South Afr J Anaesth Analg. 2023;29(5):171-177
https://doi.org/10.36303/SAJAA.2958

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173

ORIGINAL RESEARCH

Knowledge and practice of surgical antimicrobial prophylaxis at a tertiary academic hospital in a low-middle income country

YC Yu, C Steadman, S Chetty

Department of Anaesthesiology and Critical Care, Faculty of Medicine and Health Sciences, Stellenbosch University, South Africa
Corresponding author, email: *yun.chi.yu@gmail.com*

Introduction: Surgical site infections (SSI) remain a leading cause of hospital-acquired infections globally. Despite proven efficacy of surgical antimicrobial prophylaxis (SAP) in the reduction of SSI, adherence to SAP guidelines is inconsistent.

Methods: A single centre cross-sectional survey study was conducted using a peer-reviewed questionnaire to assess the knowledge, practice and awareness of SAP guidelines among perioperative clinicians at a tertiary hospital in South Africa.

Results: Of the 273 invitations sent, 153 responses were completed for analysis. The mean (SD) knowledge score was 72.5% (8.1) but knowledge on dosage, timing and redosing was poor. SAP practices among participants were adequate, except for procedures that are controversial or require complex antimicrobial cover. Registrars and specialists scored significantly higher mean knowledge scores compared to medical officers. There was no statistically significant difference in the mean knowledge scores of different disciplines. Only 50% of participants reported using a SAP guideline. More than 80% of the participants agreed that their practice would improve if guidelines were readily accessible in the operating theatre and if an effective SSI surveillance system was in place.

Conclusion: This study demonstrates that the overall SAP knowledge and practice was fair, but core principles such as dosing, timing and duration of SAP were inadequate and need urgent attention. We recommend that through a multidisciplinary collaborative effort, a recognised guideline should be adapted and introduced, and awareness of correct SAP practices promoted at Tygerberg Hospital. Furthermore, the introduction of a surveillance system will help improve the quality of surgical care.

Keywords: surgical site infection, antimicrobial prophylaxis, antibiotic prophylaxis, knowledge, practice, perioperative, infection control

Introduction

Despite modern advances in disinfection techniques, equipment and environmental control measures, surgical site infections (SSI) remain one of the most preventable yet frequent hospital-acquired infections (HAI).[1] HAI have significant implications for both the patients and the health sector. SSI are associated with a two- to elevenfold increase in mortality, prolonged hospital stay, repeated procedures, prolonged recovery period, increased intensive care admissions and loss of earnings during period of illness.[2] It is estimated that HAI can double hospital costs, owing to longer hospital stays, more diagnostic testing and increased treatment costs.[1]

The global guidelines for the prevention of SSI by the World Health Organization (WHO) require a multidisciplinary effort from the ward staff, perioperative physicians and operational managers. Strategies include, but are not limited to, surgical antimicrobial prophylaxis (SAP); mitigation of risk factors (such as smoking cessation and addressing malnutrition); preoperative bathing; antiseptic surgical site preparation and surgical hand scrubbing; and maintenance of glucose control and normothermia perioperatively.[3] These simple interventions are estimated to prevent up to 60% of SSI.[3] The selection of SAP antimicrobial cover should be based on the procedure the patient is undergoing, previous culture results and known allergies.[4,5] Published local and international guidelines of SAP for specific procedures are readily available, but adherence can vary from 40–90% across disciplines and among different regions and institutions.[6-9] Only a few studies have assessed the awareness, knowledge and practice of SAP guidelines among surgeons and/or anaesthesiologists, of which only one was conducted in South Africa. Most of these studies concluded that the knowledge and practice of SAP were inadequate.

The primary objectives of this study were to compare the knowledge and practice of perioperative clinicians at a South African tertiary academic hospital to local and international SAP guidelines; and to determine the clinicians' awareness of the available guidelines. The secondary objectives were to evaluate the relationships between (i) the grade of employment, (ii) professional experience and (iii) field of work versus knowledge of SAP.

Methods

Study setting and design

A cross-sectional survey study was conducted at Tygerberg Hospital, a tertiary academic hospital in South Africa, over a six-week period. The study population consisted of independent medical practitioners from perioperative disciplines at Tygerberg Hospital. This included medical officers, registrars and specialists working in the departments of Anaesthesiology and Critical Care, and Obstetrics and Gynaecology; as well as the divisions of Otorhinolaryngology, General Surgery, Orthopaedic Surgery and Urology. Perioperative disciplines with less than ten members of

staff, the divisions of Cardiothoracic Surgery, Ophthalmology, and Plastic and Reconstructive Surgery were excluded from the study owing to the potential risk of personal identification. Interns and locum doctors were also excluded as the former are doctors-in-training working under supervision and the latter are temporary staff and do not have any academic obligations. The Urology division declined participation in this study.

