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Identification of Risk Factors Contributing to the Development of Surgical Site Infection in Patients Undergoing Open Surgery for Closed Fractures of the Lower Extremity

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ABSTRACT

Background and Objective: Surgical site infection is one of the most prevalent and serious complications among patients undergoing surgical procedures. In orthopedic surgeries, wound infections are particularly noteworthy due to their higher incidence and clinical significance. The present study was therefore conducted to identify the risk factors contributing to the development of surgical site infection following surgical management of closed fractures of the lower extremity in patients presenting to Shahid Beheshti Hospital in Babol.

Methods: This cohort study was conducted on 133 patients who had sustained fractures of the lower extremity and had been admitted to Shahid Beheshti Hospital in Babol in 2021 and 2022. Postoperative follow-up for clinical signs of surgical site infection was performed at two intervals—2 weeks and 1 month following the procedure—and the results were systematically recorded. A comprehensive set of demographic and clinical variables was collected using a researcher-developed checklist, including age, sex, body mass index, underlying comorbidities, fracture location, length of stay, smoking status, type of surgical intervention, anesthetic technique, affected side, mechanism of injury, presence of infection, operative time (defined as time from skin incision to wound closure), and whether the procedure was performed on an emergency or elective basis.

Findings: Assessment of the overall incidence of surgical site infection following open surgery for closed lower extremity fractures, from the time of operation up to one month postoperatively, revealed that wound infection occurred in 32 patients (24.1%), representing a 24% incidence rate. At the two-week postoperative assessment, 12 patients (37.5%) demonstrated signs of infection, whereas at the one-month follow-up, 20 patients (62.5%) were found to have developed surgical site infection. Smoking status was significantly associated with the development of infection (p=0.005), and elective surgery was significantly correlated with the absence of infection (p<0.001). The mean length of hospital stay was significantly greater among patients who developed infection compared to those who did not (p<0.001). Prolonged operative time was also found to be significantly associated with infection (p=0.006). Multivariate regression analysis identified extended hospital stay and longer operative time as independent risk factors for the development of surgical site infection in patients with closed fractures.

Conclusion: The findings of the present study indicate that extended length of stay, prolonged operative time, and smoking are independent risk factors for the development of surgical site infection.

Keywords: *Infection, Closed Fracture, Lower Extremity, Risk Factor, Surgery*.

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Introduction

Surgical site infection is one of the most frequent and potentially preventable complications associated with surgical interventions. In the context of orthopedic surgery, these infections may result in significant long-term morbidity, functional disability, and increased mortality (1-3). The reported incidence of superficial wound infections or more severe deep infections in major orthopedic procedures, including total hip replacement (THR) and total knee replacement (TKR), ranges from 1% to 5% (4).

Healthcare-associated infections (HAIs) are among the most common and serious adverse events occurring in the hospital setting, and they represent a substantial threat to patient safety and clinical outcomes (5). The burden of HAIs extends across multiple dimensions: they are associated with elevated rates of morbidity and mortality, significantly increased healthcare costs attributable to extended length of stay and the use of additional diagnostic tests and therapeutic interventions, as well as prolonged periods of disability and absence from work, which in turn impose substantial social and economic burdens on patients, their families, and society (6).

Among healthcare-associated infections, surgical site infection (SSI) is directly attributable to surgical interventions (7, 8). Surgical site infections are defined as infections that occur in the tissue, organ, or body cavity that was opened or manipulated during the operative procedure (9, 10). The term "surgical site infection" has been used since 1992, replacing the earlier designation "surgical wound infection" (11).

Surgical site infections are among the most frequently encountered hospital-acquired infections (12, 13). The incidence of these infections varies considerably depending on the type of procedure: more than 2-5% of patients undergoing extra-abdominal surgeries and more than 20% of patients undergoing intra-abdominal procedures are affected (14, 15). Furthermore, it has been reported that infection contributes to 77% of deaths among surgical patients, underscoring the direct relationship between infection and open surgical wounds (16).

