Article

Perspectives of Healthcare Professionals Regarding Factors Associated with Antimicrobial Resistance (AMR) and Their Consequences: A Cross Sectional Study in Eastern Province of Saudi Arabia

Mohamed A. Baraka¹,²*, Amany Alboghdalyy³,⁴, Samar Alshawwaw⁵,⁴, Asim Ahmed Elnour⁶*, Hassan Alsultan⁵, Taha Alsalman⁵, Hussain Alaithan⁵, Md. Ashraful Islam⁶, Kareem Ahmed El-Fass⁶, Yehia Mohamed⁷,⁸, Abdulsalam A. Alasser⁹ and Khairi Mustafa Fahelelbum¹⁰

Abstract: Factors reported in the literature associated with inappropriate prescribing of antimicrobials include physicians with less experience, uncertain diagnosis, and patient caregiver influences on physicians’ decisions. Monitoring antimicrobial resistance is critical for identifying emerging resistance patterns, developing, and assessing the effectiveness of mitigation strategies. Improvement in prescribing antimicrobials would minimize the risk of resistance and, consequently, improve patients’ clinical and health outcomes. The purpose of the study is to delineate factors associated with antimicrobial resistance, describe the factors influencing prescriber’s choice during prescribing of antimicrobial, and examine factors related to consequences of inappropriate prescribing of antimicrobial. A cross-sectional study was conducted among healthcare providers (190) in six tertiary hospitals in the Eastern province of Saudi Arabia. The research panel has developed, validated, and piloted survey specific with closed-ended questions. A value of \( p < 0.05 \) was considered to be statistically significant. All data analysis was performed using the Statistical Package for Social Sciences (IBM SPSS version 23.0). 72.7% of the respondents have agreed that poor skills and knowledge are key factors that contribute to the inappropriate prescribing of antimicrobials. All of the respondents acknowledged effectiveness, previous experience with the antimicrobial, and reading scientific materials (such as books, articles, and the internet) as being key factors influencing physicians’ choice during antimicrobial prescribing. The current study has identified comprehensive education and training needs for healthcare providers about antimicrobial resistance. Using antimicrobials unnecessarily, insufficient duration of antimicrobial use, and using broad spectrum antimicrobials were reported to be common practices. Furthermore, poor skills and knowledge were a key factor that
contributed to the inappropriate use and overuse of antimicrobials, and the use of antimicrobials without a physician’s prescription (i.e., self-medication) represent key factors which contribute to AMR from participants’ perspectives. Furthermore, internal policy and guidelines are needed to ensure that the antimicrobials are prescribed in accordance with standard protocols and clinical guidelines.

**Keywords:** antimicrobial resistance; AMR; Infections; antibiotics; inappropriate prescribing; healthcare professionals; education; training; antimicrobial stewardship programs; continuous professional development

### 1. Introduction

Infectious diseases are caused by microorganism’s penetration into the epidermis, dermis, soft tissues of the skin, and other body tissues, leading to infectious diseases and comorbidities that can ultimately lead to sepsis and death [1]. Antimicrobial agents have the advantage of treating infectious diseases, and they have the potential not only to retain the quality of life of the patient but have also proved to be lifesaving in a variety of severe infectious conditions [2,3]. The improper use of antimicrobials has led to the development of antimicrobial resistant (AMR), which has been associated with a failure in managing infections, increased length of hospital stay, increased mortality, morbidity [4–6], and health costs [7,8]. Several factors have been described in the literature to be correlated with the inappropriate prescribing of antimicrobials [9] such as physicians with less experience, level of knowledge, uncertain diagnoses, and patient caregiver influences on physician’s decisions [10–12]. Over two million infections and 23,000 deaths annually in the United States were due to AMR [13]. Studies from diverse settings estimate that between 25% and 50% of antibiotic use in hospitals was suboptimal or unnecessary [14,15]. Gulf Cooperation Council countries face challenges of emerging AMR with no clear regional guidelines for antimicrobial use or specific policies for restricting and monitoring antimicrobial prescribing [16]. Monitoring AMR is critical for identifying emerging resistance and developing, monitoring, and evaluating the effectiveness of mitigation strategies [17,18]. Improvement in antimicrobial prescribing would minimize the risk of AMR, reduce healthcare costs, and improve patient clinical outcomes. In an attempt by the World Health Organization (WHO) to reduce AMR, several initiatives and programs have been established to educate healthcare providers on appropriate antimicrobial prescribing for evidence-based indications [19,20]. A study conducted in Saudi Arabia has revealed that the medications most commonly used were antibiotics [21]. In another study, it has been confirmed that certain types of medications, such as chemotherapeutic agents and antipsychotics, are exclusively prescribed by the specialists involved, while antibiotics are vigorously prescribed by all physicians as well as by allied health practitioners, irrespective of their knowledge or experience about antibiotics prescribed [22]. Accordingly, general practitioners are the most common prescribers of antibiotics in Saudi Arabia, relative to specialists and residents. The objectives of this study were to delineate the factors associated with antimicrobial resistant, describe the factors influencing prescriber’s choice during prescribing of antimicrobial, and examine the factors related to consequences of inappropriate prescribing of antimicrobial agents.