Data collection tool

A face-validated questionnaire tool, developed by the principal investigator following an extensive literature review, was used for data capturing. The peer-review validation panel consisted of two specialist anaesthesiologists, a sub-specialist intensivist with an interest in antimicrobials and a senior biostatistician. The questionnaire consisted of four sections, namely: demographics, knowledge, practice, and awareness of surgical antimicrobial prophylaxis guidelines. The spectrum of antimicrobial cover, timing of SAP, and antimicrobial dosing and redosing interval times were examined using 12 checkbox questions, which were combined into a composite knowledge score out of 51 and represented as a percentage. Practice was evaluated using a series of multiple-choice questions and Likert scale items. Participants were asked to indicate their antimicrobial of choice for surgical procedures relevant to their disciplines from a prepopulated list of antimicrobials. The local South African Society of Anaesthesiologists (SASA) surgical antimicrobial prophylaxis guidelines and the American Society of Health-System Pharmacists (ASHP) international guidelines were used as the memorandum for the knowledge and practice sections of the questionnaire.[4,5]

Email databases were obtained with permission from relevant authorities. Questionnaires were distributed via email and captured using the secure, web-based software REDCap electronic data capture tool hosted at Stellenbosch University. Convenience sampling was used and a response rate of 60% was targeted. Weekly reminders as well as a prize draw with completed questionnaires were used as incentives to reduce non-response bias.

Statistical analysis

Data was analysed in IBM® SPSS® version 27 (IBM Corp., USA) using methods of descriptive statistics for the primary objectives and analytical statistics for the secondary objectives. Categorical data was reported as frequencies and percentages, and quantitative variables as means, standard deviation and range. In addition, SAP knowledge was assessed using a cumulative score represented as a percentage. Likert scale items in the practice section were analysed as ordinal discreet variables. Statistical testing was carried out at a 0.05 level of significance for the secondary objectives. One-way ANOVA test with Bonferroni adjusted post-hoc tests were used to examine the association of grade of employment and the knowledge scores. Relationship between years of experience and cumulative knowledge scores was assessed using the Spearman's rank correlation. Independent sample t-tests were used to compare mean knowledge scores between different surgical disciplines and anaesthesiology.

Results

The study recruitment flow diagram is represented in Figure 1. The complete analysed response rate was 57.3% (153/267). The demographics of the study participants can be found in Table I and II.

Knowledge

Overall, the mean (SD) knowledge score of participants was 72.5% (8.1). Of the 153 questionnaires analysed, 86% selected the correct dose of amoxicillin-clavulanate for weight, 56% for cefazolin and 49% for clindamycin. The percentage of participants who selected the correct timing for cefazolin and vancomycin prior to surgical incision were 54% and 20.3%, respectively. Of the participants, 88% recognised that a surgery duration of more than four hours was an indication for redosing of cefazolin while only 38% recognised the indication of perioperative blood loss equal to or more than 1.5 litres.

The mean (SD) knowledge scores are tabulated against demographic data in Table I. The mean knowledge score for anaesthesiologists compared to surgeons was 74 (7.4) to 71.2 (8.5) ($p = 0.068$). The one-way ANOVA test showed a statistically significant difference among the mean percentage knowledge scores of the various disciplines ($p = 0.027$). However, the post-hoc Bonferroni test failed to show any adjusted statistical significance in pair-wise comparisons between individual disciplines. The same statistical testing was repeated for the mean percentage knowledge scores and grade of employment. Both the specialist group and the registrar group scored statistically significantly higher mean percentage knowledge scores compared to the medical officer group (both $p = 0.001$). However, there were no mean knowledge score differences between registrars and specialist groups ($p = 0.974$). A Spearman's rank test was used to determine the correlation between mean knowledge score