The clinical and economic consequences of surgical site infections are substantial and multifaceted. These infections are consistently associated with increased mortality rates, significantly higher healthcare costs, and prolonged lengths of hospital stay. When compared to patients who do not develop such infections, those affected by surgical site infections are 60% more likely to require intensive care unit admission during their postoperative course, are 5 times more likely to be readmitted to the hospital following discharge, and have a 2-fold higher risk of death (17, 18). Each of these complications—ICU admission, readmission, and mortality—not only worsens patient outcomes but also imposes a considerable financial burden on healthcare systems, thereby underscoring the importance of effective preventive strategies (19).

Infection is the most frequently encountered complication following surgical procedures, with surgical site infection being a major contributor to postoperative mortality and disability. The administration of prophylactic antibiotics, when appropriately administered in accordance with established guidelines, has been shown to be highly effective in reducing the risk of surgical site infection, a finding that has been consistently confirmed by numerous investigators across a wide range of studies (20).

Knowledge of risk factors and the promotion of preventive factors for infection can lead to a reduction in postoperative infection rates. In general, three strategies have been established for the prevention of surgical site infections: the use of disinfection and sterilization techniques, appropriate use of prophylactic antibiotics, and enhancement of each patient's ability to resist infection. Despite the remarkable advances made in recent years in the management, care, and treatment of trauma patients, injuries still remain among the most important causes of death worldwide (21, 22).

Despite considerable efforts over recent decades to reduce mortality rates among trauma victims at the scene of injury and during prehospital transport, infection remains a leading cause of death, accounting for 30% to 80% of fatalities among patients who survive the initial trauma (23, 24). A range of factors contribute to the development of surgical site infections, including the use of implantable devices, surgical drains, and the specific surgical approach employed. Trauma patients are particularly susceptible to infection due to multiple predisposing factors, notably the breach of the skin's protective barrier and the presence of devitalized or necrotic tissue, as well as viable tissue with compromised blood perfusion, which provides a favorable environment for microbial colonization (25). In accordance with the national guidelines for the prevention and control of hospital-acquired infections issued by the Iranian Ministry of Health, Treatment, and Medical Education, a postoperative infection is defined as an infection that manifests within 30 days following an orthopedic surgical procedure and is classified as a surgical site infection when it is accompanied by purulent drainage—characterized by abnormal color, odor, and volume—from the surgical incision site (26).

Among surgical site infections, those occurring in the context of orthopedic procedures are of particular clinical significance and exhibit a higher incidence. This elevated risk can be attributed to two principal factors. First, orthopedic surgeries frequently involve the use of implantable materials, which are known to increase the risk of infection (27). Second, the anatomical and physiological characteristics of bone—specifically its relatively poor vascularization compared to other tissues—render certain orthopedic procedures more susceptible to postoperative infection (28). Despite the fact that orthopedic surgery is generally classified as a clean procedure and is performed under strict aseptic conditions, surgical site infection continues to be one of the most important and challenging complications in this field. The reported incidence of surgical site infection in orthopedic surgery ranges from 1% to 3% of patients undergoing such procedures (29).

In a study conducted by Azizi et al., the incidence of surgical site infection among patients undergoing orthopedic procedures was reported to be 17.1%, with age, duration of hospitalization, operative time, diabetes mellitus, smoking, and type of anesthesia identified as significant risk factors (30). Hojjat et al. reported that among 420 patients, 37 (8.8%) developed surgical site infection requiring hospital readmission. The wide variation in reported infection rates across studies underscores the multifactorial nature of surgical site infection in orthopedic surgery (31). Li et al., in a study of 1108 patients, reported that 25 patients (2.3%) developed surgical site infection. Identified risk factors included autograft and allograft bone grafting, fracture type (Schatzker V-VI), elevated aspartate aminotransferase (>40 U/L), elevated white blood cell count ($>10.9\times10^9$/L), and increased anion gap (>16 mmol/L) (3). In a study by Lu et al., postoperative infection occurred in 29 of 724 patients. Open fractures, obesity, smoking, and diabetes were identified as adjusted risk factors significantly associated with postoperative infection (32).

