**Risk factors and the epidemiology of surgical-site infections at a tertiary care medical center in Mexico, the experience at the National Institute of Medical Sciences and Nutrition Salvador Zubirán: A 6-month-prospective cohort study; carried out during the first decade of the XXI century.**

(1) (2) Jorge E. Delgado-Hachmeister, M.D., M.P.H., M.Sc.

(1) Irene Mercado Joffre, R.N.

(1) Martha Huertas, R.N.

(1,4) Samuel Ponce de León, M.D., M.Sc.

(1,2,3) Sigfrido Rangel-Frausto, M.D., M.Sc., Ph.D.

1. Department of Hospital Epidemiology and Quality of Health Care, National Institute of Medical Sciences and Nutrition Salvador Zubirán, Mexico-City, Mexico

2. La Salle University, Mexican Faculty of Medicine, Mexico-City, Mexico

3. Hospital Epidemiology Research Unit, National Medical Center, Mexico-City, Mexico

4. Full Professor at the National Autonomous University of Mexico (UNAM), Mexico-City, Mexico

Corresponding Author: Jorge E. Delgado-Hachmeister, MD. La Salle University Mexican

Faculty of Medicine, Department of Microbiology, Islas Marianas No. 9, Fracc. Residencial Campestre Chiluca, Atizapan de Zaragoza, C.P. 52930, Edo. de Mex., Mexico

Phone: 52 55 50 19 17 36, e-mail: jorgeenriquedelgadoh@hotmail.com

Financial Support: This study was financed in part by the Ministry of Health and the National Council of Science and Technology (CONACYT), Mexico-City, Mexico.

Category: Original Article

None of the authors report conflicts of interest.

**Abbreviations:** SSI (Surgical-Site Infection); SSIs (Surgical Site Infections); Study of the Efficacy of Nosocomial Infection Control (SENIC); National Nosocomial Infection Surveillance (NNIS) System Risk Index; Red Blood Cell (RBC) products; Centers for Disease Control (CDC)

**Abstract**

Surgical site infection (SSI) is the second most common type of nosocomial infection at the National Institute of Medical Sciences and Nutrition Salvador Zubirán. SSIs are associated with increased hospital stay, costs and mortality. Despite continuous reduction in nosocomial infection rates in the last two decades at our Institution, in the 90’s SSIs increased slightly. In the present study we investigate the epidemiology and associated risk factors of SSI at our Institution. We prospectively enrolled 510 patients on postoperative day one. We recorded several risk factors for the development of SSIs. Identification of SSIs proceeded adhering to CDC definitions of SSI. We inspected surgical sites and medical records daily on week days and conducted post discharge surveillance until postoperative day 30. SSI developed in 25.5 % of patients. SSI increased hospital and postoperative stay. Stepwise logistic multivariate regression analysis identified the following risk factors for the development of a SSI: Body Mass Index >= 27 kg/m2, albumin < 3 g/dl, preoperative stay >= 5 days, red blood cell transfusions, the presence of diabetes mellitus and National Nosocomial Infection Surveillance (NNIS) System risk index. The present study provides useful information for reducing SSI rates at our Institution. We propose different strategies to reduce SSI rates at our institution. The administration of albumin during and after surgery should be explored since it potentially reduces SSI risk and increases oncotic pressure and therefore reduces the need for red blood cell transfusions. We also need to investigate a tight glucose control regimen before, during and after surgery also to demonstrate if this approach diminishes surgical site infection rates.

**Keywords:** Surgical Site Infection, Risk Factors, Body Mass Index, Red Blood Cell Transfusions, Preoperative stay, Albumin, Diabetes Mellitus, NNIS

**Introduction**

Previous studies have shown that surgical site infection (SSI) represents the second most common type of nosocomial infection at the National Institute of Medical Sciences and Nutrition Salvador Zubirán(1) and the National Institutes of Health(2), both in Mexico. This is consistent with nosocomial infection reports from other hospitals.(3-6) While nosocomial infection surveillance has reduced nosocomial infection rates at our Institution, SSI rates increased slightly as reported in a previous study.(1) SSIs are associated with a prolonged hospital stay, costs and higher mortality.(7-10, 42) SSI rates that have been reported in Mexico vary between approximately 1 to 30% (1;11-13); these rates are comparable with published data from other hospitals around the world.(14-17,43) Several studies have shown that SSI rates are reduced by SSI surveillance and reporting of postoperative wound infection rates to surgeons.(18-22, 39) In this study we identified SSIs by adhering to the CDC guidelines for SSI definition.(23) We prospectively enrolled 532 patients during a six-month period and included post-discharge surveillance for the identification of SSI until postoperative day 30. This represents the first prospective study at our Institution for the identification of SSI rates and associated risk factors. We provide valuable data to reduce SSI rates at our hospital.

