Missed	5	0.8
	M = 29.55 (*SD* = 4.74); Minimum = 18.17; Maximum = 46.11; Mode = 32.05		
Hypertension	Yes	443	75.2
	No	146	24.8
Smoking	Yes	27	4.6
	No	562	95.4
Alcohol consumption	Yes	160	27.2
	No	429	72.8
Dyslipidemia	Yes	363	61.6
	No	226	38.4
Diabetes mellitus	Yes	165	28.0
	No	424	72.0
Heart failure	Yes	54	9.2
	No	535	90.8
Kidney failure	Yes	17	2.9
	No	572	97.1
Myocardial infarction	Yes	11	1.9
	No	578	98.1
Respiratory diseases	Yes	42	7.1
	No	547	92.9
Thyroid disorder	Yes	35	5.9
	No	554	94.1
Tremor	Yes	3	0.5
	No	586	99.5
Depression	Yes	140	23.8
	No	449	76.2

Note. *n* = Frequency; *M* = Mean; *SD* = Standard deviation; BMI = Body Mass Index

TKA was the most frequent procedure (68.3% *n* =408). A total of 83.5% (*n* = 492) of patients were admitted on the day before the surgery, 65.2% (*n* =384) with ASA III score, 61.5% (*n* = 362) with surgery duration of up to 1 hour, 99% (*n* = 583) with a urinary catheter, and 89.1% (*n* = 525) received tranexamic acid. Most patients (68.3%; *n* = 402) were discharged within the first seven days and had a negative MRSA test result (99.3%; *n* = 585). Twenty-three participants (3.95) developed SSIs (Table 2).

Table 2

Distribution of participants by characteristics of the surgery (n = 589)

		n	%
Length of preoperative hospital stay (days)	0	12	2.0
	1	492	83.5
	2	15	2.5
	3	66	11.2
	4	2	0.3
	14	1	0.2
	21	1	0.2
ASA Classification	I (Healthy patient)	6	1.0
	II (Patient with mild disease)	194	32.9
	III (Patient with severe disease)	384	65.2
	IV (Patient with severe systemic disease that is a constant threat to life)	5	0.8
Duration of surgery (horas)	[0; 1[	362	61.5
	[1; 2[	217	36.8
	[2; 3[	9	1.5
	[4; 5]	1	0.2
	M = 0.75 (*SD* = 0.43); Minimum = 0.30; Maximum = 4.30		
Urinary catheter	Yes	583	99.0
	No	6	1.0
Tranexamic acid	Yes	525	89.1
	No	64	10.9
Surgical drain	Yes	173	29.4
	No	416	70.6
Blood transfusion	Yes	30	5.1
	No	559	94.9
Postoperative time (days)	[1; 7[	402	68.3
	[7; 14[	160	27.2
	[14; 21[	11	1.9
	[21; 67]	16	2.7
	M = 6 (*SD* = 4.87); Minimum = 2; Maximum = 67		
MRSA screening	Negative	585	99.3
	Positive	4	0.7
Infection	Yes	23	3.9
	No	566	96.1
Type of surgery	THA	183	31.1
	TKA	402	68.3

Note. *n* = Frequency; % percentage, *M* = Mean; *SD* = Standard deviation; MRSA = Methicillin-resistant Staphylococcus aureus; ASA = American Society of Anesthesiology; THA = Total hip arthroplasty; TKA = Total knee arthroplasty.

Overall compliance with the bundles was 91.2% in both periods, with a decrease between 2020 and 202, except for preoperative bathing (Table 3).

Table 3

Distribution of participants by compliance with the bundles, year, and SSI (n = 589)

Compliance with the bundles	**2020 (*n* = 286)** %	**2021 (*n* =303)** %	**Total (*n* = 589)** %
Preoperative bathing	**98.4%**	**100%**	**99.2%**
Normoglycemia	**97%**	**93.4%**	**95.2%**
Normothermia	**99.3%**	**98.6%**	**99%**
Antibiotic therapy	**99.4%**	**96.9%**	**98.2%**
Total	**93.7%**	**88.7%**	**91.2%**

Note. *n* = Frequency; % percentage.