Surgical site infection can, in certain instances, compromise the achievement of surgical objectives and result in irreversible harm to the patient. Moreover, this complication independently contributes to increased mortality, prolonged hospitalization, and elevated healthcare costs. Postoperative infection is a multifactorial condition influenced by a wide array of patient- and procedure-related variables. A more comprehensive understanding of these factors may facilitate the development of effective preventive strategies. Accordingly, the present study was conducted to evaluate the risk factors associated with postoperative infection following surgical management of lower extremity fractures at Shahid Beheshti Hospital in Babol.

Methods

This cohort study received ethical approval from the Research Ethics Committee of Babol University of Medical Sciences (approval code: IR.MUBBOL.HRI.REC.1401.09.01) and was conducted on patients who presented with lower extremity fractures and underwent surgical intervention at Shahid Beheshti Hospital in Babol in 2021 and 2022. Eligible participants included all patients who were admitted to the surgical ward immediately following the procedure, were between 18 and 60 years of age, provided informed consent, had a fracture that required surgical management, had no prior history of lower extremity fracture, had no diagnosed immunodeficiency disorders, and were not receiving immunosuppressive therapy. Exclusion criteria comprised incomplete medical records, concurrent upper extremity fractures, bilateral lower extremity fractures or a history of previous nonunion, inability to complete follow-up or failure to return for scheduled visits, presence of thermal burns, perioperative mortality, admission to the intensive care unit, or the need for revision surgery.

Patients were evaluated for clinical signs of surgical site infection by the research intern at two postoperative time points—2 weeks and 1 month following surgery—and the findings were systematically recorded. All follow-up visits and clinical examinations were conducted at the outpatient clinic by the same intern. Patient demographic and clinical data were extracted from hospital medical records.

The diagnosis of surgical site infection was based on the physician's clinical judgment, taking into account the specified time frame, and was supported by clinical manifestations including localized warmth, erythema, swelling, pain, purulent wound discharge, and elevated inflammatory markers, including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and leukocytosis. Regarding antibiotic prophylaxis, all patients received intravenous cefazolin at a dose of 2 grams every 8 hours for up to 24 hours postoperatively. A comprehensive set of patient variables was collected using a researcher-developed checklist, including age, sex, body mass index (BMI), comorbidities, fracture location, length of hospital stay, smoking status, type of surgical procedure, type of anesthesia, affected side, mechanism of injury, presence of infection, operative duration (from skin incision to wound closure), and whether the surgery was performed as an emergency or elective procedure.

For analytical purposes, age was dichotomized based on the mean age of the cohort into two categories: less than 41 years and 41 years or older. Body mass index was classified according to standard World Health Organization criteria as underweight (<18.5 kg/m^2), normal (18.5-24.99 kg/m^2), overweight (25-29.99 kg/m^2), and obese (≥ 30 kg/m^2) (33).

All collected data were entered into SPSS statistical software (version 25) for analysis. Descriptive statistics, including means and standard deviations, were calculated for continuous variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate, while continuous variables were compared between groups using the independent samples t-test. Multivariate logistic regression analysis was employed to identify independent risk factors for the development of surgical site infection. In all analyses, a p-value of less than 0.05 was considered statistically significant.

Results

The present study employed a convenience sampling strategy to recruit participants. A total of 133 patients who had closed fractures of the lower extremity and had undergone surgical treatment at Shahid Beheshti Hospital in Babol in 2021 and 2022 were included in the final analysis. The mean age of the study cohort was 41.48±16.12 years, with a median age of 41 years; the age of participants ranged from a minimum of 18 years to a maximum of 60 years. In terms of sex distribution, the majority of patients were male, comprising 89 individuals (66.9% of the total sample), while 44 patients (33.1%) were female. The mean body mass index of the study population was 24.16±3.53 kg/m², with a median of 23.90 kg/m² and a range of 15.70 to 40.10 kg/m². The overall incidence of surgical site infection following surgery for closed lower extremity fractures, assessed from the time of surgery up to one month postoperatively, was 24%, affecting 32 patients (24.1%).