**Methods**

We conducted a prospective cohort study at the National Institute of Medical Sciences and Nutrition Salvador Zubirán, a 211-bed, tertiary-care and national referral hospital, that provides care for patients with complex medical and surgical conditions. Patients were enrolled in the study the day after surgery (postoperative day 1). The study was approved by the Institutional Review Board of our Institution, which is the Research Ethics Committee or Comite de Etica de Investigacion (C.E.I.), Registration Code 1102. Informed consent to participate in the study was not required since nosocomial infection identification is a regular activity at our hospital. Exclusion criteria included surgery for treatment of a SSI, implantation of prosthetic material during the surgery, surgical problems of the anus or biopsies of the musculoskeletal and lymphatic apparatuses. Patients were withdrawn from the study if they died during the follow-up period (30 days) without evidence of developing a SSI; if the patient chart was not available for review 30 days after surgery; or if the development of a SSI during the study period could be attributed to other causes different than the surgery itself. To identify SSIs we adhered to CDC criteria, these definitions are widely accepted as the standard for the identification of SSI for epidemiological and research purposes.(23) We performed during week-days, daily surveillance of surgical-sites and review of medical records. Post discharge surveillance was an angular component of our study. At the moment of discharge we discussed with patients data that could be attributed to the development of a SSI. The written and oral information we provided was clear and concise. Patients would have to watch for the development of the following signs and symptoms at the wound: redness, purulent discharge, pain, heat, or dehiscence of the wound and temperature >=38℃. We could be reached by patients telephonically if the patients were concerned that they had developed a SSI. On postoperative day 30 we scheduled an appointment at the department of epidemiology in order to inspect the wound and ask for the development of symptoms and signs attributable to a SSI. If the patients did not attend the post discharge visit we would contact patients by phone and ask for the development of the following signs at the wound: redness, pus or dehiscence of the surgical-site or received a prescription of antibiotics because the surgeon in charge stated that the surgical-site was infected. Patients who unequivocally stated, over the phone or during the outpatient visit, that they presented at some time after discharge, purulent secretion from the wound (not serous or hematic) or that they received a prescription of antibiotics because of the diagnosis of a SSI by a surgeon were considered as having developed an incisional SSI; we did not attempt to diagnose Organ/Space infections over the phone, since they are of a magnitude in which hospitalization will be required. Patients who did not attend the post discharge visit or were not reached by phone were considered not infected. The following factors were gathered during interview on postoperative day 1: age, gender, loss of weight (more than 10% over the previous six months). Other preoperative risk factors we obtained from patient charts included: preoperative stay, blood count (including hemoglobin, leukocytes, neutrophils and lymphocytes), albumin, creatinine, body mass index, underlying morbidities (limited to a diagnosis of HIV/AIDS, diabetes mellitus, autoimmune and/or neoplastic disease), presence of a focus of infection at a distant site, use of steroids, use of antibiotics in the preoperative period (one week) and American Society of Anesthesiology Score.(24) Risk factors recorded from patient charts and/or inspected during the postoperative period and until discharge included: presence, location (through the operative incision or at a different site), type (closed suction vs. open) and duration of drainages, respectively; type of surgery (elective vs. emergency); transfusion of red blood cell products during the intraoperative period and until 72 hours after the completion of surgery; duration of surgery; wound class; antimicrobial surgical prophylaxis; intensive care unit stay after surgery; number of diagnoses at discharge; and Study of the Efficacy of Nosocomial Infection Control (SENIC)(4) and National Nosocomial Infection Surveillance (NNIS) System risk indices.(26) We also recorded postoperative pain with a visual analogue scale (0-100) every 24 hours on postoperative days 1, 2 and 3. (For statistical analysis Stata version 8.2 was used, College Station, TX, USA.)

