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# Saudi orthopedic surgeons' knowledge, attitude, and practice regarding surgical antibiotic prophylaxis

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## ABSTRACT

**Objectives:** The objectives of the study were to evaluate the knowledge, attitudes, and practice of orthopedic surgeons practicing in Saudi Arabia regarding surgical antibiotic prophylaxis (SAP).

**Methods:** A cross-sectional study was conducted on certified and under-training orthopedic surgeons registered in the Saudi Council for Health Specialties. An email, including an online validated self-administered survey using a voluntary response sampling technique, was sent between November 2020 and January 2021. The questionnaire comprised 12 questions that tested knowledge regarding SAP, five questions that analyzed surgeon attitudes toward SAP, and three questions on SAP-related practice.

**Results:** This study included 271 orthopedic surgeons from different areas of Saudi Arabia. The majority of respondents were registrars (or equivalent) ($n$ = 92; 33.9%), and most of them were male ($n$ = 257; 94.8%). Almost 95% of respondents reported that SAP was indicated for internal fixation, spinal surgeries, and prosthetic joint replacement. Moreover, 82.7% of the respondents stated that cefazolin was considered the first-line SAP. Almost 85% of the respondents demonstrated a positive attitude toward SAP, with a mean score of 2.48. However, 87.5% of them believed that adhering to SAP general guidelines would reduce the rate of infection in orthopedic surgeries. Almost 53% of respondents reported using only one guideline as a reference in their surgical practice. Moreover, 41.3% of surgeons switched between guidelines depending on the surgery.

**Conclusion:** This study revealed adequate knowledge and a positive attitude toward SAP among orthopedic surgeons. However, a discrepancy in the practice habits of orthopedic surgeons was observed, which is explained by non-adherence to SAP protocols. Common guidelines that can be used by all orthopedic surgeons need to be developed and implemented to reduce surgical site infections and non-adherence to SAP protocols. This task can be done by a general trusted body like the Saudi Orthopedic Association.

**Keywords:** Antibiotics, Infection, Orthopedics, Prophylaxis, Surgery

## INTRODUCTION

Surgical site infections (SSIs) are serious events that surgeons regularly encounter during their practice. According to the National Nosocomial Infection Surveillance data, SSIs are the third

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most frequently reported nosocomial infections, which are associated with substantial mortality and morbidity and are a leading cause of extended hospitalization as well as a source of a financial burden on health care.[1,2] Various studies have reported a prevalence of 1.8–22.7% in orthopedic operations. Some factors contributing to this rate were open reduction fracture, pre-operative shaving with a razor, surgical wound contamination, and clinical condition.[3-5] Furthermore, in clean orthopedic procedures, SSIs are dreaded sequelae due to their increased prevalence (1–5%) in patients undergoing total hip replacement and total knee replacement.[6,7]

To combat this overwhelming number of SSIs, surgeons use prophylactic antibiotics as an effective measure to reduce the rate of postoperative infections. In orthopedic operations, prophylactic antibiotics are most often used in surgeries that require implants, cases with a high risk of infection, and when operating on patients in whom a post-operative infection could impose a drastic danger on their prognosis.[8]

According to the latest edition of the Centers for Disease Control and Prevention (CDC) and the Saudi Ministry of Health (MOH) guidelines, which state the standard of care in orthopedic surgery, no prophylaxis is needed during closed clean orthopedic operations, such as arthroscopic procedures. However, a single dose of cefazolin or vancomycin, in cases of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization or penicillin allergy, should be administered 1 h before the incision in clean surgeries such as spinal procedures, implantation of the internal fixation devices, and total joint replacement. The dose of a given antibiotic depends on the weight of the patient. Intraoperative dose repetition should be considered in prolonged procedures (more than 3 h) or in cases of significant blood loss. Further, decisions in patient care can be discussed among the team regarding the use of prophylactic antibiotics in procedures such as the removal of orthopedic hardware due to the noted controversy surrounding its benefit in reducing the risk of SSIs.[9]

Locally in Saudi Arabia, a study was conducted in Almadinah Almunawwarah examining the medical records of 707 patients who underwent surgery, revealing that only 19% of those patients received prophylactic antibiotics according to surgical prophylaxis guidelines.[10] Some reasons behind this non-adherence were described in a previous local study in which the two main reasons revealed were drug unavailability and hospital policy.[11] Although there are no adequate data to substantiate this, non-compliance could be attributed to surgeons relying on their practice-related experience rather than on local and international guidelines, inadequate knowledge by physicians, misconceptions regarding the relationship between prophylactic antibiotics and limiting SSIs, or physician disagreements with the current guidelines.