Temporal analysis revealed that at the 2-week postoperative assessment, 12 patients (37.5%) had developed surgical site infection, whereas at the 1-month follow-up, 20 patients (62.5%) were diagnosed with surgical site infection.

Analysis of infection rates stratified by patient demographic characteristics identified a statistically significant association between smoking and the development of surgical site infection (p=0.005). No significant associations were observed for other demographic variables examined (Table 1).

Table 1. Demographic characteristics of the study population, overall and stratified by surgical site infection status

Variable	Total Number(%)	No infection (n=101) Number(%)	Infection (n=32) Number(%)	p-value*
Age (years)				
≤41	67(50.4)	53(52.5)	14(43.8)	0.390
>41	66(49.6)	48(47.5)	18(56.3)	
Sex				
Male	89(66.9)	67(66.3)	22(68.8)	0.833
Female	44(33.1)	34(33.7)	10(31.3)	
Smoking	30(22.6)	17(16.8)	13(40.6)	0.005
Opium use	8(6.0)	6(5.9)	2(6.3)	0.949
Body mass index				
Underweight	3(2.3)	3(3.0)	0(0)	0.732**
Normal	86(64.7)	64(63.4)	22(68.8)	
Overweight	38(28.6)	30(29.7)	8(25.0)	
Obese	6(4.5)	4(4.0)	2(6.3)	
Cardiovascular diseases (CABG, IHD, CHF)	20(15.0)	15(14.9)	5(15.6)	0.915
Respiratory diseases (Asthma, COPD)	4(3.0)	3(3.0)	1(3.1)	0.964
Rheumatologic diseases (Rheumatoid arthritis, rheumatism)	4(3.0)	2(2.0)	2(6.3)	0.218
Diabetes mellitus	26(19.5)	16(15.8)	10(31.3)	0.073
Hypertension	20(15.0)	16(15.8)	4(12.5)	0.781
Hyperlipidemia	15(11.3)	10(9.9)	5(15.6)	0.354

***Chi-square test; **Generalized Fisher's exact test**

The results of the present study revealed a significant association between elective surgery and a reduced likelihood of developing surgical site infection (p<0.001) (Table 2). Furthermore, the mean duration of hospitalization was substantially longer among patients who developed surgical site infection compared to those who remained infection-free, and this difference was statistically significant (p<0.001) (Table 3).

In addition, the mean operative time was found to be longer in patients who developed surgical site infection than in those who did not, indicating that prolonged surgery is a significant risk factor for infection (p=0.006) (Table 3).

Table 2. Clinical characteristics of the study population, overall and stratified by surgical site infection status

Variable	Total Number(%)	No infection (n=101) Number(%)	Infection (n=32) Number(%)	p-value*
Fracture site				
Femur	74(100)	53(71.6)	21(28.4)	
Tibia	46(100)	39(84.8)	7(15.2)	
Ankle	10(100)	8(80.0)	2(20.0)	0.061**
Knee	2(100)	0(0)	2(100)	
Fibula	1(100)	1(100)	0(0)	
Affected side				
Right	70(100)	58(82.9)	12(17.1)	0.067
Left	63(100)	43(68.3)	20(31.7)	
Type of surgery				
Elective	110(100)	91(82.7)	19(17.3)	<0.001
Emergency	23(100)	10(43.5)	13(56.5)	
Mechanism of injury				
Traffic accident	95(100)	71(74.7)	24(25.3)	0.661
Fall from height	38(100)	30(78.9)	8(21.1)	
Type of anesthesia				
Spinal	111(100)	85(76.6)	26(23.4)	0.785
General	22(100)	16(72.7)	6(27.3)	
Open reduction – Hip hemiarthroplasty	16(100)	15(93.8)	1(6.3)	0.076
Open reduction – Intramedullary nailing	17(100)	12(70.6)	5(29.4)	0.580
Open reduction – Dynamic hip screw	54(100)	44(81.5)	10(18.5)	0.216
Open reduction – Plate fixation	44(100)	29(65.9)	15(34.1)	0.083
Open reduction – Percutaneous pinning	22(100)	17(77.3)	5(22.7)	0.873