**Results**

Our study was conducted during the first decade of the XXI century, from May 1, to October 31. We enrolled 532 general surgery patients. Seventeen patients were withdrawn from the final analysis since they died without evidence of developing a SSI (Mortality rate = 3.2%). In three cases patient records were not available, however one of these developed an Organ/Space SSI, but all were excluded from final analysis. We also withdrew a patient from the study because he developed an enterocutaneous fistula and symptoms of an incisional SSI, however the SSI was attributed to the fistula. Finally, an additional patient was withdrawn since we could not clearly establish if the development of an Organ/Space infection was related to the surgery or to multiple diagnostic paracentesis after surgery. Five hundred and ten patients remained for final analysis. Of 510 patients, 130 (25.5%) developed a SSI. None of these died during follow-up. The mean age of the cohort was 49.9 ± 0.8 years (All values are summarized as Mean ± S.E.M). The mean length of hospital-stay was 13.6 ± 0.5 days. Patients who developed a SSI had significantly longer hospital and postoperative-stays (17.6 ± 1.2 vs 12.3 ± 0.5; 95 % CI 15.2 to 20.0 vs. 11.3 to 13.2; P < 0.0001) and (10.5 ± 1.1 vs. 6 ± 0.4; 95% CI 8.3 to 12.6 vs. 5.2 to 6.7; P < 0.0001), respectively. Of the 510 patients included in the study 7 (1.37%) were lost to follow-up after discharge; even though the medical records were available, we could not establish from medical charts if someone from the medical or surgical staff had inspected the wound until postoperative day 30; we were also not able to follow them in the clinic of our department or contact them by phone until postoperative day 30. But we considered these patients as not having developed a SSI. The rest of the patients were followed until postoperative day 30: 159 (31.12%) were contacted by phone, 289 (56.7%) were seen by our group at the epidemiology division, and in 55 (10.78%) patients who could not be contacted by phone or seen in our clinic the charts indicated the status of the surgical-site at least until postoperative day 30. Of 130 infections identified by our group, 63 (48.5%) were also correctly identified and recorded in patient charts by surgeons and other physicians of the hospital, in the remaining 67 (51.5%) SSIs that our study identified the medical records did not indicate the development of a SSI. Of these 67 SSIs, 58 (44.62%) were identified by our group by visually inspecting the wound and 9 (6.92%) via telephone survey. SSI rate stratified by wound class was 20.8% for clean, 25.2% for clean-contaminated, 66.7% for contaminated and 31.3% for dirty surgery. However there was not a statistical significant difference between clean and dirty wounds, or contaminated or dirty wounds. However there was a tendency for SSI rates to be lower in dirty procedures, which indicates that the surgeons or other physicians and our epidemiological division were not infecting the wound by performing a detailed inspection of the surgical sites. We performed strict hand washing techniques and use of masks before and after inspection of the surgical sites. In table 1 we report number of surgeries, and SSI rates by wound class, and for the most common surgical procedures for clean and clean-contaminated wounds, number of infections according to site (Deep incisional or Organ-space SSI), and number of infections developed during in-hospital surveillance. According to site of infection 61 (46.9%), 44 (33.8%) and 25 (19.2%) were superficial incisional, deep incisional and Organ/Space SSIs, respectively. Of 130 SSIs, 67 (51.5%) were detected during in-hospital surveillance and 63 (48.5%) developed after discharge. However, when stratified by wound class 9 (20.9%), 40 (63.5%), 9 (64.3%) and 9 (90%) of SSIs developed during hospitalization for clean, clean-contaminated, contaminated and dirty surgical procedures, respectively. The mean number of days for the development of a SSI was 12.4 ± 0.8, range 27 days (3-30), mode 30 days (16 cases). Table 2 indicates different measures of central tendency and dispersion for the day of development of a SSI stratified by wound class. We were also interested in comparing the number of SSIs detected by different surveillance methods used in our hospital, we assumed that our system was able to detect all of the SSI that developed. In table 3 we compare each method: our method, the traditional system used by our department (review of wound culture data and medical charts), and the data provided in medical charts by medical and surgical staff of the hospital who also inspected the wound during hospitalization and after discharge. However we came to the possible conclusion that surgeons usually report only Organ/Space SSIs, if we consider this only 4.9% of patients developed an infection. So CDC criteria for the identification of a SSI are much stricter and possibly help in identifying risk factors for the development of SSIs better.