Statistically significant differences were found between SSIs and smoking habits (p = 0.004), heart failure (p = 0.043), and tremor (p = 0.001; Table 4).

Table 4

Association between surgical site infection and the sociodemographic and clinical variables and risk factors (n = 589)

		SSI		*p*
		Yes (*n* = 26) ***n* (%)**	**No** (*n* = 566) ***n* (%)**	
Gender	Female	10 (2.9%)	334 (97.1%)	0.090**
	Male	13 (5.3%)	232 (94.7%)	
Age (years)	35–45	2 (25%)	6 (75%)	0.055*
	46–56	4 (10.3%)	35 (89.7%)	
	57–67	6 (3.3%)	178 (98.7%)	
	68–78	8 (3.1%)	252 (96.9%)	
	79–89	3 (3.1%)	95 (96.9%)	
BMI	Underweight	0 (0%)	3 (100%)	0.077*
	Healthy weight	2 (2.1%)	95 (97.9%)	
	Overweight	6 (2.6%)	222 (97.4%)	
	Obesity Class 1	11 (6.1%)	170 (93.9%)	
	Obesity Class 2	4 (6.3%)	60 (93.7%)	
	Obesity Class 3	0 (0%)	11 (100%)	
	Missed	0 (0%)	5 (100%)	
Hypertension	Yes	17 (3.8%)	426 (96.2%)	0.612**
	No	6 (4.1%)	140 (95.9%)	
Smoking	Yes	4 (14.9%)	23 (85.1%)	0.004**
	No	19 (3.4%)	543 (96.6%)	
Alcohol consumption	Yes	9 (5.6%)	151 (94.4%)	0.103**
	No	14 (3.3%)	415 (96.7%)	
Dyslipidemia	Yes	11 (3.0%)	352 (97.0%)	0.104**
	No	12 (5.3%)	214 (94.7%)	
Diabetes mellitus	Yes	6 (3.6%)	159 (96.4%)	0.737**
	No	17 (4.0%)	407 (96.0%)	
Heart failure	Yes	5 (9.3%)	49 (90.7%)	0.043**
	No	18 (3.4%)	517 (96.6%)	
Kidney failure	Yes	0 (0%)	17 (100%)	0.389**
	No	23 (4.0%)	549 (96.0%)	
Myocardial infarction	Yes	1 (9.1%)	10 (90.9%)	0.396**
	No	22 (3.8%)	556 (96.2%)	
Respiratory diseases	Yes	2 (4.8%)	40 (95.2%)	0.815**
	No	21 (3.8%)	526 (96.2%)	
Thyroid disorder	Yes	2 (5.7%)	33 (94.3%)	0.613**
	No	21 (3.8%)	533 (96.2%)	
Tremor	Yes	1 (33.3%)	2 (66.7%)	0.001**
	No	22 (3.8%)	564 (96.2%)	
Depression	Yes	9 (6.4%)	131 93.6%)	0.107**
	No	14 (3.1%)	435 (96.9%)	

Note. n = Frequency; * = Kruskal-Wallis Test; ** = Mann-Whitney *U*-Test; SSI = Surgical site infection; BMI = Body mass index.

Statistically significant differences were found between SSIs and duration of surgery (p = 0.025), postoperative time (p = 0.000), and type of surgery (p = 0.005; Table 5).