***Chi-square test, **Generalized Fisher exact test**

Table 3. Comparison of quantitative variables including length of stay and operative time, stratified by surgical site infection status

Variable	No infection Mean±SD	Infection Mean±SD	p-value*
Length of stay (days)	6.34±3.19	12.38±4.06	<0.001
Operative time (minutes)	106.63±35.51	127.81±41.94	0.006

***Independent samples t-test**

Multivariate regression analysis revealed that prolonged hospital stay and extended operative time were independent risk factors for the development of surgical site infection in patients with closed fractures (Table 4).

Table 4. Factors associated with the occurrence of surgical site infection based on logistic regression analysis

Variable	Crude OR	95% CI	p-value	Adjusted OR	95% CI	p-value
Smoking	3.38	1.8-40.12	0.006	3.22	0.12-86.04	0.081
Emergency surgery	6.22	2.16-38.28	<0.001	3.58	0.14-91.06	0.067
Length of stay	1.49	1.1-29.72	<0.001	1.47	1.1-25.73	<0.001
Operative time	1.01	1.1-0.02	0.009	1.01	1.1-0.02	0.055

Discussion

In the present study, the incidence of surgical site infection following open surgical management of closed lower extremity fractures was 24%. This finding is broadly consistent with the majority of previous studies that have examined infection rates and their associated risk factors in similar patient populations. Mosleh et al., in a study of 110 patients undergoing orthopedic procedures, reported an infection rate of 18.2% (16), while Azizi et al. documented a prevalence of 17.1% among patients following orthopedic surgeries (30). The slightly lower rates observed in these studies compared to our own may be attributable to differences in prophylactic antibiotic protocols, surgical field preparation, and other perioperative variables that influence the risk of surgical site infection.

Conversely, several studies have reported findings that differ from those of the present investigation. Najjar et al. reported an infection rate of 8.2% among their patient cohort (29). Shao et al. documented a surgical site infection incidence of 7.1% (34), while Sun et al. reported an incidence of 3.4% (35). In the study by Li et al., the infection rate following open reduction and internal fixation procedures was 2.3% (3). It is important to note that these discrepancies in the reported incidence and prevalence of surgical site infection are attributable to the inherently multifactorial nature of this complication. Differences in fracture location, fracture type, and patient-specific characteristics—including advanced age, diabetes mellitus, obesity, history of prior surgical infection, and poor nutritional status—may substantially influence infection rates across studies.

Another clinically significant finding of the present study was that the incidence of infection during the first postoperative month was higher than that observed at the two-week assessment. Postoperative infection remains one of the most common complications following a wide range of surgical procedures, and in some instances, it may compromise the achievement of surgical objectives and result in irreversible harm to the patient. Although the precise etiology of infection often remains unclear, a variety of factors—including operating room ventilation, inadequate sterilization of surgical instruments, extensive surgical exposure, prolonged operative duration, contamination of operating room air, and breaches in surgical hand or skin antisepsis—may all contribute to the observed infection rates.

The results of the present study revealed a statistically significant association between smoking and an increased incidence of surgical site infection. This finding is in line with the work of Lu et al., who also identified smoking as an adjusted risk factor for surgical site infection in their patient population (32). It is noteworthy, however, that in our study, although smoking was a significant predictor of infection in univariate analysis, its independent effect diminished in the multivariate regression model after controlling for other variables and their overlapping effects, suggesting that the association between smoking and infection may be partially mediated or confounded by other patient- and procedure-related factors. Multiple pathophysiological mechanisms have been proposed to explain the heightened infection risk in smokers. The constituents of cigarette smoke—including nicotine, nitric oxide, and carbon monoxide—have been shown to directly interfere with the wound healing process by impairing tissue oxygenation, reducing blood flow, and disrupting cellular repair mechanisms (36). Furthermore, smoking has been demonstrated to suppress immune function by reducing serum immunoglobulin levels and impairing macrophage activity, thereby compromising the host's ability to mount an effective defense against microbial pathogens (37).