We were able to identify several risk factors for the development of a SSI. In table 4 we present risk factors for the development of a SSI that we studied. We also performed a multivariate stepwise logistic regression analysis to identify the best independent predictors for the development of a SSI. The significance level for inclusion of a variable in this model was 0.2, recommended to avoid residual confounding. We present the results of the multivariate stepwise logistic regression analysis in table 5. Microbiologic data of wound cultures are presented in table 6. We were able to obtain microbiologic data in 96 (73.8%) of 130 SSIs. Cultures were falsely negative in 10 (10.4%) cases. Of the 86 positive cultures, 47(54.7%) were mono-microbial and in 39 (45.3%) we were able to isolate > 1 pathogen (range 2-6). The most common organism was *Enterococcus spp.* this might be significant because we might need to adapt antimicrobial prophylaxis in our Institution and these are highly pathogenic organisms, with associated high morbidity and mortality.(47) Surgical antimicrobial prophylaxis in this study was not a protective factor against the development of SSI, but is potentially related to a small sample size. However, we have raised flags in the past about the adequate design of clinical trials to correctly establish the efficacy of a clinical intervention to reduce SSI rates, particularly antibiotics.(27) In general we believe that antimicrobial prophylaxis when adequately administered protects against the development of a SSI. However, the selection of the antibiotic has to be considered and adjusted. And antimicrobial agents have to be administered with close monitoring of the timing of administration, before surgery.(40,41,45)

**Discussion**

Method and duration of surveillance of surgical sites influences SSI rates dramatically as proved in this study (Table 3) and reported previously by other authors.(29) SSI rates are a function of method of surveillance and importantly post discharge surveillance. The CDC currently recommends post discharge surveillance until postoperative day 30 for surgeries in which no implant has been left in place.(23) However, of the SSI that we report 105 (80.8%) of 130 SSIs are limited to the incisional site and 25 (19.2%) to the Organ/Space site, this is in contrast to other reports where 1/3 of SSIs are located to the Organ/Space site(30), it might not be statistically significant, but it purports that the level of expertise of the attending surgeons of our Institution is adequate. Therefore, close surveillance of surgical sites increases the sensitivity for detection of incisional SSIs in our hospital but without adding sensitivity for the detection of Organ/Space infections (Table 3). In this regard it has been shown that associated mortality of SSIs is primarily attributed to Organ/Space SSIs (93%).(28)

Interestingly, in clean surgeries at least 80% of SSIs developed after discharge, whereas for other levels of contamination of the wound this percentage fell to at least lower than 40%. This is also consistent with other reports of the epidemiology of SSIs. This underscores the need of conducting post discharge surveillance in our Institution, especially for clean surgeries; since 80% of infections for clean surgeries would go unnoticed if no post discharge surveillance would be performed. On average 48.5% of SSIs developed after discharge, which is also in accordance with other reports on the epidemiology of SSIs.(31)

SSIs are associated with higher costs, mortality and hospital-stay.(29-31) In this study we also show that both hospital and postoperative stay are increased by the development of a SSI, and increasing costs highlighting the need for SSI surveillance at our Institution(1), and also the imperative need of decreasing them.

