Incidence and Risk Factors of Surgical Site Infections: Insights from Kakamega County General Hospital in Kenya

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https://doi.org/10.51867/ajernet.6.1.43

ABSTRACT

Surgical site infections (SSIs) are common complications associated with increased morbidity, hospital stay and mortality amongst patients' post-surgery. This poses a huge economic burden and reduced quality of life in low and middle-income countries (LMICs). Data on incidence and risk factors for SSI following surgeries in Kenya is limited. Guided by the infection chain theory, this cross-sectional study investigated the incidence and risk factors associated with surgical site infections amongst the post-surgery patients in Kakamega County General Hospital (KCGH). Pus swabs were collected from infected surgical sites suspected of SSI from 128 patients attending Kakamega County General Hospital in the year 2023. Demographic data was also collected from patients who underwent a surgical procedure at KCTRH. Risk factors were identified from patient demography while wound swabs were subjected to microbiological techniques according to the Centres for Disease control guidelines for SSI surveillance. Associations between identified risk factors and the occurrence of SSIs were examined using Chi-square (categorical) and t-test (Continuous). A total of 128 patients underwent a surgical procedure during the study period. The incidence of SSI was 66% (n=84). Seven bacterial species were isolated namely, Pseudomonas aeruginosa (22%), gram negative rods (15%), Staphylococcus aureus (9%), Klebsiella species (9%), Escherichia coli (7%), Klebsiella oxytoca (2%) and gram-positive cocci (0.8%). Incidence of SSI was 66% (n=84). Diabetes was 32%, obesity 41% and smoking 17%, among the pre-operative factors but showed no association with SSIs (p > 0.05). There was a correlation between longer surgeries and fewer SSIs (mean duration 114 minutes) and pre-operative stays did not significantly contribute to SSI risk. SSIs remain a challenge in LMICs. From this study, it was concluded that there is a continued systemic and procedural element in the onset of SSIs and highlights the role of post-operative practices in the prevention of SSIs. There is need for targeted interventions in the care of surgical wounds to mitigate the burden of SSIs in the region.

Keywords: Surgical Site Infections (SSIs), Incidence, Risk Factors, Lower and Middle-Income Countries, Sub-Saharan Africa

I. INTRODUCTION

Surgical site infections (SSIs) are infections that occur at or near a surgical incision site, typically within 30 days of surgery or up to one year if an implant is left in place (Cooper, 2013; Alverdy et al., 2020). SSIs can be caused by a variety of microorganisms, including bacteria, viruses, and fungi, and can range in severity from mild to life-threatening. SSIs are a significant problem in healthcare, affecting millions of patients each year worldwide. They can result in prolonged hospital stays, increased healthcare costs, and even death. According to the Centre for Disease Control and Prevention (CDC), SSIs are the most common type of healthcare-associated infection in the United States, accounting for approximately 31% of all such infections. The incidence of SSIs can vary widely depending on the type of surgery and the patient population, with higher rates observed in certain surgical specialties (e.g. orthopaedics, cardiac surgery) and in patients with comorbidities or other risk factors (Saeedinia et al., 2015; Duran et al., 2024).

The development of SSIs is often multi-implicated, with patient, surgical, and environmental factors all playing a role. Patient factors that can increase the risk of SSIs include advanced age, obesity, smoking, diabetes, and other conditions that compromise the immune system or impair wound healing (Ansari et al., 2019; Bucataru et al., 2023). Surgical factors that can increase the risk of SSIs include the duration and complexity of the procedure, the use of implants or prostheses, and the presence of devitalized tissue. Environmental factors that can increase the risk of SSIs include inadequate sterilization of surgical equipment and poor infection control practices (Alfonso-Sanchez et al., 2017; Damonti et al., 2023; Bucataru et al., 2023)

Prevention and control of SSIs are essential to reducing their impact on patients and the healthcare system. Prevention strategies include the use of antibiotic prophylaxis, appropriate wound care techniques, and infection control

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practices such as hand hygiene and environmental cleaning (Badia et al., 2020; Seidelman et al., 2023). Treatment of SSIs typically involves a combination of antimicrobial therapy and surgical debridement or drainage.