### 2. Results

A total of 184 healthcare providers have responded to the survey with a 96.8% response rate. Results have demonstrated that more than half of the respondents (53.8%) were pharmacists, (35.8%) were physicians, and (10.9%) were nurses (56% were males). Nearly 56% of the respondents’ age was less than 30 years, around one-third (30.4%) were in the age strata from 31 to 40 years, and only 13.6% were aged ≥41 years. Regarding years of practice, 37% of the respondents had less than 3 years of clinical experience, whereas only
16% reported that their experience exceeded 10 years. The majority (72.8%) have worked more than 8 h per day. Regarding the average of continuous professional development (CPD), (71%) of the respondents had more than 20 CPD hours per year (Table 1).

Table 1. Descriptive statistics for socio-demographic characteristics of respondents (n = 184).

| Characteristics                  | Group            | Frequency (n) | Percentage (%) |
|----------------------------------|------------------|---------------|----------------|
| Gender                           | Male             | 103           | 56.0           |
|                                  | Female           | 81            | 44.0           |
| Age (year)                       | Less than 30     | 103           | 56.0           |
|                                  | 31–40            | 56            | 30.4           |
|                                  | ≥ 41             | 25            | 13.6           |
| Nationality                      | Saudi            | 154           | 83.7           |
|                                  | Non-Saudi        | 30            | 16.3           |
| Region                           | Eastern of Saudi Arabia | 178  | 96.7           |
|                                  | Others           | 6             | 3.3            |
| Profession                       | Nurses           | 20            | 10.9           |
|                                  | Physicians       | 65            | 35.3           |
|                                  | Pharmacists      | 99            | 53.8           |
| Country of last professional degree | Saudi Arabia    | 149           | 81.0           |
|                                  | Others           | 35            | 19.0           |
| Working hours (per day)          | Less than 8 h    | 50            | 27.2           |
|                                  | 8 h and more     | 134           | 72.8           |
| Years of Practice                | Less than 3 years| 68            | 37.0           |
|                                  | 3–6 years        | 50            | 27.2           |
|                                  | 6–10 years       | 36            | 19.6           |
|                                  | More than 10 years| 30          | 16.3           |
| Average of CME (continuous medical education) hours/year | Less than 20 | 53 | 28.8 |
|                                  | 20 and above     | 131           | 71.2           |

In the current study, six factors with various questions (including yes/no responses) on antimicrobial dispensing and prescribing practices were analyzed. At first, we assessed the factors influencing physicians’ choice during antimicrobial prescribing, which was reflected by eight questions. Results revealed that for the first question, “Parent/patient’s demand”, 32.6% have responded positively. For the second question, “Reading scientific materials (such as books, articles, and internet)”, 56.0% have responded positively as well. Responses retrieved from the third question, “Attending courses and lectures” were positively reported in 36.4%. Nearly half of the respondents (46.2%) agreed with the fourth question, “Cost of antibiotic”, while (59.8%) agreed with the fifth question, “Effectiveness and previous experience with the prescribed antimicrobial. Only 23.4% responded yes for the sixth question, “Recommendation by other colleagues”, while (39.7%) responded yes to the seventh question, “The knowledge gained during undergraduate or postgraduate training”. Nearly half (49.5%) of the respondents have agreed with the eighth question, “Availability of the antibiotic in the hospital formulary” (Table 2).