In the univariate analysis we identified several risk factors associated with the development of a SSI (See table 4). The NNIS index in this study predicted more accurately the risk of developing a SSI. Since the SENIC index lost its significance in the multivariate regression model. However, it is of interest that despite high SSI rates per SENIC category, we were able to identify a group of patients which are at lower risk of developing a SSI, since patients with a SENIC index of 0 had a SSI rate of 0%. The NNIS index has been recommended for comparing SSI rates between hospitals.(33) However, when comparing SSI rates between hospitals it is important to consider the method of detection of SSIs. Therefore inter-hospital comparisons of SSI rates are difficult to interpret because of the implementation of different surveillance strategies of SSIs detection and distinct severity of illness of patients between hospitals. SSI rates are highly dependent on the method of surveillance, a recent study in Spain reported a SSI rate for general surgery of 14.8% (34), and their post-discharge surveillance method was telephone survey, in contrast to our study where post discharge surveillance was more aggressive. Other studies from around the world have demonstrated similar high rates of SSI as this study, even for clean surgeries.(35-37) In 1896, Brewer, reported high surgical infection rates for clean wounds, since he observed that 39% of this type of surgical sites became infected after surgery.(39) However by adhering to Lister’s observations and changes in surgical techniques SSI rates fell dramatically. This is also observed partially in this study, since patients with a higher NNIS index and therefore disease severity had a lower risk of SSI development. This is also important because some attending surgeons at our hospital, made the observation that we were contaminating the wound, however the fact that patients with a higher NNIS index had a lower rate of developing a SSI argues strongly against this. Vide Infra. Since patients with a higher NNIS index are more immunosuppressed and if we were contaminating the wounds they would be more keen to develop a SSI. So this observation argues strongly against the comments of the attending surgeons. Since the National Institutes of Medical Sciences and Nutrition Salvador Zubiran is a tertiary referral hospital center, disease severity is higher and surgical cases are more complex as well, and leading to higher SSI rates. Not surprisingly in the multivariate analysis preoperative stay was significant for the development of a SSI. Another interesting risk factor for the development of SSI, which turned out to be significant in the multivariate analysis is the transfusion of red blood cell products. Red blood cell (RBC) product transfusion might lead to the development of immunosuppression and therefore a more likely outcome of presenting a SSI. Also the need for RBC transfusions indicate that there might be hypoxemia so this also leads to the development of a SSI.(44,46) Unfortunately we did not record oximetry values during the preoperative period to assess this as a risk factor for the development of a SSI. However, it also adds to the evidence that administering albumin might reduce SSI rates dramatically.(38,44) It is also interesting that a low albumin in the stepwise logistic regression multivariate analysis model resulted to be significant for a more likelihood of developing a SSI. Administering albumin in the preoperative period, intraoperative period and postoperative might dramatically diminish SSI rates, since albumin potentially increases oncotic pressure and might decrease the need for RBC transfusion products. In the multivariate analysis a preoperative stay >= 5 days also resulted in an increased risk of developing a SSI. In our Institution reducing preoperative stay would perhaps lead to reduced SSI rates. Of course it is also a marker of increased disease severity but it suggests that the patients might be more prone to be colonized by infectious pathogens, so this leads us to believe that implementing chlorhexidine showers among patients that will be surgically intervened might lead to diminished SSI rates. The fact that a body mass index greater or equal to 27 was also a risk factor in the multivariate analysis regression model suggests that monitoring glucose levels during the preoperative period, intraoperative period and postoperative period would decrease SSI, unfortunately we do not have data for glucose levels during the mentioned intervals, but should be explored, this is also supported by the fact that in the multivariate analysis regression model the presence of diabetes mellitus was a highly significant factor for the development of a SSI. (38,44,48) Also in obese patients it is suggested that laparoscopic procedures might reduce the risk of developing a SSI.(49)

Finally the number of infections per NNIS category for superficial incisional SSI was 16, 23, 11 and 2, respectively for a NNIS index of 0, 1, 2 and 3. For deep incisional it was 6, 20, 15 and 2, respectively. And for Organ/Space SSI it was 4 (0.78%), 11 (2.16%), 6 (1.18%) and 1 (0.2%), respectively, suggesting that the attending surgeons treat more severe cases with better Listerian principles.

**Reference List**

(1) Ponce de Leon S, Rangel-Frausto MS, Elias-Lopez JI, Romero-Oliveros C, Huertas-Jimenez M. [Nosocomial infections: secular trends of a control program in Mexico]. Salud Publica Mex 1999; 41 Suppl 1:S5-11.

(2) Ponce de Leon S, Garcia GML, Volkow-Fernandez P. [Initial results of a nosocomial infection surveillance program in the National Institutes of Health]. Salud Publica Mex 1986; 28:583-592.

(3) Nichols RL. Postoperative wound infection. N Engl J Med 1982; 307(27):1701-1702.

(4) Haley RW, Culver DH, White JW, Morgan WM, Emori TG. The nationwide nosocomial infection rate. A new need for vital statistics. Am J Epidemiol 1985; 121(2):159-167.