A 5-year analysis conducted in Saudi Arabia that included more than 3000 patients undergoing orthopedic operations revealed an SSI rate of 2.5%.[12] Moreover, following spine surgeries, the rate reached 9% in one local study.[13] Adhering to evidence-based guidelines has been shown to decrease the risk of SSIs, which is a devastating sequela of some orthopedic surgeries.[6,14] Thus, to expand on the causes of this non-adherence and to uncover the lack of evidence in Saudi Arabia, our main research objective was to evaluate the compliance of orthopedic surgeons to current guidelines regarding the use of prophylactic antibiotics in their practice. The advantage of our study is that it is one of the few studies in Saudi Arabia to investigate surgical antibiotic prophylaxis (SAP)-related behavior among orthopedic surgeons.

## MATERIALS AND METHODS

### Study design, settings, and participants

This was a descriptive cross-sectional (questionnaire based) study targeting 338 out of 2794 certified and trainee orthopedic surgeons registered in the Saudi Council for Health Specialties (SCFHS) in Saudi Arabia. This number was reached using the formula provided by Raosoft® sample size calculator. All certified and trainee orthopedic surgeons in Saudi Arabia who responded were included in the study. The respondents were 271 surgeons, with a response rate of 9.7%. Responders were questioned using a non-random sampling method (convenience sampling) on their knowledge, attitudes, and practice regarding SAP. An email, including an online validated self-administered survey using a voluntary response sampling technique, was sent between November 2020 and January 2021 through SCFHS.

### Data collection methods

Since we were unable to obtain a validated questionnaire that matched the aim of our study in the literature, we developed a questionnaire that was sent to three expert consultants who reviewed the questionnaire for structure, content validity, and applicability, and conducted a pilot study to assess the clarity, understandability, and organization of the questionnaire. An online self-administered survey was conducted using Google Forms, which automatically pooled the data into an Excel sheet. The questionnaire included 20 questions that assessed orthopedic surgeons' knowledge, attitudes, and practice of SAP: 12 questions on surgeons' knowledge, five questions on surgeons' attitude, and three questions on SAP-related practice. Regarding the knowledge section, it is important to note that questions 5 and 6 were dependent on the answers to questions 2 and 3, respectively, and that questions 9 and 10 were both dependent on the answer to question 8. Thus, only those who answered the initial questions correctly were eligible for analysis for the subsequent dependent questions.

Finally, the survey was distributed through email to all orthopedic surgeons who were registered in the SCFHS, comprising a maximum sample size of 338 surgeons.

### Statistical analysis

The data analysis process in this study comprised two stages. The first stage included a descriptive analysis in which numerical variables were reported in terms of means and standard deviations, while categorical variables were described using frequencies and percentages. The second stage included hypothesis testing using the Chi-square test and likelihood Chi-square test. Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 25.0 (SPSS, Chicago, IL, USA). All answers in accordance with the CDC, the American Academy of Orthopedic Surgeons (AAOS), and the Saudi MOH guidelines were given a score of 1 if correct. Scores above the mean were considered "good knowledge," Likert scale analysis was used to analyze the attitude, and answers above the mean were considered "positive attitude."

## RESULTS

Our study included a sample of 271 orthopedic surgeons out of a total of 2794 surgeons in the country, all registered orthopedic surgeons in SCFHS, with a response rate of 9.7% in different areas of Saudi Arabia. Most of the respondents were male ($n$ = 257; 94.8%). The sample size included Saudi and non-Saudi surgeons who were practicing in local hospitals. The majority of respondents were registrars (or equivalent) ($n$ = 92; 33.9%) followed by consultants ($n$ = 60; 22.1%). Table 1 provides an overview of our sample's sociodemographic characteristics.