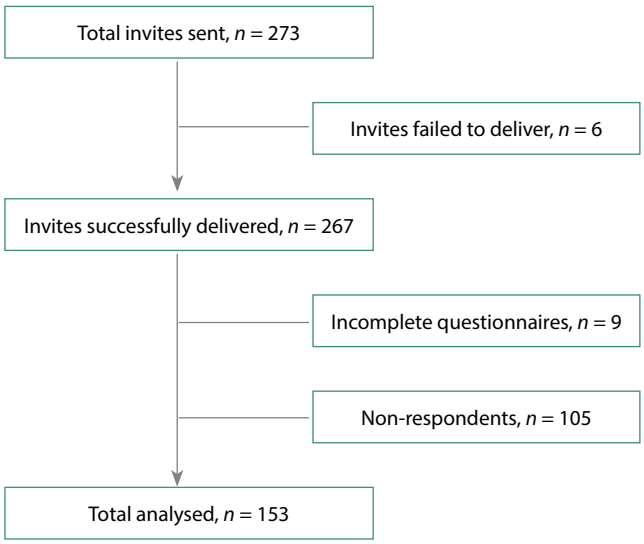

Figure 1: Flow diagram of analysed responses

Table I: Demographic characteristics of participants and mean knowledge score

Demographic	*n* (%) or mean (SD)	Mean knowledge score % (SD)	Range	
			Min	Max
Age (years)	35.0 (5.0)			
Disciplines				
Anaesthesiology	78/153 (51)	73.6 (7.4)	54.9	88.2
ENT	6/153 (3.9)	77.5 (6.3)	66.7	86.3
General surgery	19/153 (12.4)	73.5 (6.0)	60.8	84.3
Obstetrics & gynaecology	29/153 (19)	69.0 (9.2)	52.9	84.3
Orthopaedic surgery	21/153 (13.7)	70.6 (9.3)	52.9	82.4
Years of experience in discipline				
Anaesthesiology	7.4 (4.8)			
ENT	5.17 (2.64)			
General surgery	6.3 (2.7)			
Obstetrics & gynaecology	6.0 (2.7)			
Orthopaedic surgery	8.2 (4.8)			
Grade of employment				
Medical officer	10/153 (6.5)	63.5 (7.11)	52.9	74.5
Registrar	105/153 (68.6)	72.7 (7.94)	52.9	88.2
Specialist	38/153 (24.8)	74.15 (7.35)	58.8	88.2

ENT – ear, nose and throat; SD – standard deviation

Table II: Demographic characteristics of registrars

Demographic	Mean (SD)
Years in registrar post	
Anaesthesiology	2.22 (1.1)
ENT	2.4 (1.3)
General surgery	2.76 (1.5)
Obstetrics & gynaecology	2.76 (1.1)
Orthopaedic surgery	3.0 (1.1)
Completed part 1 examination	
Yes	85/115 (73.9)
No	26/115 (22.6)
Not applicable	4/115 (3.5)
Completed intermediate examination	
Yes	34/115 (29.6)
No	24/115 (20.9)
Not applicable	57/115 (49.6)
Completed ICU rotation during registrar training	
Yes	77/115 (67)
No	34/115 (29.6)
Not applicable	4/115 (3.5)
Completed final examination	
Yes	9/115 (7.8)
No	105/115 (91.3)
Not applicable	1/115 (0.9)

ENT – ear, nose and throat; ICU – intensive care unit; SD – standard deviation

Table III: Breakdown of knowledge score

Components	Mean score % (SD)
Spectrum	
Gram positive	77.2 (11.8)
Gram negative	70.3 (16.1)
MRSA	82.7 (11.5)
Anaerobic	77.1 (13.4)
Timing (first dose and redose)	31.4 (29.7)
Dosage	62.0 (14.6)
Overall knowledge score	72.46 (8.1)

MRSA – methicillin resistant *Staphylococcus aureus;* SD – standard deviation

percentage and years of experience. It revealed a weak positive correlation with a correlation coefficient of 0.18 ($p = 0.027$).

Practice

The percentage of participants who selected the correct antimicrobial spectrum according to the SASA infection control guidelines and the ASHP guidelines are illustrated in Figure 2. Procedures with the highest correct SAP spectrum were caesarean section, arthroplasty, orthopaedic surgery with implants and spine surgery. In contrast, the most incorrect were arthroscopy, lower limb amputation, endoscopic stone fragmentation and transrectal prostate biopsy.

Factors that may either hinder or enable SAP practice is illustrated in Figure 3. The majority of participants (97.4%) agreed that they administer SAP to prevent SSI. Seven participants (0.04%) believed that there is little supporting evidence. Fear of anaphylaxis and time constraints in theatre did not prevent participants from administering SAP. Approximately 80% of participants agreed that their practice would improve if guidelines were readily accessible in theatre and if an effective SSI surveillance system was in place.

Awareness of guidelines

Of the 153 participants, 76 (49.7%) reported following a published guideline in their practice. Participants were permitted to select multiple guidelines they follow in their practice.

Twenty-five participants reported using the South African Antibiotic Stewardship Programme (SAASP) pocket guide to antibiotic prescribing, 21 reported using the Western Cape academic hospital antimicrobial recommendation by the National Health Laboratory Service (NHLS), while 20 reported using the SASA guidelines, 19 used the WHO global guideline, 9 selected other and only 2 used ASHP therapeutic guideline in their practice. When unsure of a drug dosage, 98 (64.1%) participants reported using mobile phone applications like Medscape, 73 (47.7%) use internet search engines such as