(5) Pittet D, Ducel G. Infectious risk factors related to operating rooms. Infect Control Hosp Epidemiol 1994; 15(7):456-462.

(6) Horan TC, Culver DH, Gaynes RP, Jarvis WR, Edwards JR, Reid CR. Nosocomial infections in surgical patients in the United States, January 1986-June 1992. National Nosocomial Infections Surveillance (NNIS) System. Infect Control Hosp Epidemiol 1993; 14(2):73-80.

(7) Green JW, Wenzel RP. Postoperative wound infection: a controlled study of the increased duration of hospital stay and direct cost of hospitalization. Ann Surg 1977; 185(3):264-268.

(8) Nelson RM, Dries DJ. The economic implications of infection in cardiac surgery. Ann Thorac Surg 1986; 42(3):240-246.

(9) 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):725-730.

(10) McGarry SA, Engemann JJ, Schmader K, Sexton DJ, Kaye KS. Surgical-site infection due to Staphylococcus aureus among elderly patients: mortality, duration of hospitalization, and cost. Infect Control Hosp Epidemiol 2004; 25(6):461-467.

(11) Valenzuela-Flores AA, Rangel-Frausto MS, Gutierrez-Garcia JN, Valenzuela-Flores AG, Tabal-Galan N. [Nosocomial infection surveillance: experience at a cardiology hospital in Mexico]. Cir Cir 2004; 72(1):41-46.

(12) Vilar-Compte D, Jacquemin B, Robles-Vidal C, Volkow P. Surgical site infections in breast surgery: case-control study. World J Surg 2004; 28(3):242-246.

(13) Porras-Hernandez JD, Vilar-Compte D, Cashat-Cruz M, Ordorica-Flores RM, Bracho-Blanchet E, Avila-Figueroa C. A prospective study of surgical site infections in a pediatric hospital in Mexico City. Am J Infect Control 2003; 31(5):302-308.

(14) Swenne CL, Lindholm C, Borowiec J, Carlsson M. Surgical-site infections within 60 days of coronary artery by-pass graft surgery. J Hosp Infect 2004; 57(1):14-24.

(15) Oliveira AC, Carvalho DV. Postdischarge surveillance: the impact on surgical site infection incidence in a Brazilian university hospital. Am J Infect Control 2004; 32(6):358-361.

(16) Smith RL, Bohl JK, McElearney ST, Friel CM, Barclay MM, Sawyer RG et al. Wound infection after elective colorectal resection. Ann Surg 2004; 239(5):599-605.

(17) Martorell C, Engelman R, Corl A, Brown RB. Surgical site infections in cardiac surgery: an 11-year perspective. Am J Infect Control 2004; 32(2):63-68.

(18) Cruse PJ, Foord R. A five-year prospective study of 23,649 surgical wounds. Arch Surg 1973; 107(2):206-210.

(19) Cruse PJ, Foord R. The epidemiology of wound infection. A 10-year prospective study of 62,939 wounds. Surg Clin North Am 1980; 60(1):27-40.

(20) Condon RE, Schulte WJ, Malangoni MA, Anderson-Teschendorf MJ. Effectiveness of a surgical wound surveillance program. Arch Surg 1983; 118(3):303-307.

(21) Olson MM, Lee JT, Jr. Continuous, 10-year wound infection surveillance. Results, advantages, and unanswered questions. Arch Surg 1990; 125(6):794-803.

(22) Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985; 121(2):182-205.

(23) Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 1999; 20(4):250-278.

(24) Keats AS. The ASA classification of physical status--a recapitulation. Anesthesiology 1978; 49(4):233-236.

(25) Haley RW, Culver DH, Morgan WM, White JW, Emori TG, Hooton TM. Identifying patients at high risk of surgical wound infection. A simple multivariate index of patient susceptibility and wound contamination. Am J Epidemiol 1985; 121(2):206-215.

(26) Culver DH, Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. Am J Med 1991; 91(3B):152S-157S.

(27) Delgado-Hachmeister JE, Graviss EA, Correspondence, N Engl J Med 2002; 347(15):1207-8.

(28) Swenne CL, Lindholm C, Borowiec J, Carlsson M. Surgical-site infections within 60 days of coronary artery by-pass graft surgery. J Hosp Infect 2004; 57(1):14-24.