Findings revealed that a maximum of 72.7% of the respondents have agreed that poor skills and knowledge are a key factor which contributes to the inappropriate prescribing of antimicrobials. However, nearly half of the respondents (47.5%) have concurred that unrestricted availability of antimicrobials, inadequate supervision (45.4%), overworked/busy health care providers (32.2%), lack of physicians’ interest in the subject of antimicrobial prescribing (41.5%), and a lack of microbiology lab facilities (43.7%) were the major causes of inappropriate use of antimicrobial agents (Table 3).
Table 2. Factors influencing physicians’ choice during antimicrobial prescribing.

| Items                                      | Short Item Name | Responses | Yes (n & %) | No (n & %) |
|--------------------------------------------|-----------------|-----------|-------------|------------|
| Parent/patient’s demand                    | PD              | 60 (32.6) | 124 (67.4) |
| Reading scientific materials (such as, books, articles, and internet) | RSM             | 103 (56.0)| 81 (44.0)  |
| Attending courses and lectures.            | ACL             | 67 (36.4) | 117 (63.6) |
| Cost of antibiotic                         | CA              | 85 (46.2)| 99 (53.8)  |
| Effectiveness and previous experience with the drug antimicrobial | EEDA            | 110 (59.8)| 74 (40.2)  |
| Recommendation by other colleagues        | RC              | 43 (23.4)| 141 (76.6) |
| The knowledge gained during undergraduate or postgraduate training | KT              | 73 (39.7)| 111 (60.3) |
| Availability of the antibiotic in the hospital formulary | AAHF            | 91 (49.5)| 93 (50.5)  |

Table 3. Factors related to important causes of inappropriate prescribing of antimicrobial.

| Items                                      | Short Item Name | Responses | Yes (n & %) | No (n & %) |
|--------------------------------------------|-----------------|-----------|-------------|------------|
| Poor skills and knowledge                  | PSK             | 133 (72.7)| 50 (27.3)  |
| Unrestricted availability of antimicrobials | UAA             | 87 (47.5)| 96 (52.5)  |
| Inadequate supervision                     | IS              | 83 (45.4)| 100 (54.6) |
| Lack of physician interest in the subject of antimicrobial prescribing and infection management | LPI            | 76 (41.5)| 107 (58.5) |
| Lack of effective hospital policies        | LHP             | 85 (46.4)| 98 (53.6)  |
| Overworked/busy health care providers      | OHP             | 59 (32.2)| 124 (67.8) |
| Lack of microbiology lab facilities (lack of antimicrobial susceptibility test results) | LML            | 80 (43.7)| 103 (56.3) |

Concerning the causes of AMR, the highest number of respondents (80.4%) concurred that using antimicrobial when they were not necessary, whereas not completing the full course of antimicrobials (59.8%) and using antimicrobials without physician prescription as self-medication (66.3%) were reported as the key factors which contribute to AMR (Table 4).

Table 4. Factor associated with the causes of antimicrobial resistant.

| Items                                      | Short Item Name | Responses | Yes (n & %) | No (n & %) |
|--------------------------------------------|-----------------|-----------|-------------|------------|
| Using antimicrobial when they are not necessary | UANN            | 148 (80.4)| 36 (19.6)  |
| Not completing the full course of antimicrobial | NCFA            | 110 (59.8)| 74 (40.2)  |
| Using the same antimicrobial with a different brand | USADB           | 47 (25.5)| 137 (74.5) |
| Using antimicrobials without physician prescription (self-medication) | UAWPP           | 122 (66.3)| 62 (33.7)  |
| Using broad spectrum antimicrobial, as a common practice | UBSA            | 94 (51.1)| 90 (48.9)  |
| Patient pressure for antibiotics as part of treatment | PPAT            | 77 (41.8)| 107 (58.2) |
| Patients are able to buy antibiotics over-the-counter | PABA            | 80 (43.5)| 104 (56.5) |
Regarding the factors detecting the important consequences of antimicrobial overuse, the results have shown that the majority (78.8%) of respondents agreed that it will lead to AMR. The inverse results found for the question “Reduce the duration of hospitalization” have shown that 79.9% of respondents disagreed with this statement. Furthermore, 85.9% of respondents didn’t believe that better patient outcomes can be a consequence of antimicrobial overuse. (54.9%) of respondents have denied that waste of resources and recurrence of infections (56.5%) can be the consequence of antimicrobials overuse (Table 5).