Overall, SSIs are a significant and complex problem in healthcare, but with careful attention to prevention and control, their incidence and impact can be reduced. There are several risk factors for surgical site infections (SSIs), but well-reported in developed countries with a dearth of information in sub-Saharan Africa. Some of the most common and well-established risk factors can be categorised into patient factors which compromise the immune system or impair wound healing can increase the risk of SSIs; surgical factors environmental factors, microbiological factors, and antibiotic use- a problem this study addresses.

Therefore, it is important to note that the relative importance of these risk factors can vary depending on the type of surgery, the patient population, and location. Therefore, to get a clear picture of the compounding incidence and risk factors in Western Kenya, the present study was conducted. A comprehensive approach to SSI prevention should consider all relevant risk factors and tailor interventions to specific contexts.

1.1 Statement of the Problem

Surgical site infections (SSIs) continue to be a major healthcare challenge attributed to high rates of morbidity, high healthcare costs drawing from prolonged stays in hospitals. While there is data on risk factors and strategies for prevention for these infections, it is geographically limited to developed countries like Europe and the United States. The lack of comprehensive data on the risk and incidences of SSIs in sub-Saharan Africa especially Western Kenya, continues to cripple infection control programs. Therefore, an understanding of factors influencing the development of SSIs in the region is important in shaping the trajectory of effective infection control programs.

1.2 Research Objective

The main objective of this research is to investigate the incidence and risk factor attributed to the development of SSIs on Western Kenya. It aims to identify the key contributors of the infections by providing evidence-based recommendations such that strategies for infection control are improved, in line with curbing the burden of infections in the region.

II. LITERATURE REVIEW

2.1 Theoretical Framework

The present study focuses on surgical site infections in Kakamega County General Hospital and therefore can be frame well within the Epidemiologic Triad Model (ETM) - a model well-used in infectious diseases research. The model underscores the importance of the interaction between pathogens, the host (patients) and the environment (the hospital/surgical sites). Furthermore, it analyses how bacteria- PA and other associated ones like Staphylococcus aureus, patient factors (obesity, diabetes), and surgical procedures altogether contribute to the onset of risks of surgical site infections.

2.1.1 The Chain Infection Theory

The present study aligns with the chain of infection theory- a theory explaining the transmission of infections via the key six elements which include the infectious agent, the reservoir, the portal of exit, the mode of transmission, the portal of entry and the usually susceptible host (Van Seventer & Hochberg, 2016). Therefore, by way of identifying these risk factors as well as the bacterial agents, the present research attempted to break this chain at several points, in line with curbing the rates of infections.

2.2 Empirical Review

Previous several studies have attempted to examine SSIs in LMICs by virtue of underscoring the risk factors, prevalence of microbes and their prevention strategies. Previous research shows that SSI incidence rates vary between 10-70% based on such factors as hospital hygiene, patient conditions and techniques employed during surgery (Allegranzi et al., 2018). Similarly, Kenyan studies have underscored the importance of diabetes, obesity, and prolonged stays in hospital in risk factors (Temu et al., 2021), although data on statistical significance vary widely. Other studies have consistently reported that PA, *S. aureus, Klebsiella spp* and *Escherichia coli* are the leading pathogens implicated in SSIs (Hou et al., 2022), and that antimicrobial resistance continues to complicate the available treatment options (World Health Organization, 2023). Nevertheless, existing evidence points out that stringent aseptic procedures, post-operative care and targeted antibiotic therapy continues to reduce risk of SSIs (Haegdorens et al., 2019).

There is still a scarcity of data on the influence of factors relating to microbiology and antibiotic misuse, a scenario that continues to exacerbate the development of antimicrobial resistance, thus tightening the grip around attempts to manage SSIs (Iskandar et al., 2021). In Kenya, for example, published records underscore inconsistencies

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in adherence to programs which underscore antimicrobial stewardship thus leading to a continued spread of multi-drug resistant strains in SSIs (Ezugwu et al., 2024; Mogoi et al., 2024). This necessitates the integration of antimicrobial stewardship in post-surgical care in line with mitigating any risks attributed to SSIs from drug-resistant pathogens.