**Table 1:** Demographics of participants ($n$=271).

| Characteristic | *n* | (%) |
|---|---|---|
| Gender | | |
| Male | 257 | 94.8 |
| Female | 14 | 5.2 |
| Nationality | | |
| Saudi | 98 | 36.2 |
| Non-Saudi | 173 | 63.8 |
| Age | | |
| 25–34 | 101 | 37.3 |
| 35–44 | 87 | 32.1 |
| 45–55 | 58 | 21.4 |
| More than 55 | 25 | 9.2 |
| Current level of practice | | |
| Consultant | 60 | 22.1 |
| Fellow | 9 | 3.3 |
| Senior registrar (or equivalent) | 45 | 16.6 |
| Registrar (or equivalent) | 92 | 33.9 |
| R5 | 14 | 5.2 |
| R4 | 13 | 4.8 |
| R3 | 9 | 3.3 |
| R2 | 12 | 4.4 |
| R1 | 17 | 6.3 |
| Region of practice | | |
| Central region | 100 | 36.9 |
| Western region | 61 | 22.5 |
| Eastern region | 52 | 19.2 |
| Southern region | 42 | 15.5 |
| Northern region | 16 | 5.9 |
| Type of hospital you are currently practicing on | | |
| Governmental hospital "Tertiary care center" | 100 | 36.9 |
| Governmental hospital "Secondary care center" | 96 | 35.4 |
| University hospital | 12 | 4.4 |
| Private hospital | 63 | 23.2 |

Approximately 60% of our respondents had good knowledge [Table 2]. When asked about orthopedic surgeries that require SAP, almost 95% of respondents said that prophylactic antibiotics are indicated in open reduction and internal fixation, spinal surgeries, and prosthetic joint replacement. However, around 63% also believed that SAP was indicated in patients undergoing clean arthroscopic procedures and 59% for procedures before closed reduction and internal fixation (CRIF). Moreover, 82.7% stated that cefazolin is considered the first line of SAP, but only 50% of them knew the appropriate dose in normal weight patients. In cases of allergy to first-line agents, only 23% of surgeons chose vancomycin as the proper SAP. In contrast, most respondents (84%) knew that the first line of SAP in cases with MRSA was vancomycin. Moreover, only 20% knew that SAP should be readministered if significant blood loss is encountered intraoperatively. Regarding post-operative antibiotics, 55% claimed that continuation of SAP postoperatively in clean cases is recommended for up to 24 h, while 12% responded that patients should be discharged on oral antibiotics. Finally, there was a significant association between the level of knowledge, current level of practice, and the type of hospital in which surgeons are practicing. We found that consultants and registrars had the highest level of knowledge regarding SAP and that those who practiced in a governmental tertiary hospital also displayed higher knowledge than the other groups [Table 3]. Table 4a-c summarizes the results for respondent knowledge in our study.

Based on our data, it has been shown that most respondents demonstrated a positive attitude toward SAP, with a mean score of 2.48, which indicates an 83% level of attitude toward SAP [Table 5]. When it comes to adhering to SAP general guidelines, 87.5% believed that such practice would positively affect the infection rate in orthopedic surgeries. Finally, around 67% mentioned that the following guidelines would impact antibiotic resistance levels, while 80% also thought that it would reduce the side effects of antibiotics [Table 4b].

**Table 2:** Surgeons' level of knowledge toward surgical antibiotic prophylaxis.

| Statement | Mean (%) | SD (%) | Rank | Level of knowledge |
|---|---|---|---|---|
| 1. What kind of orthopedic surgeries need SAP? | | | | |
| 1.1. Open reduction and internal fixation | 97 | 170 | 1 | Adequate knowledge |
| 1.2. Prosthetic joint replacement | 96 | 189 | 2 | Adequate knowledge |
| 1.3. Spinal surgeries | 93 | 249 | 3 | Adequate knowledge |
| 2. What is the first line for SAP for clean cases? | 83 | 379 | 6 | Adequate knowledge |
| 3. What is the second line for SAP in case of penicillin allergy for clean cases? | 23 | 423 | 10 | Inadequate knowledge |
| 4. In case of MRSA colonization what would be your first-line SAP? | 84 | 369 | 5 | Adequate knowledge |
| 5. What is the appropriate time for first-line SAP administration in clean cases? | 65 | 477 | 7 | Moderately adequate knowledge |
| 6. What is the appropriate time for second-line SAP administration in clean cases? | 14 | 344 | 14 | Inadequate knowledge |
| 7. During which condition(s) it is rational to give another SAP dose in clean cases? | | | | |
| 7.1. In case of significant blood loss | 20 | 397 | 12 | Inadequate knowledge |
| 7.2. In case of prolonged procedure | 93 | 262 | 4 | Adequate knowledge |
| 8. Which of the following SAP could need dosage adjustment, in some circumstances, in a patient with NO renal or hepatic impairment undergoing a clean procedure? | 21 | 411 | 11 | Inadequate knowledge |
| 9. Regarding the previous question, in which of the following circumstances should SAP dose be increased in clean cases? | | | | |
| 9.1. If the weight is >80 kg | 07 | 256 | 16 | Inadequate knowledge |
| 9.2. If the weight is >120 | 14 | 348 | 15 | Inadequate knowledge |
| 10. Regarding the previous question, what is the appropriate dose? | 15 | 359 | 13 | Inadequate knowledge |
| 11. For how long SAP should be continued in clean cases indicated? | 25 | 434 | 9 | Inadequate knowledge |
| 12. Should patients be discharged on oral antibiotics after clean cases? | 64 | 480 | 8 | Moderately adequate knowledge |
| Mean score | 61 | | | |