Table 5. Factor related to important consequences of antimicrobial overuse.

| Items                                | Factor Short Name | Responses |
|--------------------------------------|-------------------|-----------|
|                                      |                   | Yes (n & %) | No (n & %) |
| Antimicrobial resistant               | AMR               | 145 (78.8) | 39 (21.2)  |
| Adverse drug reactions and medication | ADRME             | 78 (42.4)  | 106 (57.6) |
| errors                               |                   |            |            |
| Reduce duration of hospitalization    | RDH               | 37 (20.1)  | 147 (79.9) |
| Better patient outcome               | BPO               | 26 (14.1)  | 158 (85.9) |
| Waste of resources                   | WR                | 83 (45.1)  | 101 (54.9) |
| Recurrence of infections             | RI                | 80 (43.5)  | 104 (56.5) |

In order to assess the factors that may help to control AMR, nine questions were used. Results demonstrated that the question about “Physician education” reported a higher proportion (66.8%) of respondent’s agreement. On the other hand, for the question of “Consulting with infectious diseases experts” 55.4% of respondents agreed, and 58.2% have believed that providing local antimicrobial guidelines will contribute to the control of AMR. However, only 56% agreed with the statement that providing knowledge of pathogens and antimicrobial susceptibility test results will contribute to control AMR. The respondents have rejected the assumptions that obtaining local AMR profiles, practicing antimicrobial restriction, removing catheters when not essential, and targeting antimicrobial therapy to likely pathogens could contribute to controlling AMR (51.6%), (59.2%), (66.3%), and (70.1%), respectively (Table 6).

Table 6. Factors that may help to control antimicrobial resistant.

| Items                                | Factor Short Name | Responses |
|--------------------------------------|-------------------|-----------|
|                                      |                   | Yes (n & %) | No (n & %) |
| Treating infection, not contamination or colonization | TINCC | 74 (40.2) | 110 (59.8) |
| Physician education on appropriate antimicrobial therapy | PEAAT | 123 (66.8) | 61 (33.2) |
| Consulting with infectious diseases experts | CIDE | 102 (55.4) | 82 (44.6) |
| Providing local antimicrobial guidelines | PLAG | 107 (58.2) | 77 (41.8) |
| Knowledge of pathogens and antimicrobial susceptibility test results | KPASR | 103 (56.0) | 81 (44.0) |
| Obtaining local antibiotic resistant profiles | OLARP | 89 (48.4) | 95 (51.6) |
| Practicing antimicrobial restriction | PAR | 75 (40.8) | 109 (59.2) |
| Removing catheters when not essential | RCNE | 62 (33.7) | 122 (66.3) |
| Targeting antimicrobial therapy to likely pathogens | TALP | 55 (29.9) | 129 (70.1) |

The survey’s final theme was designed to know about the most common resources used by healthcare providers for knowledge towards antimicrobials. Slightly above half (57.6%) of respondents have agreed that the Lexicomp/Sanford guide/up-to-date or other online resources were common resources. Most respondents, on the other hand, did not
agree with other common resources, such as national/Saudi guidance, hospital/internal guidelines, smartphone medical applications, Red Book, Quick reference guides or booklets or medical journals, and other guidelines by professional organizations, infectious diseases specialists/service in the hospital, colleagues or seniors from your own team or specialty. The clinical pharmacists and medical representatives have not been considered as a source of information for antimicrobials Table 7.

Table 7. Factors associated with most common resources used for knowledge toward antimicrobials.

| Items                                                      | Factor Short Name | Responses |
|------------------------------------------------------------|-------------------|-----------|
| National/Saudi guidelines                                  | NG                | Yes (n & %) 83 (45.1) No (n & %) 101 (54.9) |
| Hospital/internal guidelines                               | HG                | Yes (n & %) 78 (42.4) No (n & %) 106 (57.6) |
| Lexicomp/Sanford guide/UPTODATE or other Online resources   | LG                | Yes (n & %) 106 (57.6) No (n & %) 78 (42.4) |
| Smart phone medical applications                           | SMA               | Yes (n & %) 80 (43.5) No (n & %) 104 (56.5) |
| Red Book, Quick reference guides or booklets or Medical journals | RBRJ             | Yes (n & %) 41 (22.3) No (n & %) 143 (77.7) |
| Other guidelines by professional organizations (IDSA, CDC, . . . etc.) | OG                | Yes (n & %) 62 (33.7) No (n & %) 122 (66.3) |
| Infectious diseases specialists/service in the hospital    | IDSH              | Yes (n & %) 66 (35.9) No (n & %) 118 (64.1) |
| Colleagues or seniors from your own team or specialty       | CTS               | Yes (n & %) 36 (19.6) No (n & %) 148 (80.4) |
| Hospital/Clinical pharmacists or Drug information centres  | HPGIC             | Yes (n & %) 62 (33.7) No (n & %) 122 (66.3) |
| Medical/Pharmaceutical representatives Others              | MR                | Yes (n & %) 31 (16.8) No (n & %) 153 (83.2) |
| Others                                                     | Others            | Yes (n & %) 9 (4.9) No (n & %) 175 (95.1) |

3. Discussion

Our study documented the perceptions of healthcare professionals working in six tertiary hospitals in the eastern province of Saudi Arabian tertiary hospitals. The current study has delineated the factors associated with antimicrobial resistance (AMR), described the factors influencing prescriber’s choice during prescribing antimicrobials, and examined the factors related to the consequences of inappropriate prescribing of antimicrobials.