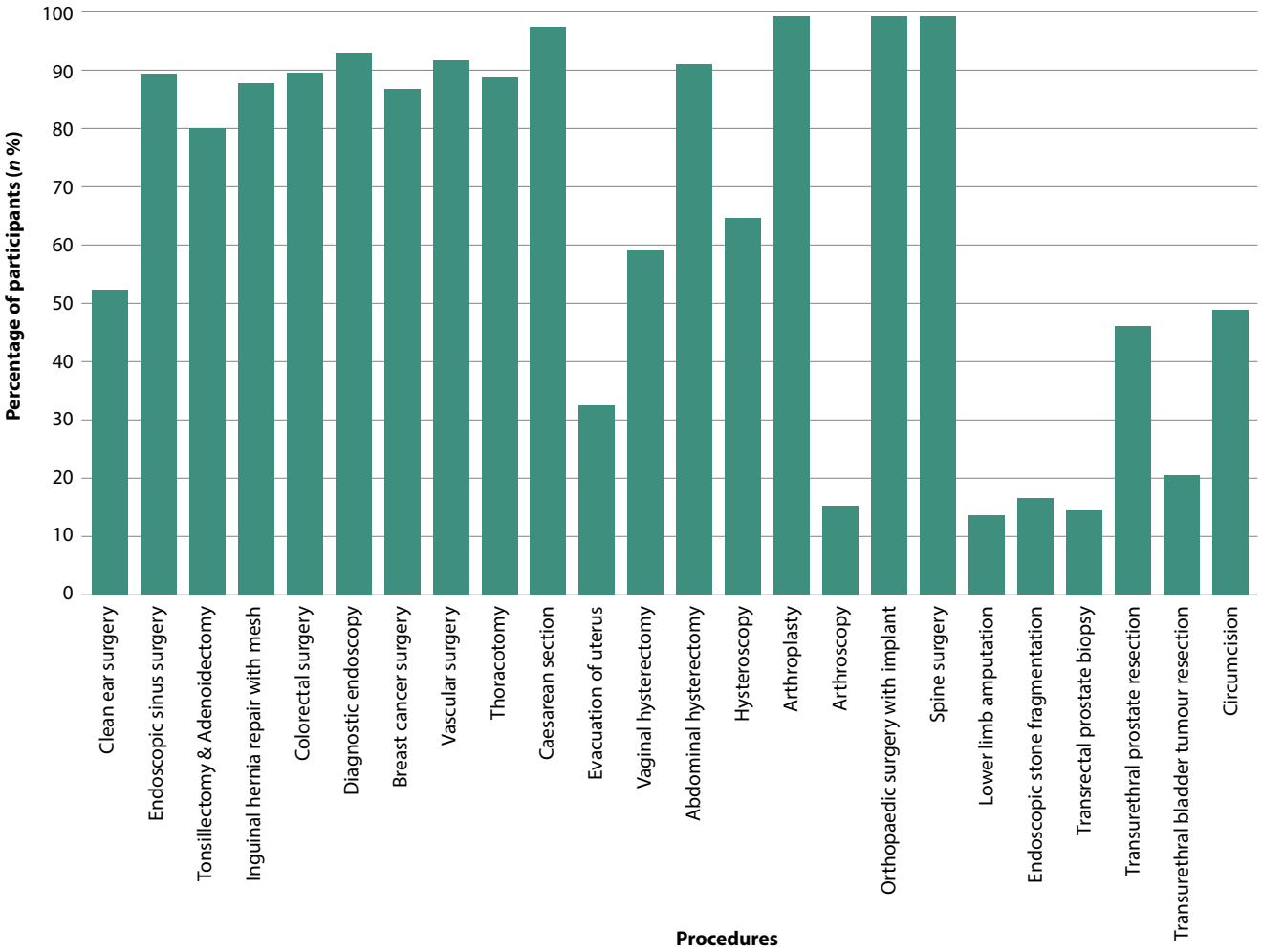

Figure 2: Percentage of participants selecting the correct SAP spectrum for various surgical procedures