SAP: Surgical antibiotic prophylaxis

Regarding practice-related questions, 52.4% of the respondents reported that they only used one guideline as a reference in their surgical practice, and 6.3% mentioned that they did not follow any specific guidelines. The most commonly used guidelines were hospital guidelines, followed by the AAOS guidelines, at 36% and 31.7%, respectively [Figure 1]. Moreover, the most frequent condition that led our sample to deviate from the guidelines that they were following was the availability of the drug (45%), as well as previous experience with similar surgical cases (23%) [Table 4c]. There was a significant association between a surgeon's current level of practice and their adherence to international guidelines; consultants were the dominant group that followed only one guideline in their practice and did not switch between guidelines as much as other groups [Table 3].

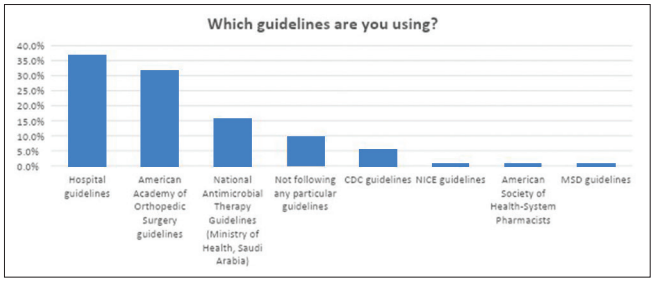


**Figure 1:** Reported used guidelines.

## DISCUSSION

Similar to many international studies, our respondents displayed good knowledge regarding SAP.[15,16] According to the CDC guidelines, cefazolin is considered the first-line surgical prophylactic agent. Almost 83% of respondents to our survey were knowledgeable when they were asked about first-line prophylaxis. This was better than the data reported in Ethiopia, in which 62.3% chose cefazolin.[15] Another study among thoracic surgeons showed approximately similar results, in which 70% used cefazolin as a first-line treatment.[16] In contrast, the literature showed that ceftriaxone has been commonly used as a first-line agent

**Table 3:** Testing the association between the sociodemographic factors with surgeons' level of knowledge and their practice toward surgical antibiotic prophylaxis.

| Demographics | Level of knowledge | | | *P*-value |
|---|---|---|---|---|
| | Inadequate knowledge *n* (%) | Moderately adequate knowledge *n* (%) | Adequate knowledge *n* (%) | |
| Gender | | | | |
| Female | 0 (0.0) | 6 (42.9) | 8 (57.1) | 0.083 |
| Male | 29 (22.7) | 45 (35.2) | 54 (42.2) | |
| Nationality | | | | |
| Saudi | 1 (1.0) | 50 (51.0) | 47 (48.0) | 0.000* |
| Non-Saudi | 23 (13.3) | 104 (60.1) | 46 (26.6) | |
| Age | | | | |
| 25–34 | 3 (3.0) | 57 (56.4) | 41 (40.6) | 0.014* |
| 35–44 | 6 (6.9) | 50 (57.5) | 31 (35.6) | |
| 45–55 | 11 (19.0) | 34 (58.6) | 13 (22.4) | |
| More than 55 | 4 (16.0) | 13 (52.0) | 8 (32.0) | |
| Current level of practice | | | | |
| Consultant | 3 (5.0) | 35 (58.3) | 22 (36.7) | 0.000* |
| Fellow | 0 (0.0) | 4 (44.4) | 5 (55.6) | |
| Senior registrar (or equivalent) | 5 (11.1) | 18 (40.0) | 22 (48.9) | |
| Registrar (or equivalent) | 16 (17.4) | 63 (68.5) | 13 (14.1) | |
| R5 | 0 (0.0) | 7 (50.0) | 7 (50.0) | |
| R4 | 0 (0.0) | 7 (53.8) | 6 (46.2) | |
| R3 | 0 (0.0) | 2 (22.2) | 7 (77.8) | |
| R2 | 0 (0.0) | 8 (66.7) | 4 (33.3) | |
| R1 | 0 (0.0) | 10 (58.8) | 7 (41.2) | |
| Region of practice | | | | |
| Central region | 7 (7.0) | 51 (51.0) | 42 (42.0) | 0.186 |
| Western region | 6 (9.8) | 35 (57.4) | 20 (32.8) | |
| Eastern region | 6 (11.5) | 26 (50.0) | 20 (38.5) | |
| Southern region | 3 (7.1) | 31 (73.8) | 8 (19.0) | |
| Northern region | 2 (12.5) | 11 (68.8) | 3 (18.8) | |
| Type of hospital you are currently practicing in | | | | |
| Governmental hospital "Tertiary care center" | 2 (2.0) | 52 (52.0) | 46 (46.0) | **0.000*** |
| Governmental hospital "Secondary care center" | 9 (9.4) | 61 (63.5) | 26 (27.1) | |
| University hospital | 1 (8.3) | 3 (25.0) | 8 (66.7) | |
| Private hospital | 12 (19.0) | 38 (60.3) | 13 (20.6) | |
| **Demographics** | **Do you adhere to one specific guideline when prescribing prophylactic antibiotics for orthopedic surgeries?** | | | ***P*-value** |
| | **Yes, I use one guideline *n* (%)** | **No, I switch between guidelines (depending on the case) *n* (%)** | **No, I do not follow any specific guidelines *n* (%)** | |
| Gender | | | | |
| Female | 9 (64.3) | 3 (21.4) | 2 (14.3) | 0.201 |
| Male | 133 (51.8) | 109 (42.4) | 15 (5.8) | |
| Nationality | | | | |
| Saudi | 48 (49.0) | 40 (40.8) | 10 (10.2) | 0.127 |
| Non-Saudi | 94 (54.3) | 72 (41.6) | 7 (4.0) | |
| Age | | | | |
| 25–34 | 34 (33.7) | 55 (54.5) | 12 (11.9) | 0.000* |
| 35–44 | 56 (64.4) | 28 (32.2) | 3 (3.4) | |
| 45–55 | 33 (56.9) | 24 (41.4) | 1 (1.7) | |
| More than 55 | 19 (76.0) | 5 (20.0) | 1 (4.0) | |