The present study demonstrated that emergency surgical procedures were significantly associated with a higher incidence of surgical site infection. This finding is consistent with the results of Mosleh et la., who similarly reported that emergency orthopedic surgeries carried an elevated risk of postoperative infection (16). Emergency surgery, by its nature, entails minimal preoperative preparation and limited time for optimization of patient status, which may directly contribute to the increased risk of infection.

Prolonged operative time was also identified as a factor contributing to a higher incidence of surgical site infection, a finding consistent with the studies of Najjar et al. (29) and Li et al. (38). The use of internal fixation devices inherently extends the duration of surgery and, consequently, increases the length of hospital stay. Furthermore, the surgical intervention itself, in conjunction with the placement of fixation hardware, induces local tissue alterations and may impair the function of immune cells at the operative site. In addition to these iatrogenic factors, the soft tissues and vasculature surrounding the fracture are often damaged as a result of the initial trauma, which further compromises the local immune response and delays the host defense mechanisms (39).

The findings of the present study demonstrated a significant and direct correlation between length of stay and the occurrence of surgical site infection. This observation is corroborated by the study of Hojjat et al., who similarly reported that patients who developed postoperative infection had significantly longer hospital stays compared to their infection-free counterparts (31). A growing body of evidence from previous studies has consistently indicated that prolonged hospitalization is associated with an elevated risk of infection (40), a finding that is biologically plausible given that the hospital environment, despite rigorous infection control measures, is never completely free of pathogenic microorganisms. Extended exposure to this environment increases the likelihood of colonization with healthcare-associated pathogens and subsequent infection. Therefore, patients who present with one or more identified risk factors at the time of admission should be carefully evaluated, and appropriate preventive strategies should be implemented to minimize the risk of surgical site infection. In conclusion, the results of this study indicate that the incidence of surgical site infection following surgical management of closed lower extremity fractures is substantial. Prolonged hospital stay, extended operative time, and smoking were identified as independent risk factors for the development of surgical site infection. These findings highlight the pressing need for comprehensive preventive and therapeutic programs, as well as the importance of more precise risk factor identification and stratification, to facilitate effective infection control and improve patient outcomes in orthopedic trauma populations.

Conflicts of Interest: The authors declare that they have no competing interests.

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References

1Rahimi H, Bahari M, Gharehdaghi M, Sarvari Y. Prevention of infection after surgery in fractures with the use of antibiotics. J Mashhad Univ Med Sci. 2001;44(73):31-8. [In Persian]

2.Ghanei Gheshlagh R, Parizad N, Ebrahimi A, Baghi V. Nurses' knowledge on the prevention of surgical site infection: a systematic review and meta-analysis study. Nurs Midwifery J. 2023;21(1):58-65. [In Persian]

3.Li J, Zhu Y, Zhao K, Zhang J, Meng H, Jin Z, et al. Incidence and risks for surgical site infection after closed tibial plateau fractures in adults treated by open reduction and internal fixation: a prospective study. J Orthop Surg Res. 2020;15(1):349.

4.Rodriguez L, Jung HS, Goulet JA, Cicalo A, Machado-Aranda DA, Napolitano LM. Evidence-based protocol for prophylactic antibiotics in open fractures: improved antibiotic stewardship with no increase in infection rates. J Trauma Acute Care Surg. 2014;77(3):400-7.

5.Ercole FF, Chianca TC, Duarte D, Starling CE, Carneiro M. Surgical site infection in patients submitted to orthopedic surgery: the NNIS risk index and risk prediction. Rev Lat Am Enfermagem. 2011;19(2):269-76.