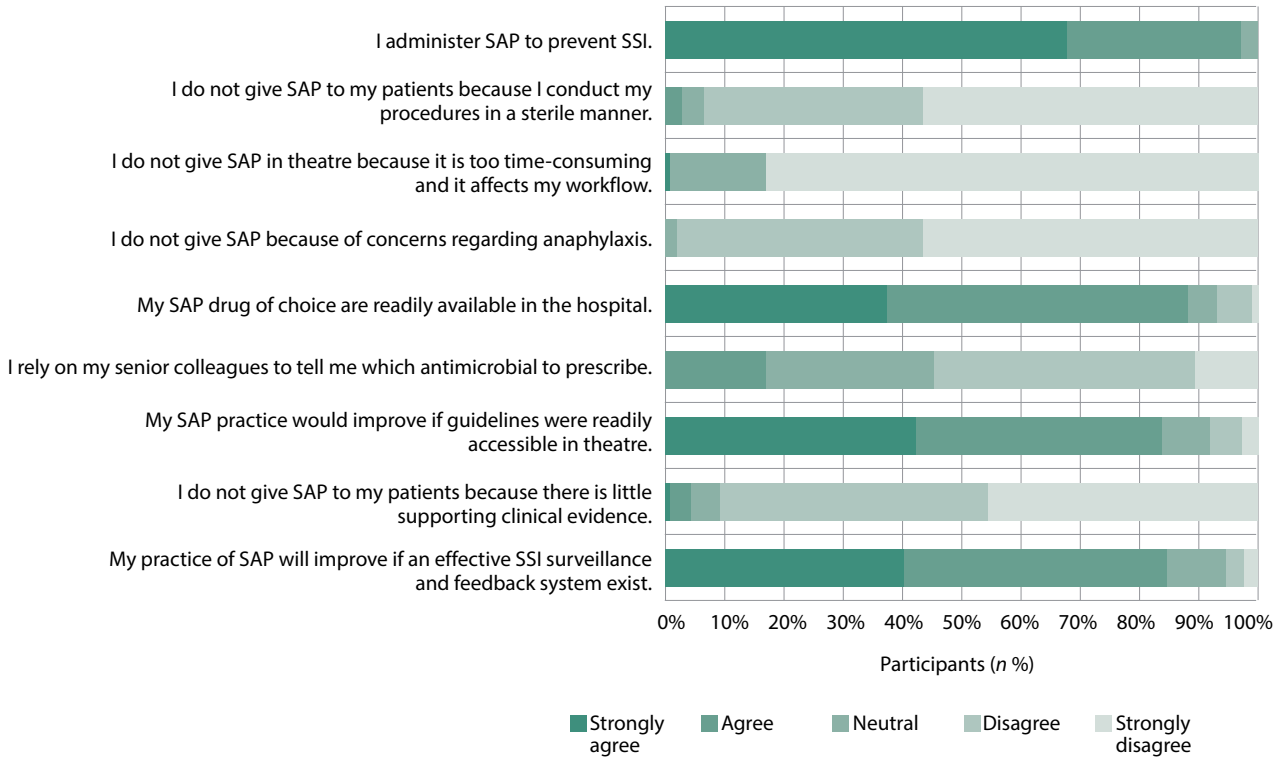

Figure 3: Practice of SAP: barriers and enablers

Google, 61 (39.7%) use the South African Medicines Formulary (SAMF) and 45 (29.4%) would ask a colleague.

Discussion

The aim of this study was to review the knowledge and practice of SAP at Tygerberg Hospital in comparison to local and international guidelines. The mean (SD) SAP knowledge score of anaesthesiologists and surgeons was 72.5% (8.1). Questions on SAP dosage, timing of first dose and redosing intervals were answered poorly. SAP practice for orthopaedic and general surgical procedures were satisfactory but substandard for urological and gynaecological procedures. Specialists and registrars scored statistically significantly better on SAP knowledge than medical officers. There was no statistically significant difference in mean knowledge scores between different perioperative disciplines. Only half of the participants reported using a SAP guideline in their practice.

Approximately half of the study sample (51%) comprised of anaesthesiologists and 49% of surgeons. The Department of Anaesthesiology was the largest discipline in the study. Ear, nose and throat (ENT) was the smallest discipline in this study and represented 3.9% of the study sample. The mean SAP knowledge scores of anaesthesiologists and surgeons ranged from 69–77% which was adequate but has scope for improvement. A number of survey studies have found that the overall knowledge of SAP in medical practitioners was poor.[10-12] Jocum et al.[10] demonstrated that the timing of less frequently used antimicrobials such as vancomycin and fluoroquinolones, redosing intervals and duration of prophylaxis were inadequate which was in keeping with our findings. Our study also found that participants were unfamiliar with antimicrobial dosage based on weight, but comparatively had a good knowledge on the spectrum of antimicrobial.[10]

The knowledge results for the commonly used SAP agent, cefazolin, was poor. Cefazolin is a first-generation cephalosporin with good activity against methicillin susceptible gram-positive *Staphylococcus aureus* (MSSA). MSSA is responsible for 20–26% of SSI, thus inappropriate knowledge of this antimicrobial will potentially lead to an increase in SSI and patient morbidity.[2,13,14] Only 56% and 54% of the participants selected its correct dosage for weight and timing prior to surgical incision, respectively. Vancomycin, another antimicrobial with excellent gram-positive cover, as well as activity against methicillin resistant *Staphylococcus aureus* (MRSA), were poorly known by participants in this study. An explanation may be that vancomycin is more commonly used in intensive care units (ICU) to treat gram-positive and MRSA infection, thus the perioperative practitioners are less familiar with it. It is, however, important that practitioners are acquainted with this antimicrobial as MRSA colonisation can be associated with a ninefold increase in MRSA SSI and should be covered for appropriately during the perioperative period.[15]