This study revealed that around half of the respondents acknowledged the importance of previous experience with antimicrobials, and reading scientific materials as contributing factors influencing physicians’ choice during antimicrobial prescribing. Conforming with a study conducted in Jeddah city in Saudi Arabia, our results confirmed their study findings [2]. Interestingly, attending courses and lectures was not considered a factor that may help control AMR. This might explain the poor knowledge among our respondents about the importance of attending courses and lectures to improve their antimicrobial practices [23,24].

Similar to healthcare professionals from other parts of the world, 72.7% of the respondents agreed that poor skills and knowledge were a key factor that contributes to the inappropriate use of antimicrobials [2,25]. However, most of the respondents have agreed that unrestricted availability of antimicrobials, overworked/busy health care providers, and lack of physicians’ interest in the subject of antimicrobial prescribing and infection management were not causes of the inappropriate prescribing of antimicrobials.

Many healthcare providers in our study have agreed that using antimicrobials when they were not necessary, not completing the full course of antimicrobials, and using broad spectrum antimicrobials were common practices. Further, using antimicrobials without physician prescription (self-medication) were identified as the key factors which contribute to AMR [23,26]. Our findings lend support to previously published studies [2,21,25]. In response to this, and based on the current study results, this can be controlled via increasing the sessions of CPD for healthcare providers on appropriate antimicrobial treatment,
providing local antimicrobial guidelines and consulting with experts on infectious diseases. The majority of healthcare professionals have believed that AMR was a consequence of antimicrobial overuse [27–29]. On the other hand, they have denied that the waste of resources and recurrence of infections can be the consequences of antimicrobials’ overuse. We highly encourage each hospital to generate their internal policy or guidelines to guide and restrict antimicrobials’ overuse. In response to this, and based on healthcare professionals’ responses here, this can be rectified via CPD awareness programs and education on appropriate antimicrobial therapy, providing local antimicrobial guidelines, consulting with infectious diseases experts, and (above all) implementing antimicrobial stewardship programs. Yusef, D. et al. concluded that antimicrobial stewardship programs (ASPs) helped to reduce the use of antifungals in hospitalized patients and highlighted the importance of promoting antifungal stewardship among antibiotic stewardship [30]. Additionally, Rodolfo E. Quirós et al. showed significant improvement in antimicrobial utilization after multiple and intensive ASPs [5]. Interestingly, targeting antimicrobial therapy to likely pathogens was not mostly considered a factor that may help control AMR. This may be due to the poor of knowledge in our respondents on the importance of targeting pathogens. Some recent studies conducted in Saudi Arabia by Al-Harthi and colleague were in line with our results, wherein they identified the importance of healthcare professional education on appropriate antimicrobial therapy, providing local antimicrobial guidelines, and consulting with infectious diseases experts as crucial factors that can control AMR and its consequences. [8]

In fact, further studies are needed to target the reasons behind the gap in knowledge, experience, and skills on antimicrobials, as revealed by the current study respondents. This will help in controlling AMR and its consequences in our region.

Limitations of the Study

There are some limitations to be considered when interpreting the study findings. First, although the research was conducted at six hospitals in the Eastern province that were well-resourced, the findings of the study may not be generalizable to other regions in Saudi Arabia. Second, participants were selected randomly and the characteristics of those who did not participate in the survey are unknown. Furthermore, purposive sampling was used to target doctors, nurses, and pharmacists from departments with high antibiotic use. Therefore, there are departments (such as psychiatry, for example) that are underrepresented. It is possible, therefore, that the sampling approach and recruitment limit the generalizability of the study results to other departments or hospitals. Finally, the sample included in the study was small, with a moderate response rate. We believe the results from the current study will be valuable in guiding educational efforts in order to prevent antimicrobial resistance and well received by clinicians in their respective institutions. However, our study’s strength lies in the fact that, to the best of our knowledge, it is the first study that investigates healthcare providers’ perceptions regarding understanding factors associated with AMR, their consequences, and possible ways to control such a problem.

4. Materials and Methods

The study was a cross-sectional study among health care providers (190) in six tertiary hospitals (4 governmental and 2 private hospitals with more than 500 beds) in the Eastern province of Saudi Arabia.