6.van Walraven C, Musselman R. The Surgical Site Infection Risk Score (SSIRS): A Model to Predict the Risk of Surgical Site Infections. PLoS One. 2013;8(6):e67167.

7.Lipponen A, El-Osta A, Kaspi A, Ziemann M, Khurana I, Kn H, et al. Transcription factors Tp73, Cebpd, Pax6, and Spi1 rather than DNA methylation regulate chronic transcriptomics changes after experimental traumatic brain injury. Acta Neuropathol Commun. 2018;6(1):17.

8.Kraus K, Mikziński P, Widelski J, Paluch E. Prevention and Modern Strategies for Managing Methicillin-Resistant Staphylococcal Infections in Prosthetic Joint Infections (PJIs). Antibiotics (Basel). 2024;13(12):1151.

9.Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS. Surgical site infection (SSI) rates in the United States, 1992-1998: the National Nosocomial Infections Surveillance System basic SSI risk index. Clin Infect Dis. 2001;33(Suppl 2):S69-77.

10.Pereira HO, Rezende EM, Couto BR. Length of preoperative hospital stay: a risk factor for reducing surgical infection in femoral fracture cases. Rev Bras Ortop. 2015;50(6):638-46.

11.Owens CD, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. J Hosp Infect. 2008;70(Suppl 2):3-10.

12.Matthaiou DK, Peppas G, Falagas ME. Meta-analysis on surgical infections. Infect Dis Clin North Am. 2009;23(2):405-30.

13.Bratzler DW, Houck PM; Surgical Infection Prevention Guideline Writers Workgroup. Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. Am J Surg. 2005;189(4):395-404.

14.Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control. 1999;27(2):97-132; quiz 133-4; discussion 96.

15.Leaper DJ, van Goor H, Reilly J, Petrosillo N, Geiss HK, Torres AJ, et al. Surgical site infection - a European perspective of incidence and economic burden. Int Wound J. 2004;1(4):247-73.

16.Mosleh S, Baradaran Fard F, Jokar M, Akbari L, Aarabi A. Prevalence of Surgical Site Infection after Orthopedic Surgery and Some Related Factors at the Selected Hospitals of Isfahan University of Medical Sciences. Paramed Sci Military Health. 2019;13(4):43-53.

17.Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. Infect Control Hosp Epidemiol. 1999;20(11):725-30.

18.DiPiro JT, Martindale RG, Bakst A, Vacani PF, Watson P, Miller MT. Infection in surgical patients: effects on mortality, hospitalization, and postdischarge care. Am J Health Syst Pharm. 1998;55(8):777-81.

19.Prado MA, Lima MP, Gomes Ida R, Bergsten-Mendes G. The implementation of a surgical antibiotic prophylaxis program: the pivotal contribution of the hospital pharmacy. Am J Infect Control. 2002;30(1):49-56.

20.Pons-Busom M, Aguas-Compaired M, Delás J, Eguileor-Partearroyo B. Compliance with local guidelines for antibiotic prophylaxis in surgery. Infect Control Hosp Epidemiol. 2004;25(4):308-12.

21.Harlan LC, Harlan WR, Parsons PE. The economic impact of injuries: a major source of medical costs. Am J Public Health. 1990;80(4):453-9.

22.Rice DP, MacKenzie EJ. Cost of injury in the united states: A report to congress. San Francisco: Institute for health & Aging, University of California, and injury prevention center, the Johns Hopkins University; 1989. p.743-6. Available from: https://www.careforcrashvictims.com/wp-content/uploads/2017/01/CostofInjury.compressed.pdf

23.Zare M, Mirshamsi MH, Modir A, Karegar S, Shiryazdi SM, Haji Esmaeili MR. Comparison of oral antibiotics to prevent wound infection, traumatic Grade II teaching hospital in Yazd University. J Med Health Yazd. 2007;15(3):9-13. [In Persian] Available from: https://jssu.ssu.ac.ir/article-1-642-en.pdf

24.Dhammi IK, Ul Haq R, Kumar S. Prophylactic antibiotics in orthopedic surgery: Controversial issues in its use. Indian J Orthop. 2015;49(4):373-6.