Table 5

Association between surgical site infection and variables related to the surgery (n = 589)

		SSI		*p*
		Yes (*n* = 23) ***n* (%)**	**No** (*n* = 566) ***n* (%)**	
Preoperative time	0	0 (0%)	12 (100%)	0.237*
	1	22 (4.5%)	470 (95.5%)	
	2	1 (6.7%)	14 (93.3%)	
	3	0 (0%)	66 (100%)	
	4	0 (0%)	2 (100%)	
	14	0 (0%)	1 (100%)	
	21	0 (0%)	1 (100%)	
ASA Classification	I	1 (16.7%)	5 (83.3%)	0.337*
	II	8 (4.1%)	186 (95.6%)	
	III	14 (3.6%)	370 (96.4%)	
	IV	0 (0%)	5 (100%)	
Duration of surgery (hours)	[<1 [	8 (2.2%)	354 (97.8%)	0.025*
	[1; 2[	13 (6.0%)	204 (94.0%)	
	[2; 3h[	2 (20.0%)	8 (80.0%)	
	[4; 5h]	0 (0%)	1 (100%)	
Urinary catheter	Yes	23 (3.9%)	560 (96.1%)	0.612**
	No	0 (0%)	6 (100%)	
Tranexamic acid	Yes	21(4.0%)	504 (96.0%)	0.684**
	No	2 (3.1%)	62 (96.9%)	
Surgical drain	Yes	11 (0.6%)	162 (99.4%)	0.071**
	No	12 (2.9%)	404 (97.1%)	
Blood transfusion	Yes	1 (3.3%)	29 (96.7%)	0.833**
	No	22 (3.9%)	537 (96.1%)	
Postoperative time (days)	[1; 7[	8 (1.99%)	394 (98.0%)	0.000*
	[7; 14[	5 (3.1%)	155 (96.9%)	
	[14; 21[	4 (36.4%)	7 (63.3%)	
	[21; 67]	6 (37.5%)	10 (62.5%)	
MRSA screening	Negative	23 (3.4%)	562 (96.6%)	0.679**
	Positive	0 (0%)	4 (100%)	
Type of surgery	THA	12 (6.2%)	183 (93.8%)	0.005**
	TKA	11 (2.6%)	406 (97.4%)	

Note. *n* = Frequency; * = Kruskal-Wallis Test; ** = Mann-Whitney *U*-test; Methicillin-resistant Staphylococcus aureus; ASA = American Society of Anesthesiology; THA = Total hip arthroplasty; TKA = Total knee arthroplasty; SSI = Surgical site infection.

Discussion

The sample of patients with SSIs is mostly composed of men, aged 57 to 78 years. There are several findings in the literature on the gender and age of patients with SSIs, with mostly male samples (Silva et al., 2021). One study found that 88.7% of traffic accidents with trauma involved men, being associated with greater vulnerability to trauma both in accidents and in work activities (Soares et al., 2016). There is a greater colonization of Staphylococcus aureus