Most participants were aware that cefazolin requires redosing four hours into the surgery but were unaware that redosing is also required in cases where blood loss exceeds 1.5 litres. In a level 1 trauma centre like Tygerberg Hospital, perioperative bleeding during emergency surgery requiring transfusions is common. Ignorance of these redosing recommendations according to the half-life of the selected antimicrobial could further potentiate the risk of SSI in an already at-risk group of patients, with other contributary factors being a high American Society of Anaesthesiologists (ASA) risk classification, emergency surgery, or dirty, infected or contaminated wounds and other comorbidities.[16]

Infection control is a fundamental principle in the enhanced recovery after surgery (ERAS) pathway, therefore it is not unexpected that both registrars and specialists scored statistically better in mean knowledge scores compared to medical officers as they have likely encountered SAP in their preparation for the specialist examinations. Contrary to expectation, our study showed that more years of experience did not necessarily equate to better SAP knowledge and vice versa. There was only a low degree of correlation ($r = 0.18$) between the two. This was in keeping with findings from similar research projects. A local South African study found no statistically significant difference in knowledge scores between anaesthesiologists with five years or more experience versus those with less than five years of experience.[10] On the other hand, Khan et al.[12] noted that more experienced surgeons had a poorer knowledge of SAP than junior surgeons. This was attributed to the teaching of junior doctors taking precedence over that of senior doctors.[12] Another possible explanation may be that junior doctors who lack experience may have more interest in keeping up with the latest recommendations. There were no statistical differences between the mean knowledge scores of the various disciplines or between anaesthesiologists and surgeons.

We found that the SAP practice for general surgery and orthopaedic procedures were the most consistent with the benchmark guidelines. The antimicrobial spectrum for these procedures were relatively simple and frequently only required gram-positive cover. In contrast, SAP for urological and gynaecological procedures is more controversial due to the mixture of gram-positive, gram-negative and anaerobic flora.[17-20] Patients with indwelling urinary catheters may also have urinary tract infection (UTI) which may further complicate the choice of antimicrobial.

Clean urological surgery often require no (or simple) SAP cover, whereas procedures involving instrumentation of the urinary tract such as transurethral resection of bladder tumour (TURBT) and transurethral resection of prostate (TURP) or urinary division with bowel involvement are associated with a higher risk of bacteriuria, bacteraemia and symptomatic UTI.[4,21,22] Although SAP significantly reduces postoperative bacteriuria, there are inconsistencies in the recommended SAP regimens across the literature.[22] Because the Department of Urology declined the invitation to participate, our results were a direct representation of the anaesthesiologists' lack of SAP knowledge on urological procedures. It is unclear whether this result would directly lead to poor clinical practice at the institution as the SAP decision

rests with both the surgeon and the anaesthesiologist as part of the multidisciplinary team. A recent South African SAP audit at a similar tertiary academic institution found that there is an alarming 54% non-adherence rate to SAP guidelines in urological procedures.[7] To this author's knowledge, Schuster et al.[7] were the first to publish a prospective audit on SAP practice in South Africa. This demonstrates the paucity of data in South Africa. Efforts should be made to ensure SAP practice is audited and guarantee that our practice is on par with international standards. Barriers to adherence should also be addressed.

We further found that participants opted for SAP in clean procedures when it is not indicated. Approximately 85% of participants opted for cefazolin as their choice of SAP for knee arthroscopies which is out of keeping with current recommendations by the ASHP and SASA guidelines.[4,21] SAP for arthroscopic surgery has become controversial with its evolvement from a diagnostic tool to a treatment modality due to technological advances. It has been suggested that SAP should be considered in the case of long operating duration; when implants such as sutures and screws are used; and in high risk patients.[20] Nearly all participants agreed that they use SAP to prevent SSI. Factors hindering the use of SAP in other studies such as time limitation, work flow and sterility, and fear of anaphylaxis did not appear to be barriers in our study.[12,23] Despite South Africa being a low- and middle-income country, it was reassuring that 89% of participants reported that their antimicrobial of choice is readily available at Tygerberg Hospital. Resource constraints did not appear to affect the SAP practice in our setting.

The use of clinical guidelines has been shown to not only standardise our practice, but also improve quality of patient care.[24] Lack of awareness of guidelines as well as lack of guideline content are the two major contributors to guideline non-adherence.[23] Therefore, it is concerning that only half of the participants reported using an SAP guideline in their practice, as awareness of a guideline increases the odds of compliance by fourfold.[6] Most participants reported using the pocket guideline to antibiotics prescribing and the Western Cape Academic Hospitals Antimicrobial Recommendations. Both of these are simple guidelines with limited or no SAP recommendations and are unsuitable to serve as guidelines in a tertiary academic hospital.[25,26]

The previous SASA Infection Control guidelines, published in 2014, showed similar shortcomings, but the issue has largely been resolved with its latest update.[27] The SAP guideline in the 2021 document is comprehensive and was adopted from the French Society of Anaesthesia and Intensive Care Medicine (SFAR).[4] Adaptation of this guideline to the South African setting, considering factors such as cost, preference, drug availability, infection trends and antimicrobial resistance in local institution, is important. However, this is unattainable without a good national surveillance programme like that of the American College of Surgeons (National Surgical Quality Improvement Program) or the Centers for Disease Control and Prevention (National Healthcare Safety Network) to monitor the SSI trends of local facilities.