*(Contd...)*

**Table 3:** *(Continued)*.

| Demographics | Do you adhere to one specific guideline when prescribing prophylactic antibiotics for orthopedic surgeries? | | | *P*-value |
|---|---|---|---|---|
| | Yes, I use one guideline *n* (%) | No, I switch between guidelines (depending on the case) *n* (%) | No, I do not follow any specific guidelines *n* (%) | |
| Current level of practice (*n*=385) | | | | |
| Consultant | 40 (66.7) | 16 (26.7) | 4 (6.7) | 0.000* |
| Fellow | 6 (66.7) | 3 (33.3) | 0 (0.0) | |
| Senior registrar (or equivalent) | 32 (71.1) | 13 (28.9) | 0 (0.0) | |
| Registrar (or equivalent) | 40 (43.5) | 50 (54.3) | 2 (2.2) | |
| R5 | 6 (42.9) | 7 (50.0) | 1 (7.1) | |
| R4 | 5 (38.5) | 6 (64.2) | 2 (15.4) | |
| R3 | 4 (44.4) | 4 (44.4) | 1 (11.1) | |
| R2 | 5 (41.7) | 5 (41.7) | 2 (16.7) | |
| R1 | 4 (23.5) | 8 (47.1) | 5 (29.4) | |
| Region of practice | | | | |
| Central region | 54 (54.0) | 38 (38.0) | 8 (8.0) | 0.406 |
| Western region | 36 (59.0) | 20 (32.8) | 5 (8.2) | |
| Eastern region | 27 (51.9) | 23 (44.2) | 2 (3.8) | |
| Southern region | 17 (40.5) | 24 (57.1) | 1 (2.4) | |
| Northern region | 8 (50.0) | 7 (43.8) | 1 (6.3) | |
| Type of hospital you are currently practicing on | | | | |
| Governmental hospital "Tertiary care center" | 57 (57.0) | 37 (37.0) | 6 (6.0) | 0.595 |
| Governmental hospital "Secondary care center" | 44 (45.8) | 44 (45.8) | 8 (8.3) | |
| University hospital | 7 (58.3) | 5 (41.7) | 0 (0.0) | |
| Private hospital | 34 (54.0) | 26 (41.3) | 3 (4.8) | |