25.Houshian S, Seyedipour S, Wedderkopp N. Epidemiology of bacterial hand infections. Int J Infect Dis. 2006;10(4):315-9.

26.Allah-Bakhshian A, Moghaddasian S, Zamanzadeh V, Parvan K, Allah-Bakhshian M. Knowledge, attitude, and practice of ICU nurses about nosocomial infections control in teaching hospitals of Tabriz. Iran J Nurs. 2010;23(64):17-28.

27.Khan MS, ur Rehman S, Ali MA, Sultan B, Sultan S. Infection in orthopedic implant surgery, its risk factors and outcome. J Ayub Med Coll Abbottabad. 2008;20(1):23-5.

28.Carvalho RLR, Campos CC, Franco LMC, Rocha AM, Ercole FF. Incidence and risk factors for surgical site infection in general surgeries. Rev Lat Am Enfermagem. 2017;25:e2848.

29.Najjar YW, Al-Wahsh ZM, Hamdan M, Saleh MY. Risk factors of orthopedic surgical site infection in Jordan: a prospective cohort study. Int J Surg Open. 2018;15:1-6.

30.Azizi H, Janmohammadi N, Bahrami M, Rouhi M, Falsafi M, Bijani A, et al. The Rate of Surgical Site Infection and Associated Factors in Patients Undergoing Orthopedic Surgeries in Babol, Northern. J Babol Univ Med Sci. 2018;20(8):37-43. [In Persian]

31.Hojjat M, Karimyar Jahromi M, Keshaei N, Salehifard A. Assessment of the prevalence of post-operation orthopedic wound infection in the orthopedic ward of Motahari hospital (2009-2010). 2012;20:51-8. [In Persian]

32.Lu K, Zhang J, Cheng J, Liu H, Yang C, Yin L, et al. Incidence and risk factors for surgical site infection after open reduction and internal fixation of intra-articular fractures of distal femur: A multicentre study. Int Wound J. 2019;16(2):473-8.

33.Zehni K, Rokhzadi MZ. Relationship between Body Mass Index with Physical Activity and Some of demographicCharacteristics among students in kurdistan university of medical sciences. Sci J Nurs Midwifery Paramed Facult. 2017;2(3):49-57.

34.Shao J, Zhang H, Yin B, Li J, Zhu Y, Zhang Y. Risk factors for surgical site infection following operative treatment of ankle fractures: A systematic review and meta-analysis. Int J Surg. 2018;56:124-32.

35.Sun Y, Wang H, Tang Y, Zhao H, Qin S, Xu L, et al. Incidence and risk factors for surgical site infection after open reduction and internal fixation of ankle fracture: A retrospective multicenter study. Medicine (Baltimore). 2018;97(7):e9901.

36.Rahman MM, Laher I. Structural and functional alteration of blood vessels caused by cigarette smoking: an overview of molecular mechanisms. Curr Vasc Pharmacol. 2007;5(4):276-92.

37.Najafizadeh M, Yasrebi SS, Dahim A, Zarei-Yazdeli M, Azadchehr MJ, Pahlavani H. Investigation of factors associated with surgical site infection after neurosurgery procedures in kashan shahid beheshti hospital. Stud Med Sci. 2024;35(2):84-92. [In Persian]

38.Li J, Zhu Y, Liu B, Dong T, Chen W, Zhang Y. Incidence and risk factors for surgical site infection following open reduction and internal fixation of adult tibial plateau fractures. Int Orthop. 2018;42(6):1397-403.

39.Al-Mulhim FA, Baragbah MA, Sadat-Ali M, Alomran AS, Azam MQ. Prevalence of surgical site infection in orthopedic surgery: a 5-year analysis. Int Surg. 2014;99(3):264-8.

40.Li GQ, Guo FF, Ou Y, Dong GW, Zhou W. Epidemiology and outcomes of surgical site infections following orthopedic surgery. Am J Infect Control. 2013;41(12):1268-71.