Study strengths and limitations

Following on from the study by Jocum et al.,[10] this study provides further insight into the South African SAP practice in a tertiary hospital setting. It has identified knowledge gaps in our everyday practice which allows for quality improvement projects in the future. Although the generalisability of this study to other tertiary centres may be limited due to the exclusion of small subspecialties and the non-participation of the Urology division, the results are likely still generalisable to secondary hospitals.

The exclusion of smaller subspecialties was intended to protect individual identity, but this may have led to sampling bias. Furthermore, the participants were a self-selected group of individuals with an interest in SAP. This leads to self-selection bias and may lead to falsely elevated knowledge scores. Although a modest response rate of 57% was achieved, non-response bias should be considered when interpreting results. This study examined self-reported knowledge and practice of SAP, and may not truly reflect adherence to SAP guidelines. Although the use of a composite scoring system allows for quantification of knowledge, facilitates data analysis and allows for easy comparison between studies, all components of the score are integral to best practice and impact on patient outcome and antimicrobial resistance (AMR). The composite mean knowledge scores should be interpreted with the breakdown to avoid false reassurance of SAP knowledge.

Conclusion

This study demonstrates that the overall knowledge of SAP is fair, but knowledge on the key components of SAP principles such as dosing, timing and duration were largely inadequate and warrants urgent attention and intervention. Reported SAP practices were mostly appropriate for general surgery and orthopaedic procedures but suboptimal for urological and gynaecological procedures. It is evident from our study that awareness of both national and international guidelines is poor.

It remains a major problem that our institution does not have SAP guidelines. An institution endorsed guideline should be introduced as a matter of urgency, as well as interventions to improve SAP knowledge, practice and awareness. Ideally, a collaborated effort will be launched by the departments of Infectious Disease, Microbiology, Anaesthesiology, Obstetrics and Gynaecology, and all surgical divisions. Furthermore, we recommend that the undergraduate and postgraduate programmes should continue to place an emphasis on the importance of SSI prevention. A reliable surveillance system for incidence of SSI on a national level should also be introduced to improve the quality of surgical care provided to our patients. Future studies at non-academic hospitals as well as in the private sector will provide further information regarding SAP practices in South Africa.

Acknowledgements

We acknowledge Ms Tonya Esterhuizen (Department of Epidemiology and Biostatistics, Stellenbosch University) for her assistance with the data analysis. We acknowledge research funding from the Jan Pretorius Fund of the South African Society of Anaesthesiologists. The research for this study was done in partial fulfilment of the requirements for the MMed (Anaes) degree at Stellenbosch University (YY).

Conflict of interest

The authors declare no conflict of interest.

Funding source

The three gift vouchers for the lucky draw was sponsored from the Jan Pretorius Fund.

Ethical approval

Ethical approval was obtained from the Human Research Ethics Committee of Stellenbosch University (Reference number S20/05/127). Participation was voluntary and all participants provided informed electronic consent. All data was anonymised to ensure privacy and confidentiality of participants' personal information.