Additionally, there is under exploration of the roles of institutional and environmental factors in SSIs in many African healthcare settings, yet they form part of contributing factors. Recent reports have underscored the role of inadequate operating rooms, poor adherence to aseptic protocols, and gaps in the infection control programs, as key contributors to increased levels of SSIs in sub-Saharan Africa (Allegranzi et al., 2010). Moreover, overcrowding, and insufficient healthcare personnel have shown to continue crippling surgical infection control programs (Nejad et al., 2011). Addressing these challenges through interventions, personnel training and improved infrastructure in hospitals will strengthen efforts toward reducing SSIs in Kenya.

III. METHODOLOGY

3.1 Study Design and Setting

This cross-sectional study was conducted at the Kakamega County General Hospital (KCGH), a level 5 government health facility located in Kakamega County, western Kenya (Latitude: 0° 16' 60.00" N Longitude: 34° 45' 0.00" E) with a population of approximately 2 million people (Kenya National Bureau of Statistics, 2019). Kakamega County General Hospital has a wide catchment of patients as the main public hospital serving residents of the Western region of Kenya including Kakamega county, as well as other neighbouring counties such as Vihiga, Bungoma and Busia. Patients who underwent a surgical procedure in 2023 at KCGH were recruited into the study.

3.2 Laboratory Analysis

Surgical sites were examined from the 2^{nd} postoperative day for pain, redness, warmth, swelling and purulent drainage at the incision site by certified clinicians. SSIs were diagnosed and defined by the attending physician according to the Centres for Disease Control (CDC) guidelines (CDC, 2024). Pus swabs were collected from infected surgical sites suspected of SSI and immediately taken to the laboratory for wet preparations, gram stain, ZN-stain, plate inoculation and culture at 37^{o}C overnight. Isolation and identification of microbial isolates was based on typical growth colony characteristics on differential media (MacConkey agar (MAC), blood agar (BA) (Oxoid, UK)), gram stain and biochemical tests (catalase, indole, motility test, urease, citrate utilization test, oxidase) and growth at 42°C.

3.3 Statistical Analysis

Data on patient demographics were collected in an excel spread sheets and analysed for statistical differences using the Statistical package for social sciences (SPSS v30). Categorical variables such as gender, age group, antimicrobial exposure, duration of hospital stay, and SSI infections were evaluated using the Chi-squared test. Continuous variables such as pre-op hospital stay, and surgery duration were analysed using independent t-test.

3.4 Ethical Consideration

Ethical approval was obtained from the Institutional Ethical Review Committee (IREC) of the Masinde Muliro University of Science and Technology MMUST/IERC/176/2023 and the Kenya National Commission for Science, Technology, and Innovation NACOSTI/P/23/28712. Permission to conduct the study was also sought from the Kakamega County Hospital ethics committee (No. ERC/226-11/2023). Findings were presented anonymously, and measures were taken to minimize the risks of data breaches during information transmission. Written informed consent to participate in the study was obtained from the participants and guardians of minors (<18years) prior to enrolment into the study.

IV. FINDINGS & DISCUSSION

4.1 Patient demographics

In this study, a total of 128 (male, n=46 and female, n=82) patients attending Kakamega County General Hospital in the year 2023 were evaluated as summarized in **Table 1.** The median patient age, height and weight were 67 years (range 2-97), 152.7cm (range 111-172) and 61kg (range 47-72), respectively.

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Table 1. Characteristics of study participants

Characteristics	n =128 (%)	X^2	*P*
Gender			
Male	46 (36.0)	10.125	0.002
Female	82 (64.0)		
Age, yrs			
≤ 20	19 (14.8)		
21-40	45 (35.2)	0.007	0.998
41-60	35 (27.3)		
>60	29 (22.7)		
Wards			
Burns unit	2 (1.7)		
Female surgical	46 (35.9)		
ICU	6 (4.7)		
Male surgical	26 (20.3)		
Obs/gyn	15 (9.3)	-	-
Oncology	3 (2.3)		
Orthorpedic	6 (4.7)		
Pediatric	1 (0.8)		
Post-natal unit	21 (18.6)		
Renal unit	2 (1.7)		
Surgical sites			
Abdomen	32 (25.0)		
Cardiac	1 (0.8)		
Head	3 (2.3)		
Limb	30 (23.4)	-	-
Reproductive	50 (39.1)		
Respiratory	1 (0.8)		
Skeletal	4 (3.1)		
Skin	7 (5.5)		

The table shows the characteristics of participants who were positive for SSIs. It presents the patient characteristics as frequencies and percentages in brackets. Abbreviations: ICU-intensive care unit. *P*-values obtained from a Chi-square analysis of the categorical variables: gender, age, wards, and surgical sites.