in men undergoing orthopedic surgery, which is the main cause of SSI. Li et al. (2020) also found an association with gender, which was not significant in this study, but was more common. All participants were screened for MRSA (n = 589), as recommended by the bundles, and all patients with SSI (n = 23) had a negative result. Older age is a risk factor for SSIs (Yang et al., 2020), so older people are at greater risk of developing infections, not only due to comorbidities but also due to limitations in maintaining normothermia and fluid and electrolyte balance (Martins & Fernandes, 2019; Sousa et al., 2021). In this study, the presence of infection is more evident in younger patients. Santos et al. (2017) also concluded that young people are more subject to more severe traumatic accidents and to treatments for inflammatory diseases with prostheses or post-traumatic osteoarthritis, increasing the risk of SSI (Santos et al., 2017). The majority of patients with SSIs had a BMI greater than 25 kg/m^2. Several authors have identified high BMI as a predictive factor for SSIs (Marusic et al., 2021; Yang et al., 2020). Obese people have thicker layers of adipose tissue and require more extensive surgical fields (Júnior et al., 2021). The majority of patients had hypertension, dyslipidemia, and diabetes mellitus. These comorbidities are strongly associated with the onset of SSIs (Yang et al., 2020). Changes in vascularization, sensitivity, and glycemic control inhibit the healing process (Júnior et al., 2021). Patients with diabetes have a threefold increased risk of developing SSIs in orthopedic surgery (Santos et al., 2017; Silva et al., 2021). All participants in this study underwent elective surgery and had regular follow-up visits, so they were medicated and their conditions were controlled to minimize complications. Close monitoring of diabetic patients during consultations increases surgical safety (Silva et al., 2021). Heart failure was found to be a risk factor for SSIs and even increased mortality risk (Bozic et al., 2011). Although there was a statistically significant difference between SSIs and tremor (p = 0.01), this data refers to a single study patient and is therefore not representative. Smoking was associated with the development of SSIs in this study. Smoking has been identified as a predictive factor for SSIs because it reduces tissue oxygenation and microvascular constriction. Smokers have a 1.8 times higher risk of developing SSIs (Marusic et al., 2021) because nicotine prevents fibroblast proliferation, slows collagen production, and hinders angiogenesis (Santos et al., 2018). The literature suggests smoking cessation for a period of four weeks before surgery (Silva et al., 2021). Alcohol consumption has been associated with physiological disturbances of the immune, cardiovascular, and central nervous systems (Santos et al., 2018). Regarding surgery-related variables, most patients with SSIs were hospitalized the day before surgery. Length of preoperative hospital stay longer than 24 hours increases the patient's exposure to the hospital environment (DGS, 2018). Most study patients had an ASA classification of III. The ASA classification identifies the patient's physical status before surgery and has been found to influence the onset of SSIs if higher than III (Carvalho et al., 2017; Marusic et al., 2021; Yang et al., 2020) due to the presence of underlying diseases and personal history. In this study, patients' comorbidities were controlled through regular consultations and medication. If diseases and comorbidities are uncontrolled, patients' health status worsens and the risk of SSIs increases (Carvalho et al., 2017). Regarding the duration of surgery, almost all surgeries lasted up to two hours. The duration of surgery is a crucial factor for the onset of SSI (Marusic et al., 2021) since it increases the complexity of the procedure, prolonging the exposure of the surgical site. For each hour elapsed, the risk of SSI increases by 34% (Carvalho et al., 2017). Regarding postoperative time, 68.3% (n = 402) of participants had a length of stay of up to seven days. In this sample, the longer the length of stay, the higher the prevalence of infection, which can be justified by the need for intravenous antibiotic therapy to control infection. TKA was the most frequent surgery and THA was the surgery with the highest number of SSIs. This finding aligns with the Program for the Prevention and Control of Infection and Antimicrobial Resistance, which states that, in Portugal, the incidence of SSI in THA (1.46%) was higher than in TKA (1.03%; DGS, 2018). In Europe, infection rates in THA (1.0%) are also higher than in TKA (0.5%; ECDC, 2017). The rate of compliance with the bundles in the service contradicted studies that found low compliance (Marques et al., 2020). Compliance with the bundles requires that all interventions are performed correctly (DGS, 2022a). The overall score of nurses' compliance with the bundles was high. Strong compliance significantly reduces the risk of SSI (Marques et al., 2020), even reducing it by 28.4% (Martins & Fernandes, 2019). It is important to note that the COVID-19 pandemic has reinforced infection prevention measures and increased patient and professional adherence (DGS, 2022b). The limitations of this study are the small sample size (limited to one hospital unit) and the use of secondary data with unclear records in some situations, which did not allow the analysis of other variables.

Conclusion

The sample consisted mainly of women, with a mean age of 69.54 years, overweight, hypertensive, dyslipidemic, non-smokers, without alcohol habits, and without comorbidities. They were admitted the day before the surgery, with ASA III, with a surgery lasting up to one hour, with clinical discharge within the first seven days, and a negative MRSA test result. The most common surgery was TKA. Nurses' compliance with SSI prevention bundles was high. The incidence of SSIs decreased between 2020 and 2021. The frequency of SSIs was significant, namely among men, aged 57 to 78 years, obese and hypertensive, admitted the day before surgery, with an ASA classification of III, a negative MRSA test result, longer surgery and hospitalization times, and undergoing THA. A statistically significant association was found between SSI and smoking, heart failure, tremor, duration of surgery, postoperative time, and type of surgery. As a preventive measure, smokers should be referred to smoking cessation programs before surgery and receive information about the harmful effects of smoking on surgical complications. Concerning the statistically significant

non-modifiable factors, such as heart failure and tremor, the diseases should be controlled through medication and health-seeking and self-care behaviors before surgery. With regard to the duration and type of surgery and postoperative hospital stay, the surgical team, in collaboration with the inpatient team, should limit surgical and hospitalization times to the shortest possible, while maintaining the quality of care. In light of these results, future studies should be conducted in other healthcare units to compare data and continuously improve care. Larger samples should also be used, as the small sample size was a limitation of this study.