(29) Weiss CA, III, Statz CL, Dahms RA, Remucal MJ, Dunn DL, Beilman GJ. Six years of surgical wound infection surveillance at a tertiary care center: review of the microbiologic and epidemiological aspects of 20,007 wounds. Arch Surg 1999; 134(10):1041-1048.

(30) Green JW, Wenzel RP. Postoperative wound infection: a controlled study of the increased duration of hospital stay and direct cost of hospitalization. Ann Surg 1977; 185(3):264-268.

(31) Nelson RM, Dries DJ. The economic implications of infection in cardiac surgery. Ann Thorac Surg 1986; 42(3):240-246.

(32) 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):725-730.

(33) Ronveaux O, Mertens R, Dupont Y. Surgical wound infection surveillance: results from the Belgian hospital network. Acta Chir Belg 1996; 96(1):3-10.

(34) Delgado-Rodriguez M, Gomez-Ortega A, Sillero-Arenas M, Llorca J. Epidemiology of surgical-site infections diagnosed after hospital discharge: a prospective cohort study. Infect Control Hosp Epidemiol 2001; 22(1):24-30.

(35) Vilar-Compte D, Jacquemin B, Robles-Vidal C, Volkow P. Surgical site infections in breast surgery: case-control study. World J Surg 2004; 28(3):242-246.

(36) Oliveira AC, Carvalho DV. Postdischarge surveillance: the impact on surgical site infection incidence in a Brazilian university hospital. Am J Infect Control 2004; 32(6):358-361.

(37) Swenne CL, Lindholm C, Borowiec J, Carlsson M. Surgical-site infections within 60 days of coronary artery by-pass graft surgery. J Hosp Infect 2004; 57(1):14-24.

(38) Cuomo R, Nisi G, Brandi C, Giardino FR, Grimaldi L. Future directions to limit surgical site infections. Journal of Investigative Surgery 2020; 30(8):759-761.

(39) Brewer GE. Studies in aseptic technic, with a report of some recent observations at the Roosevelt hospital. JAMA 1915; LXIV(17):1369-72.

(40) Lizan-Garcia M, Garcia-Caballero J, Asensio-Vegas A. Risk factors for surgical-wound infection in general surgery: a prospective study. Infect Control Hosp Epidemiol 1997; 18:310-15.

(41) Dellinger EP, Gross PA, Barrett TL, *et. al.* Quality Standard for antimicrobial prophylaxis in surgical procedures. Clinical Infectious Diseases 1994;18:422-7.

(42) Badia JM, Casey AL, Petrosillo N, Hudson PM, Mitchell SA, Crosby C. Impact of surgical site infection of healthcare costs and patient outcomes: a systematic review in six European countires. Journal of Hospital Infection 96(2017):1-15.

(43) Leaper DJ, Ousey K. Evidence update on prevention of surgical site infection. Current Opinion in Clinical Infectious diseases. 2015. 28(2):158-63.

(44) Cheadle WG. Risk factors for surgical site infection. Surg Infect (Larchmt). 2006;7 Suppl 1:S7-11.

(45) Young PY, Khadaroo RG. Surgical site infections. Surg Clin North Am. 2014 Dec;94(6):1245-64.

(46) Liu Z, Dumville JC, Norman G, *et. al.* Intraoperative interventions for preventing surgical site infection: an overview of Cochrane Reviews. Cochrane Database Syst Rev. 2018 6;2(2)

(47) Mora-Guzmán I, Rubio-Perez I, Maqueda González R, Domingo Garcia D, Martín-Pérez E. Surgical site infection by carbapenemase-producing Enterobacteriaceae. A challenge for today's surgeons. Cir Esp (Engl Ed);98(6):342-349.

(48) Domingos CM, Iida LI, Poveda VB. Glycemic control strategies and the occurrence of surgical site infection: a systematic review. Rev Esc Enferm USP. 2016 Sep-Oct;50(5):868-874.

(49) Shabanzadeh DM, Sørensen LT. Laparoscopic surgery compared with open surgery decreases surgical site infection in obese patients: a systematic review and meta-analysis. Ann Surg. 2012 Dec;256(6):934-45.