In this study, there were 64.0% males (46 individuals) and 36.0% females (82 individuals) in terms of gender distribution. The chi-square value of 10.125 and a *P*-value of 0.002 in the statistical analysis suggest that the proportions of males and females are significantly different. The age distribution of the sample is as per the following: 14.8% of the population is under the age of 20, 35.2% are between the ages of 21 and 40, 27.3% are between the ages of 41 and 60, and 22.7% are over 60 years old. The chi-square test for age distribution produced a *P*-value of 0.998 and a Chi-square P-value of 0.007, indicating that the age distribution is not substantially different across the categories. The patients were admitted to a variety of wards. The female surgical ward was home to the majority, with 35.9% of patients. The male surgical ward followed, with 20.3% of patients. The post-natal unit (18.6%), obstetrics/gynaecology (9.3%), orthopaedic (4.7%), ICU (4.7%), oncology (2.3%), burns unit (1.7%), renal unit (1.7%), and paediatric (0.8%) were the other wards. The reproductive system was the most frequently reported surgical site, accounting for 39.1% of the total. The abdomen (25.0%) and extremities (23.4%) followed. The epidermis (5.5%), skeletal system (3.1%), head (2.3%), respiratory system (0.8%), and cardiac (0.8%) were the other surgical sites.

4.2 Recovery of Microbes from Surgical Wounds

Figure 1 presents data on the prevalence of bacteria isolated from surgical sites and the burden of individual microbes per gender. Panel A illustrates the prevalence of different bacteria isolated from surgical sites as a percentage of the total cases. The most prevalent bacterium is *Pseudomonas aeruginosa*, accounting for 38.9% of the isolates. Following this, Gram-negative rods represent 25.8% of the bacterial isolates. *Staphylococcus aureus* and *Klebsiella spp*. are also notable, with lower prevalence rates, while *Escherichia coli* and *Klebsiella oxytoca* are the least prevalent among the bacteria identified. Panel B depicts the frequency of individual microbes according to gender. The graph shows that both males and females are affected by similar types of bacteria, with *P. aeruginosa* being the most frequent in both genders. Gram-negative rods, *Staphylococcus aureus*, and *Klebsiella spp*. also have notable frequencies. The frequencies are represented by different colors for males (yellow) and females (red), with the height of the bars indicating the number of cases. The statistical analysis reveals no significant difference in microbial burden between males and

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females, as indicated by a *P*-value of 0.942. Overall, *P aeruginosa* is the most common bacterium isolated from surgical sites and that there is no significant difference in the distribution of bacterial infections between males and females.