*Association found at 0.05 level of significant. **n*=sample size or total number of cases

in some countries, such as India, Sudan, and Iran.[17-19] Satti *et al.* noticed a trend in developing countries in which they tended to use broad-spectrum antibiotics in their surgical setting.[20] Although the general knowledge in our sample was adequate, the surgeons lacked knowledge in some critical areas. This was clear when surgeons were asked about indications for SAP in orthopedic surgeries. Approximately 63% of those with good knowledge also chose diagnostic arthroscopy and CRIF as an indication for SAP. In addition, almost half of those who chose cefazolin as a first-line drug were not aware of the proper dosage of this drug. Similar findings were reported in Canada, where 70% of orthopedic surgeons who chose cefazoline as a first-line SAP prescribed a dose that was inconsistent with the general guidelines.[21] These practices could expose patients to unneeded antibiotic doses that could predispose them to bacterial resistance, infections in case of insufficient dosing, and other feared complications.[14] Moreover, consultants and registrars had the highest levels of knowledge among our sample. This finding, though different from a thematic analysis done in India in which junior and senior surgery residents had higher guideline-related knowledge, might be because consultants and registrars have more practice-related experience and their roles as leaders of their units demand up-to-date knowledge.[22] Moreover, surgeons practicing in governmental and tertiary care hospitals demonstrated higher knowledge than other groups. This could be attributed to these surgeons having international degrees and multiple years of experience aside from them leading well-structured, teaching-oriented residency programs with strict hospital policies that limit any deviation from international guidelines. This finding was similar to that of a Nigerian study, which showed awareness of standard guidelines in up to 86.36% among orthopedic surgeons.[23] However, findings were superior to those of a retrospective study conducted in an orthopedic and trauma unit in a tertiary care hospital in Addis Ababa, where the practice was unfamiliar with standard guidelines, which is indicative of poor general knowledge as it is a prerequisite for safe practice.[24]

Surgeons responding to our survey displayed a positive attitude toward SAP. Although most of our sample believed that following standard guidelines would reduce the rate of SSIs and antibiotic resistance, around 33% reported

**Table 4:** Knowledge, attitude, and practice toward surgical antibiotic prophylaxis.

| Question | *n* (%) | Question | *n* (%) |
|---|---|---|---|
| **A. Knowledge** | | | |
| **What kind of orthopedic surgeries need SAP? (*n*=271) (k=1257)** | | **During which condition(s) it is rational to give another SAP dose in clean cases? (*n*=271) (k=404)** | |
| Close reduction and internal fixation | 160 (12.7) | In case of significant blood loss | 53 (13.1) |
| Open reduction and internal fixation | 263 (20.9) | In case patient is previously colonized with MRSA | 83 (20.5) |
| Diagnostic arthroscopy for any joint | 172 (13.7) | In case of prolonged procedure | 251 (62.1) |
| Soft tissue release or repair with or without sutures "no implant" | 148 (11.8) | The SAP dose should never be repeated | 17 (4.2) |
| Prosthetic joint replacement | 261 (20.8) | **Which of the following SAP could need dosage adjustment, in some circumstances, in a patient with NO renal or hepatic impairment undergoing a clean procedure? (*n*=271)** | |
| Spinal surgeries | 253 (20.1) | Cefazolin | 58 (21.4) |
| **What is the first line for SAP for clean cases? (*n*=271)** | | Cefuroxime | 12 (4.4) |
| Cefazolin | 224 (82.7) | Gentamicin | 49 (18.1) |
| Cefuroxime | 40 (14.8) | Vancomycin | 60 (22.1) |
| Gentamicin | 2 (0.7) | Clindamycin | 16 (5.9) |
| Augmentin | 2 (0.7) | Teicoplanin | 2 (0.7) |
| Ciprofloxacin | 1 (0.4) | SAP is fixed for all patients | 74 (27.3) |
| Ceftriaxone | 2 (0.7) | **Regarding the previous question, in which of the following circumstances SAP dose should be increased in clean cases? (*n*=271) (k=355)** | |
| **What is the second line for SAP in case of penicillin allergy for clean cases? (*n*=271)** | | In case of elderly patient | 17 (4.8) |
| Cefazolin | 33 (12.2) | If the weight is >80 kg | 49 (13.8) |
| Cefuroxime | 55 (20.3) | If the weight is >120 | 168 (47.3) |
| Gentamicin | 27 (10.0) | In case patient is diabetic | 67 (18.9) |
| Vancomycin | 63 (23.2) | SAP dose is fixed for all patients | 54 (15.2) |
| Clindamycin | 86 (31.7) | **Regarding the previous question, what is the appropriate dose? (*n*=271)** | |
| Teicoplanin | 4 (1.5) | 1 g | 35 (12.9) |
| I do not know | 3 (1.1) | 1.5 g | 5 (1.8) |
| **In case of MRSA colonization what would be your FIRST line SAP? (*n*=271)** | | 2 g | 120 (44.3) |
| Cefazolin | 10 (3.7) | 3 g | 23 (8.5) |
| Cefuroxime | 4 (1.5) | NA | 88 (32.5) |
| Gentamicin | 6 (2.2) | **For how long SAP should be continued in indicated clean cases? (*n*=271)** | |
| Vancomycin | 227 (83.8) | No need for post-op antibiotics | 68 (25.1) |
| Clindamycin | 12 (4.4) | 24 h | 150 (55.4) |
| Teicoplanin | 12 (4.4) | 72 h | 48 (17.7) |
| **What is the appropriate time for FIRST line SAP administration in clean cases? (*n*=271)** | | More than 72 h | 5 (1.8) |
| >120 min before the procedure | 11 (4.1) | **Should patients be discharged on oral antibiotics after clean cases? (*n*=271)** | |
| 60–120 min before the procedure | 55 (20.3) | Yes | 33 (12.2) |
| <60 min before the procedure | 131 (48.3) | Sometimes | 64 (23.6) |
| On induction | 74 (27.3) | No | 174 (64.2) |
| **What is the appropriate time for SECOND line SAP administration in clean cases? (*n*=271)** | | | |
| >120 min before the procedure | 21 (7.7) | | |
| 60–120 min before the procedure | 71 (26.2) | | |
| <60 min before the procedure | 92 (33.9) | | |