Author contributions

Conceptualization: Fernandes, D. A., Martins, D. S.
Data curation: Fernandes, D. A., Martins, D. S.
Formal analysis: Fernandes, D. A., Martins, D. S.
Investigation: Fernandes, D. A., Martins, D. S.
Methodology: Fernandes, D. A., Martins, D. S.
Project administration: Martins, D. S.
Resources: Fernandes, D. A., Martins, D. S.
Supervision: Martins, D. S.
Validation: Fernandes, D. A., Martins, D. S.
Visualization: Fernandes, D. A., Martins, D. S.
Writing - original draft: Fernandes, D. A., Martins, D. S.
Writing - review and editing: Martins, D. S.

References

Bozic, K. J., Lau, E., Kurtz, S., Ong, K., & Berry, D. J. (2011). Patient-related risk factors for postoperative mortality and periprosthetic joint infection in Medicare patients undergoing TKA. *Clinical Orthopaedics and Related Research®, 470*(1), 130–137. https://doi.org/10.1007/s11999-011-2043-3

Carvalho, R. L., Campos, C. C., Franco, L. M., Rocha, A. D., & Ercole, F. F. (2017). Incidence and risk factors for surgical site infection in general surgeries. *Revista Latino-Americana de Enfermagem, 25*, e2848. https://doi.org/10.1590/1518-8345.1502.2848

Direção-Geral da Saúde. (2022a). *"Feixe de Intervenções" para a prevenção da infeção do local cirúrgico: Norma clínica 020/2015 de 15/12/2015 atualizada a 17/11/2022*. https://normas.dgs.min-saude.pt/wp-content/uploads/2015/12/norma_020_2015_atualizada_17_11_2022_prev_inf_local_cirurgico.pdf

Direção-Geral da Saúde. (2013). *Precauções Básicas do Controlo da Infeção (PBCI)*. https://normas.dgs.min-saude.pt/wp-content/uploads/2019/10/precaucoes-basicas-do-controlo-da-infecao-pbci.pdf

Direção-Geral da Saúde. (2018). *Infeções e resistências aos antimicrobianos: Relatório anual do programa prioritário 2018*. https://www.arscentro.min-saude.pt/wp-content/uploads/sites/6/2020/05/Relatorio-Anual-do-Programa-Prioritario-2018.pdf

Direção-Geral da Saúde. (2022b). *Infeções e resistências aos antimicrobianos: Relatório anual do programa prioritário PPCIRA, 2021*. https://www.dgs.pt/programa-nacional-de-controlo-da-infeccao/relatorios/infecoes-e-resistencias-aos-antimicrobianos-2021-relatorio-anual-do-programa-prioritario-pdf.aspx

European Centre for Disease Prevention and Control. (2017). *Healthcare-associated infections: surgical site infections*: *Annual epidemiological report for 2017*. https://www.ecdc.europa.eu/en/publications-data/healthcare-associated-infections-surgical-site-infections-annual-1

Ferreira, M., Nogueira, A., & Ferreira, C. (2022). *Prevenção e controlo de infeção em cuidados de saúde*. Editora Quântica.