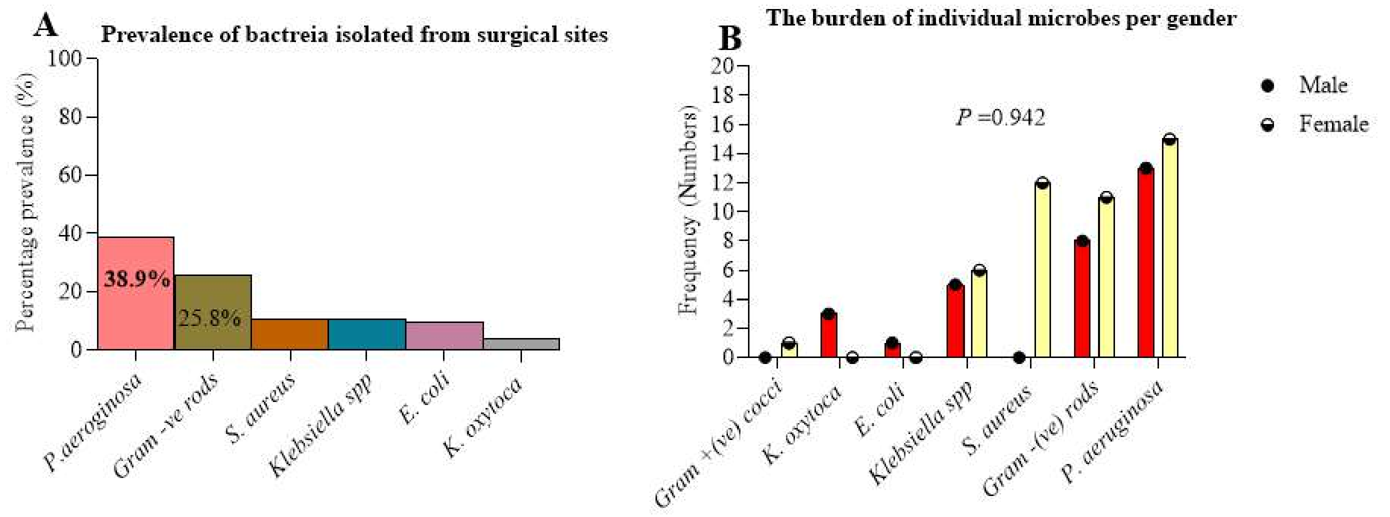

Figure 1
Bacterial Isolates from Surgical Site Infections. (A). The Prevalence of Bacteria Isolated from Surgical Site Infections. (B). The Burden of Individual Microbes per Gender

4.3 Incidence and risk factors

In this study, the incidence of surgical site infections (SSIs) was 66% (n=84), out of the sampled 128 patients. Statistical analyses showed that there was limited significant associations between risk factors and SSI occurrence. Obesity (41%) and diabetes (32%) were the common comorbidities among the pre-operative factors **(Table 2a)** but did not show any significant association with SSIs (p = 0.786 and p = 0.388 respectively) **(Table 2b).** Furthermore, smoking which was present among 17% of the patients showed no significant association with infection risk (p = 1.000). The mean operative hospital stay was approximately 5.2 days also with no significant difference between SSI and non-SSI (p= 0.718). For the intraoperative factors, the mean surgery duration was 104.4 minutes, with longer duration of surgery observed in the non-SSI group (114 minutes) against 101 minutes for the SSI group **(Table 2c).** However, there was no significant differences (p=0.116). Additionally, there was no significant association between the use of surgical drains (54%) with SSIs (p=0.828). Adherence to wound care and patient mobility were attributed to have an influence on SSIs incidence, among the post-operative factors. In this study, moreover, poor wound care was more prevalent in the SSIs, underscoring its role in the infections. These findings show that while intra-operative factors and comorbidities lead to the burden of SSIs, other important variables like post-operative undertakings may have a role in the onset of SSIs.

Table 2
Risk factors and association with the occurrence of SSIs

a. Overall proportions of risk factors			
Risk factor		**Prevalence (%)**	
Diabetes		32	
Obesity		41.4	
Smoking		17.2	
Use of drains		53.9	
b. Risk factors by SSI occurrence			
Risk Factor	**No SSI (%)**	**SSI present (%)**	**Chi-square**
Diabetes	35.1	30.8	$\chi^2 = 0.073$, p = 0.786 (no significant association with SSI occurrence).
Obesity	48.6	38.5	$\chi^2 = 0.744$, p = 0.388 (no significant association).
Smoking	16.2	17.6	$\chi^2 = 0.000$, p = 1.000 (no significant association)
Use of drains	56.8	52.7	$\chi^2 = 0.047$, p = 0.828 (no significant association).
c. Pre- Operative and Intra-operative factors by SSI occurrence			
Factor	**No SSIs (Mean)**	**SSI (Mean)**	**Independent t-Test)**
Pre-operative hospital stays	5.1	5.3	t = -0.362, p = 0.718 (no significant difference between SSI and non-SSI groups).
Surgery duration	113.8	100.5	t = 1.581, p = 0.116 (not statistically significant).

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4.4 Discussion

This study investigated the incidence and risk factors attributed to surgical site infections at the Kakamega general hospital while focusing on surgical site of patients, as well as post-operative factors. These findings highlight the key interplay on the aetiology of SSIs, between patients, procedures, and factors of the environments, in line with the development of SSIs. This study unravelled a high incidence of 66% which is consistent with available data on the incidence of SSIs from lower and middle-income countries (LMICs) of between 60-70%, owing to resource constraints which lead to crippled infection control programs (Haegdorens et al., 2019; Badia et al., 2020). As compared to high-income countries with rates of between 2% and 11% (Allegranzi et al., 2016), this incidence in this study is seen as significantly high. The difference seen here can highlight on the challenges that LMICs continue to face, which span from limited access to sterile surgical supplies to inadequate staffing, altogether contributing to poor implementation of infection control programs (IPCs).