ORCID

YC Yu https://orcid.org/0000-0003-0033-8629

S Chetty https://orcid.org/0000-0002-9878-5488

References

1. Badia JM, Casey AL, Petrosillo N, et al. Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries. J Hosp Infect. 2017;96(1):1-15. https://doi.org/10.1016/j.jhin.2017.03.004.
2. European Centre for Disease Prevention and Control (ECDC). Healthcare-associated infections: Surgical site infections. Annual epidemiology report for 2015. Stockholm: ECDC; 2017.
3. World Health Organization. Global guidelines for the prevention of surgical site infection. 2nd edition. Geneva: World Health Organization; 2018:1-184.
4. South African Society of Anaesthesiologists. Guidelines for infection control and prevention in anaesthesia in South Africa. S Afr J Anaesth. 2021;27(4):Supplement 1. https://doi.org/10.36303/SAJAA.2021.27.4.S1.
5. File TM. New guidelines for antimicrobial prophylaxis in surgery. Infect Dis Clin Pract. 2013;21(3):185-6. https://doi.org/10.1097/IPC.0b013e3182905630.
6. Satti MZ, Hamza M, Sajid Z, et al. Compliance rate of surgical antimicrobial prophylaxis and its association with knowledge of guidelines among surgical residents in a tertiary care public hospital of a developing country. Cureus. 2019;11(5):e4776. https://doi.org/10.7759/cureus.4776.
7. Schuster D, Fagan JJ, Flint M, et al. Compliance with surgical antibiotic prophylaxis guidelines: A prospective descriptive study at a tertiary level hospital in Cape Town, South Africa. S Afr J Anaesth Analg. 2020;26(6):300-5. https://doi.org/10.36303/SAJAA.2020.26.6.2402.
8. Morris AJ, Roberts SA, Grae N, et al. The New Zealand surgical site infection improvement (SSII) programme: A national quality improvement programme reducing orthopaedic surgical site infections. NZ Med J. 2018;131(1479):45-56.
9. Van der Sandt N, Schellack N, Mabope LA, et al. Surgical antimicrobial prophylaxis among pediatric patients in South Africa comparing two healthcare settings. Pediatr Infect Dis J. 2019;38(2):122-6. https://doi.org/10.1097/INF.0000000000002072.
10. Jocum J, Lowman W, Perrie H, Scribante J. Anaesthetists' knowledge of surgical antibiotic prophylaxis: A prospective descriptive study. S Afr J Anaesth Analg. 2018;24(4):97-102. https://doi.org/10.1080/22201181.2018.1487634.
11. Ahmed AM, Nasr S, Ahmed AM, Elkhidir O. Knowledge, attitude and practice of surgical staff towards preoperative surgical antibiotic prophylaxis at an academic tertiary hospital in Sudan. Patient Saf Surg. 2019;13(42):1-6. https://doi.org/10.1186/s13037-019-0224-2.
12. Khan F, Chaudhary B, Sultan A, Ahmad M, Alvi Y. Qualitative thematic analysis of knowledge and practices of surgical antimicrobial prophylaxis at a tertiary care teaching hospital. Surg Infect. 2021;22(4):1-8. https://doi.org/10.1089/sur.2020.181.
13. Weigelt JA, Lipsky BA, Tabak YP, et al. Surgical site infections: Causative pathogens and associated outcomes. Am J Infect Control. 2010;38(2):112-20. https://doi.org/10.1016/j.ajic.2009.06.010.
14. Health Protection Agency. Surveillance of surgical site infections in NHS hospitals in England, 2011/2012. London: Health Protection Agency; 2012. Available from: http://www.hpa.org.uk
15. Kalra L, Camacho F, Whitener CJ, et al. Risk of methicillin-resistant Staphylococcus aureus surgical site infection in patients with nasal MRSA colonization. Am J Infect Control. 2013;41(12):1253-7. https://doi.org/10.1016/j.ajic.2013.05.021.
16. Mueck KM, Kao LS. Patients at high-risk for surgical site infection. Surg Infect. 2017;18(4):440-6. https://doi.org/10.1089/sur.2017.058.
17. Mcintosh J, Earnshaw JJ. Antibiotic prophylaxis for the prevention of infection after major limb amputation. Eur J Vasc Endovasc Surg. 2009;37(6):696-703. https://doi.org/10.1016/j.ejvs.2009.01.013.
18. American College of Obstetricians and Gynecologists. Use of prophylactic antibiotics in labor and delivery. ACOG Pract Bull. 2018;132(3):e103-19. https://doi.org/10.1097/AOG.0000000000002833.
19. American College of Obstetricians and Gynecologists. Prevention of infection after gynecologic procedures. ACOG Pract Bull. 2018;131(6):e172-89. https://doi.org/10.1097/AOG.0000000000002670.
20. Kurzweil PR. Antibiotic prophylaxis for arthroscopic surgery. Arthroscopy. 2006;22(4):452-4. https://doi.org/10.1016/j.arthro.2006.02.004.
21. Bratzler DW, Dellinger EP, Olsen KM. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Heal Pharm. 2013;70:195-283. https://doi.org/10.2146/ajhp120568.
22. Alsaywid B, Smith G. Antibiotic prophylaxis for transurethral urological surgeries: Systematic review. Urol Ann. 2013;5(2):61-74. https://doi.org/10.4103/0974-7796.109993.
23. Hassan S, Chan V, Stevens J, Stupans I. Factors that influence adherence to surgical antimicrobial prophylaxis (SAP) guidelines: a systematic review. Syst Rev. 2021;10(1):1-20. https://doi.org/10.1186/s13643-021-01577-w.
24. Woolf SH, Grol R, Hutchinson A, Eccles M, Grimshaw J. Potential benefits, limitations, and harms of clinical guidelines. Br Med J. 1999;318:527-30. https://doi.org/10.1136/bmj.318.7182.527.
25. Wasserman S, Boyles T, Mendelson M. A pocket guide to antibiotic prescribing for adults in South Africa. South African Antibiotic Stewardship Programme. Atlasville: Federation of Infectious Diseases Societies of Southern Africa; 2015:1-60.
26. Olivier S. Western Cape academic hospitals antimicrobial recommendations. Johannesburg: National Health Laboratory Services; 2013:44-6.
27. South African Society of Anaesthesiologists. Guidelines for infection control in anaesthesia in South Africa 2014. South African J Anaesth. 2014;20(3):1-44.