Júnior, F. M., Oliveira, I. S., Correia, K. R., Machado, M. P., Quinteiro, J., & Costa, R. S. (2021). Fatores de risco para infecção de sítio cirúrgico em pacientes ortopédicos. *Revista Ciência E Saúde On-Line, 6*(3), 22-31. https://revistaeletronicafunvic.org/index.php/c14ffd10/article/view/278/231

Li, J., Zhu, Y., Zhao, K., Zhang, J., Meng, H., Jin, Z., Ma, J., & Zhang, Y. (2020). Incidence and risks for surgical site infection after closed tibial plateau fractures in adults treated by open reduction and internal fixation: A prospective study. *Journal of Orthopaedic Surgery and Research, 15*(1), 349. https://doi.org/10.1186/s13018-020-01885-2

Marques, A., Osório, C., Aguiar, C., Lopes, G., & Rodrigues, T. (2020). *Implementação de uma bundle para redução do risco de infeção no local cirúrgico em doentes submetidos a colecistectomia.* https://e-rol.es/wp-content/uploads/2020/01/Implementacao-de-uma-bundle-para-reducao-do-risco-de-infecao.pdf

Martins, M., & Fernandes, A. (2019). *Implementação de bundles na prevenção de infeção após prótese total da anca.* https://doi.org/10.12707/RIV18051

Marusic, V., Markovic-Denic, L., Djuric, O., Cirkovic, A., Nikolic, V., Dubljanin-Raspopovic, E., & Kadija, M. (2021). Incidence and risk factors of 30-day surgical site infection after primary total joint arthroplasty in a middle-income country: A single-center experience. *International Journal of Environmental Research and Public Health, 18*(3), 863. https://doi.org/10.3390/ijerph18030863

Santos, P. V., Jesus, K. B., Santana, K. I., Nogueira, E. C., Cariri, L. S., & Brito, F. P. (2017). Infecção do sítio cirúrgico em pacientes no pós-operatório de cirurgias ortopédicas eletivas. *Interfaces Científicas: Saúde e Ambiente, 5*(2), 71–79. https://doi.org/10.17564/2316-3798.2017v5n2p71-79

Santos, M., Burci, L., Weigert, S. (2018). Fatores de risco e prevenção de infeção do sitio cirurgico. *Revista Gestão & Saúde, 18*(1), 39-45. https://www.herrero.com.br/files/revista/file1697952adda1ba567e1b860228dc424f.pdf

Silva, E. N., Silva, R. K., Carvalho, S. B., Façanha, D. M., Carvalho, R. E., & Pereira, F. G. (2021). Factores de riesgo e infección del sitio quirúrgico en cirugías ortopédicas y traumatológicas. *Revista Cuidarte, 12*(2), e1292. https://doi.org/10.15649/cuidarte.1292

Soares, L. S., Sousa, D. A., Machado, A. L., & Silva, G. R. (2016). Caracterização das vítimas de traumas por acidente com motocicleta internadas em um hospital público. *Revista Enfermagem UERJ, 23*(1), 115-121. https://doi.org/10.12957/reuerj.2015.15599

Sousa, A. F., Oliveira, L. B., Carvalho, H. E., Ribeiro, I. P., Fronteira, I., & Andrade, D. (2021). Occurrence of late postoperative knee and hip arthroplasty postoperative complications. *Revista de Pesquisa Cuidado é Fundamental Online, 13*, 1271–1276. https://doi.org/10.9789/2175-5361.rpcfo.v13.9692

Souza, K. V., & Serrano, S. Q. (2020). Saberes dos enfermeiros sobre prevenção de infecção do sítio cirúrgico. *Revista SOBECC, 25*(1), 11–16. https://doi.org/10.5327/Z1414-4425202000010003

Stryja, J., Sandy-Hodgetts, K., Collier, M., Moser, C., Ousey, K., Probst, S., Wilson, J., & Xuereb, D. (2020). Prevention and management across health-care sectors. *Journal of Wound Care, 29*(Sup 2b), S1–S72. https://doi.org/10.12968/jowc.2020.29.sup2b.s1

Yang, J., Zhang, X., & Liang, W. (2020). A retrospective analysis of factors affecting surgical site infection in orthopaedic patients. *Journal of International Medical Research, 48*(4). https://doi.org/10.1177/0300060520907776