In this study, obesity and diabetes were prominent among the comorbidities on patient-related factors. This is consistent with existing evidence that pairs these factors to prolonged wound healing (Kabir, 2022), but their weaker association with SSIs seen here may suggest the presence of other more “contextual” factors at play, such as the role of resource availability and perioperative care. Although smoking was only seen in a minority perhaps due to underreporting, its implications cannot be overlooked. Longer surgeries in this study correlated with fewer incidences of SSIs was an unexpected finding. The widely accepted concept is that prolonged operations may increase risk for developing infections (Hou et al., 2022). As seen here, however, the difference may draw from post-operative management practices, or the quality of surgery performed. Nevertheless, the strong correlations with SSIs seen in post-operative care of wounds and mobility in patients explains that poor care for wounds is a critical player in the onset of infections- in line with previous studies which underscored the need of maintaining sterility throughout the procedures (Ansari et al., 2019)

To address the high SSI burden seen here, it is prudent that IPCS are further strengthened, to improve on patient preparations to enhance post-operative care. Findings here expand on most of existing body of knowledge in sub-Saharan Africa, which continues to highlight on the importance of stringent infection control practices. However, key limitation here is the over-reliance on one study centre, which potentially limits generalisability of the data and reporting bias in such lifestyles as smoking. This can be a focus for future studies, to investigate larger centres to explore other factors such as socio-economic disparities and infrastructure, and their role in SSIs.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study begins to paint the picture of the burden of SSI in Western Kenya. It has outlined the incidence and risk factors attributed to the onset of SSIs in the Kakamega County hospital. It underscores the urgent need to tap into patient-centred interventions to reduce the SSIs in resource-constrained regions. By way of addressing the pre-operative comorbidities and strengthening pre- and post-operative patient management, the burden of SSI can be significantly reduced in sub-Saharan Africa.

5.2 Recommendation

Drawing from the high incidence rate of SSIs from this study, there is need for immediate targeted interventions to mitigate the rising post-surgical infections. Hospitals in the region should reinforce infection control programs through underscoring the need for wound care protocols like pre-operative skin preparation, and post-wound management. Further, antimicrobial stewardship program should be taught to the public to curb the rise in antibiotic resistance among the isolates recovered. There is also need for public health sector to address such modifiable risk factors as obesity, smoking and diabetes before any surgery. Further research, finally, should focus on cost-effective interventions for LMICs to curb long hospital stays and mortality rates.

ACKNOWLEDGEMENTS

We thank the Kakamega County General hospital for facilitating sample processing. All the co-authors are acknowledged for their contributions towards the manuscript.

FUNDING

This work was supported by Commonwealth Partnerships for Antimicrobial Stewardship – No. CwE.A15.

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AUTHOR CONTRIBUTION

Sarah Kindiki and **Sabella Kiprono** were involved in conceptualization of the study and methodology and writing the original manuscript draft. **Sarah Kindiki** was involved in the sample collection and all laboratory procedures. **Nicholas Mogoi** was involved in reviewing and editing the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Alfonso-Sanchez, J. L., Martinez, I. M., Martín-Moreno, J. M., González, R. S., & Botía, F. (2017). Analyzing the risk factors influencing surgical site infections: the site of environmental factors. *Canadian Journal of Surgery*, *60*(3), 155–161. https://doi.org/10.1503/cjs.017916

Allegranzi, B., Aiken, A. M., Kubilay, N. Z., Nthumba, P., Barasa, J., Okumu, G., Mugarura, R., Elobu, A., Jombwe, J., Maimbo, M., Musowoya, J., Gayet-Ageron, A., & Berenholtz, S. M. (2018). A multimodal infection control and patient safety intervention to reduce surgical site infections in Africa: a multicentre, before–after, cohort study. *The Lancet Infectious Diseases*, *18*(5), 507–515. https://doi.org/10.1016/s1473-3099(18)30107-5