*(Contd...)*

**Table 4:** *(Continued)*.

| Question | *n* (%) | Question | *n* (%) |
|---|---|---|---|
| On induction or incision | 87 (32.1) | | |
| **B. Attitude** | | | |
| **Do you think following a guideline for prophylactic surgical antibiotics would affect the rate of infection in orthopedic surgical procedures? (*n*=271)** | | **Rate your level of confidence of patient outcome when prescribing prophylactic antibiotics apart from the guidelines? (*n*=271)** | |
| Yes | 237 (87.5) | Not confident at all | 51 (18.8) |
| Maybe | 26 (9.6) | Slightly confidant | 47 (17.3) |
| No | 8 (3.0) | Somewhat confidant | 55 (20.3) |
| **Rate your level of confidence of patient outcome when prescribing prophylactic antibiotics according to a guideline? (*n*=271)** | | Fairly confidant | 55 (20.3) |
| Not confident at all | 6 (2.2) | Completely confidant | 37 (13.7) |
| Slightly confidant | 22 (8.1) | Not applicable to me | 26 (9.6) |
| Somewhat confidant | 35 (12.9) | **Do you think following a guideline would affect antibiotic resistance level? (*n*=271)** | |
| Fairly confidant | 83 (30.6) | Yes | 182 (67.2) |
| Completely confidant | 117 (43.2) | Maybe | 42 (15.5) |
| Not applicable to me | 8 (3.0) | No | 47 (17.3) |
| | | **Do you think following a guideline would reduce antibiotics side-effects? (*n*=271)** | |
| | | Yes | 214 (79.0) |
| | | Maybe | 34 (12.5) |
| | | No | 23 (8.5) |
| **C. Practice** | | | |
| **Do you adhere to one specific guideline when prescribing prophylactic antibiotics for orthopedic surgeries? (*n*=271)** | | **During which conditions would you deviate from the guidelines? (*n*=271) (k=463)** | |
| Yes, I use one guideline | 142 (52.4) | Cost saving | 41 (8.9) |
| No, I switch between guidelines (depends on the case) | 112 (41.3) | Availability of the drug | 209 (45.1) |
| No, I do not follow any specific guidelines | 17 (6.3) | Due to previous experience of infection to similar cases | 107 (23.1) |
| | | Preference of the main responsible physician (This answer is not for consultants) | 94 (20.3) |
| | | Patient preference | 12 (2.6) |

All values presented as number and percentage. **n*: Sample size or total number of cases, k: Total number of responses in multiple-choice questions, SAP: Surgical antibiotic prophylaxis, MRSA: Methicillin-resistant *Staphylococcus aureus*

that they were fairly confident when prescribing SAP not in accordance with the guidelines. The practice-related experience could be one explanation; however, this result needs further investigation in future research to find the driving reason behind this attitude. Furthermore, our measured level of attitude was consistent with the data reported in Sudan and was higher than Ethiopian data.[15,18] However, different measures were used to assess the level of attitude in the studies mentioned above. Although not statistically significant, our data showed that the younger age group demonstrated a better attitude toward SAP guidelines than other age groups, which might be related to their lack of practice-related experience regarding patient outcomes on deviation from the guidelines.