Allegranzi, B., Bischoff, P., De Jonge, S., Kubilay, N. Z., Zayed, B., Gomes, S. M., Abbas, M., Atema, J. J., Gans, S., Van Rijen, M., Boermeester, M. A., Egger, M., Kluytmans, J., Pittet, D., & Solomkin, J. S. (2016). New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. *The Lancet Infectious Diseases*, *16*(12), e276–e287. https://doi.org/10.1016/s1473-3099(16)30398-x

Allegranzi, B., Nejad, S. B., Combescure, C., Graafmans, W., Attar, H., Donaldson, L., & Pittet, D. (2010). Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. *The Lancet*, *377*(9761), 228–241. https://doi.org/10.1016/s0140-6736(10)61458-4

Alverdy, J. C., Hyman, N., & Gilbert, J. (2020). Re-examining causes of surgical site infections following elective surgery in the era of asepsis. *The Lancet Infectious Diseases*, *20*(3), e38–e43. https://doi.org/10.1016/s1473-3099(19)30756-x

Ansari, S., Hassan, M., Barry, H. D., Bhatti, T. A., Hussain, S. Z. M., Jabeen, S., & Fareed, S. (2019). Risk Factors Associated with Surgical Site Infections: A Retrospective Report from a Developing Country. *Cureus*. https://doi.org/10.7759/cureus.4801

Badia, J. M., Pérez, I. R., Manuel, A., Membrilla, E., Ruiz-Tovar, J., Muñoz-Casares, C., Arias-Díaz, J., Jimeno, J., Guirao, X., & Balibrea, J. M. (2020). Medidas de prevención de la infección de localización quirúrgica en cirugía general. Documento de posicionamiento de la Sección de Infección Quirúrgica de la Asociación Española de Cirujanos. *Cirugía Española*, *98*(4), 187–203. https://doi.org/10.1016/j.ciresp.2019.11.010

Bucataru, A., Balasoiu, M., Ghenea, A. E., Zlatian, O. M., Vulcanescu, D. D., Horhat, F. G., Bagiu, I. C., Sorop, V. B., Sorop, M. I., Oprisoni, A., Boeriu, E., & Mogoanta, S. S. (2023). Factors contributing to surgical site infections: A Comprehensive Systematic review of etiology and risk factors. *Clinics and Practice*, *14*(1), 52–68. https://doi.org/10.3390/clinpract14010006

CDC. (2025). Surgical Site Infection Event (SSI). In *January 2025 Procedure-associated Module SSI Events* (pp. 9–1). https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf

Cooper, R. A. (2013). Surgical site infections: epidemiology and microbiological aspects in trauma and orthopaedic surgery. *International Wound Journal*, *10*(s1), 3–8. https://doi.org/10.1111/iwj.12179

Damonti, L., Atkinson, A., Fontannaz, L., Burnham, J., Jent, P., Troillet, N., Widmer, A., & Marschall, J. (2023). Influence of environmental temperature and heatwaves on surgical site infection after hip and knee arthroplasty: a nationwide study. *Journal of Hospital Infection*, *13*(5), 125–131. https://doi.org/10.1016/j.jhin.2023.03.014

Duran, A., Gülay, H., & Terzi, M. C. (2024). Risk factors in surgical site infections. *Surgical Science*, *15*(02), 64–80. https://doi.org/10.4236/ss.2024.152008

Ezugwu, N. V., Gayle, A., & Anyamene, C. (2024). Epidemiology of Antimicrobial Resistance and the WASH Project: Averting a Potential public health crisis in Nigeria using the United Kingdom as a case study. *International Journal of TROPICAL DISEASE & Health*, *45*(6), 87–104. https://doi.org/10.9734/ijtdh/2024/v45i61542

Haegdorens, F., Van Bogaert, P., De Meester, K., & Monsieurs, K. G. (2019). The impact of nurse staffing levels and nurse's education on patient mortality in medical and surgical wards: an observational multicentre study. *BMC Health Services Research*, *19*(1). https://doi.org/10.1186/s12913-019-4688-7

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Hou, Y., Collinsworth, A., Hasa, F., & Griffin, L. (2022). Incidence and impact of surgical site infections on length of stay and cost of care for patients undergoing open procedures. *Surgery Open Science*, *11*, 1–18. https://doi.org/10.1016/j.sopen.2022.10.004