Regarding practice, half of our respondents mentioned that they only used one guideline in their clinical practice. On the other hand, 41% reported switching between guidelines and 6% said that they did not use any specific guidelines. This was different from multiple international data in which the primary reference for SAP administration between surgeons was textbooks and medical articles.[16,18,25] Such discrepancies could explain the findings of a previous study conducted in Saudi Arabia in which patients' surgical records in accordance with SAP guidelines were surveyed, with low adherence by surgeons being found.[10] Moreover, our data found that the most used guidelines among our sample were hospital guidelines followed by the AAOS guidelines and national antimicrobial therapy guidelines

**Table 5: Surgeons' level of attitude toward surgical antibiotic prophylaxis.**

| Statement | Mean | SD | Rank | Level of attitude |
|---|---|---|---|---|
| 1. Do you think following a guideline for prophylactic surgical antibiotics would affect the rate of infection in orthopedic surgical procedures? | 2.85 | 0.437 | 1 | Positive attitude |
| 2. Rate your level of confidence of patient outcome when prescribing prophylactic antibiotics according to a guideline? | 2.58 | 0.794 | 3 | Positive attitude |
| 3. Rate your level of confidence of patient outcome when prescribing prophylactic antibiotics apart from the guidelines? | 1.79 | 1.021 | 5 | Neutral |
| 4. Do you think following a guideline would affect antibiotic resistance level? | 2.50 | 0.774 | 4 | Positive attitude |
| 5. Do you think following a guideline would reduce antibiotics side effects? | 2.70 | 0.616 | 2 | Positive attitude |
| Mean score | 2.48 | | | |

issued by the Saudi MOH. In addition, most of those who claim to strictly use one guideline in their surgical practice were employed by governmental tertiary hospitals. This, as mentioned above, supports our interpretation that tertiary hospitals in Saudi Arabia seem to have strict hospital policies and medicolegal consequences of malpractice. Finally, the most frequent reason given by our participants on the rationale behind their deviation from the guidelines was the availability of the drug followed by experience with similar cases and the preference of the attending physician. Other reasons have been described in the literature, such as the poor quality of infection control protocols in some hospitals, which led surgeons to be more aggressive when it comes to prescribing SAP to minimize postoperative infections.[17] In addition, cost saving seemed to be an important reason behind the necessity of SAP guideline adherence, which was concluded in multiple international studies.[24-29] For instance, in a review article, RS *et al*. described the economic burden that could emerge on the inappropriate use of SAP.[26-29]

There were some limitations to our study. First, we considered answers to be correct if they were according to CDC, AAOS, and national guidelines. However, some participants chose other guidelines, which broadly used evidence-based recommendations and their answers were incorrect in our survey because they were inconsistent with the three guidelines mentioned above. In addition, our original sample size was estimated to be 338, but we were only able to reach 271 participants, which was a relatively small number compared to the entire population of orthopedic surgeons in Saudi Arabia. Moreover, our survey was an online self-administered form distributed through the SCFHS. Thus, respondents were not chaperoned while filling out the survey, and some of them might have sought information before answering the questions.

## CONCLUSION

The results of our study demonstrated adequate knowledge and a positive attitude regarding SAP among orthopedic surgeons, with some inconsistencies in some parts of the practice. Moreover, deviation from the guidelines was a possibility in some scenarios, such as practice-related experience and the preference of the attending physicians.

## RECOMMENDATIONS

Adherence to SAP protocols should be addressed in educational intervention and discussion sessions conducted by orthopedic consultants in cooperation with infection control departments. Moreover, control systems performed by hospital audits and quality improvement departments should cooperate with the MOH or general trusted bodies like the Saudi Orthopedic Association to come out with common guidelines that can be used by all orthopedic surgeons in the country to maximize patient care and reduce SSIs and non-adherence to SAP protocols.

## AUTHORS' CONTRIBUTIONS

KB and FA conceived and designed the study, and provided the research materials. KB, FA, AJ, and AS collected and organized the data. KB, FA, and AJ analyzed and interpreted the data. FA, AJ, and AS wrote the initial and final drafts of the article. All authors critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

## ETHICAL APPROVAL

The research project was approved by the Institutional Review Board of Prince Sultan Military Medical City (PSMMC), with approval number: 1438 issued on October 19, 2020.

**Declaration of participants consent**

The authors certify that they have obtained all appropriate participants consent forms. In the form, the participants have given their consent for their images and other clinical information to be reported in the journal. The participants understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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