Iskandar, K., Molinier, L., Hallit, S., Sartelli, M., Hardcastle, T. C., Haque, M., Lugova, H., Dhingra, S., Sharma, P., Islam, S., Mohammed, I., Mohamed, I. N., Hanna, P. A., Hajj, S. E., Jamaluddin, N. a. H., Salameh, P., & Roques, C. (2021). Surveillance of antimicrobial resistance in low- and middle-income countries: a scattered picture. *Antimicrobial Resistance and Infection Control*, *10*(1), 13-17. https://doi.org/10.1186/s13756-021-00931-w

Kabir, C. M. N. (2022, October 21). *Surgical site infection: impacts and challenges of antibiotic rationalism*. Abstract. https://www.pulsus.com/abstract/surgical-site-infection-impacts-and-challenges-of-antibiotic-rationalism-11242.html

Kenya National Bureau of Statistics & The National Treasury and Planning. (n.d.). *Kenya National Bureau of Statistics*. https://www.knbs.or.ke/wp-content/uploads/2023/09/2019-Kenya-population-and-Housing-Census-Analytical-Report-on-Population-Dynamics.pdf

Magalhães, J. M., Zambelli, R., Oliveira-Júnior, O., Avelar, N. C. P., Polese, J. C., & Leopoldino, A. A. (2024). Incidence and associated factors of surgical site infection in patients undergoing foot and ankle surgery: a 7-year cohort study. *The Foot*, *59*, 102092. https://doi.org/10.1016/j.foot.2024.102092

Mogoi, N. N., Sifuna, A. W., Okoth, P. K., Reva, O., Malaba, R., Negesa, R., Nyongesa, K. P., Osoro, K. E., & Welch, M. (2024). Staphylococcus aureus associated with surgical site infections in Western Kenya reveals genomic hotspots for pathogen evolution. *Access Microbiology*, *6*(6). https://doi.org/10.1099/acmi.0.000734.v4

Nejad, S. B., Allegranzi, B., Syed, S., Ellis, B., & Pittet, D. (2011). Health-care-associated infection in Africa: a systematic review. *Bulletin of the World Health Organization*, *89*(10), 757–765. https://doi.org/10.2471/blt.11.088179

Pal, S., Sayana, A., Joshi, A., & Juyal, D. (2019). Staphylococcus aureus: A predominant cause of surgical site infections in a rural healthcare setup of Uttarakhand. *Journal of Family Medicine and Primary Care*, *8*(11), 3600. https://doi.org/10.4103/jfmpc.jfmpc_521_19

Saeedinia, S., Nouri, M., Azarhomayoun, A., Hanif, H., Mortazavi, A., Bahramian, P., Yarandi, K. K., & Amirjamshidi, A. (2015). The incidence and risk factors for surgical site infection after clean spinal operations: A prospective cohort study and review of the literature. *Surgical Neurology International*, *6*(1), 154. https://doi.org/10.4103/2152-7806.166194

Seidelman, J. L., Mantyh, C. R., & Anderson, D. J. (2023). Surgical site infection prevention. *JAMA*, *329*(3), 244. https://doi.org/10.1001/jama.2022.24075

Temu, T. M., Macharia, P., Mtui, J., Mwangi, M., Ngungi, P. W., Wanjalla, C., Bloomfield, G. S., Farquhar, C., Nyanjau, L., Gathecha, G. K., & Kibachio, J. (2021). Obesity and risk for hypertension and diabetes among Kenyan adults. *Medicine*, *100*(40), e27484. https://doi.org/10.1097/md.0000000000027484

Tessy, A., Awandu, S. S., Ochung, A., Mudibo, E. O., & Ayodo, G. (2024). Factors associated with hospitalisation among diabetes patients in Western Kenya. *African Journal of Health Sciences*, *37*(1), 65–75. https://doi.org/10.4314/ajhs.v37i1.7

Van Seventer, J. M., & Hochberg, N. S. (2016). Principles of infectious diseases: transmission, diagnosis, prevention, and control. In *Elsevier eBooks* (pp. 22–39). https://doi.org/10.1016/b978-0-12-803678-5.00516-6

World Health Organization: WHO. (2023, November 21). *Antimicrobial resistance*. https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

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