4.1. Sample Size

A published statistical formula was used to calculate the sample size for the unknown nature of population size. Finally, the sample was adjusted for potential missing or non-response error using the formula:

\[ n = \left( \frac{Z_{1-\beta}}{d} \right)^2 \frac{p(1-p)}{d^2} \]
where, \( n \) is the required sample size; \( Z_{1−\beta} = Z \) is the value at power \( 1−\beta \) (at power 90\% this value is 1.24); \( p \) is the preferred population proportion (0.5); \( d \) is the margin of error (ideal value is 0.05); and \( n_1 = n/(1−e) \), where ‘n’ is the required sample size as per formula, ‘\( n_1 \)’ is the adjusted sample size, and ‘d’ is the potential missing or non-response rate. A minimum number of 190 samples was required to achieve 90\% power when considering a 5\% margin of error and a 10\% missing/non-response error rate. Participants responses with multiple missing values have been removed from the SPSS database before analysis. The proportion of responses with missing data ranged from 5\% to 7\% across all questions in Part B.

4.2. Data Collection Instrument and Quality Assurance

Survey Development

Survey questions have been adopted and compiled from previously validated questionnaires from the published articles during literature review phase [6,8,10–12]. The initial version of the structured survey was developed after in-depth literature review to assess healthcare providers’ perceptions regarding understanding factors associated with AMR, their consequences, and possible ways to control such problem. The research panel (three pharmacists, statisticians, physicians, and the director of clinical pharmacy services) developed the survey and divided it into two parts with closed ended questions. This expert advisory panel finalized the survey and assured the quality after addressing the comments and corrections.

The survey was subdivided into two parts. The first (part A) including respondents’ characteristics and experiences. These characteristics included respondents’ gender, age, nationality, and city of residence in addition to their professional status, country of last professional degree, daily working hours, years of practice and average continuous medical education hours earned per year. The second part (part B) has described the factors related to antimicrobial prescribing and dispensing practices. This has contained a total of six factors with different options (wherein one is allowed to choose multiple options). These factors include factors influencing the choice during antimicrobial prescribing, factors that might be identified as causes of inappropriate antimicrobial use, causes of antimicrobial resistance, possible consequences of antimicrobial overuse, and factors that might help control antimicrobial resistance and the most common resources used for knowledge toward antimicrobials. In addition to evaluating the viability of the survey, the survey has been piloted to ensure face validity and has resolved both improvements in terminology and ease of use. However, the data collected from the pilot study were not involved in the final analysis. In terms of reliability, a variety of factors have been taken into account when planning this analysis to reduce the risk to the reliability. This has included that the data collection process was clearly documented and research procedures were followed as per the data collection protocol during the research process. Furthermore, the results were obtained on one occasion to simplify the capture of answers from participants and to help mitigate any unintended bias in the analysis of responses; close-ended questions were purposely selected for this survey design.

4.3. Administration of the Survey

A standard set of the pre-tested validated survey was used to collect data among health care providers (physicians, pharmacists, and nurses) by self-administrative procedure. In addition, questions for online surveys (QuestionPro) have been distributed to the hospital administration, pharmacy directors, and nursing supervisors via e-mails and related social media accounts to boost data collection. The data collection procedure was administrated by the investigators via several necessary visits, reminders by phone calls, and emails.

4.4. Statistical Analysis

The online survey (QuestionPro) has enabled the view of some missing cases among the data set. Therefore, we have used the ‘last-observation-carried-forward method’. Some
of these cases were treated, and the rest were cleaned from the final analysis. Additionally, an informal technique was used to check and cleaned the whole data set. Variables were coded and recoded as per the requirements of study objectives. Descriptive statistics were utilized for data analysis. Frequencies and their corresponding percentages were reported to describe the factors and their respective items. A value of $p < 0.05$ was considered to be statistically significant. The whole data analysis was conducted using the Statistical Package for Social Sciences (IBM SPSS version 23.0).

5. Conclusions

The current study has identified comprehensive education and training needs for healthcare providers about the AMR and how to prevent such a problem. Using antimicrobials unnecessarily, insufficient duration of antimicrobial use, and using broad spectrum antimicrobials were all reported to be common practices. Furthermore, poor skills and knowledge were identified as a key factor that contributed to the inappropriate use and overuse of antimicrobials. Using antimicrobials without physician prescription (i.e., self-medication) were the key factors which contribute to AMR from participants’ perspectives. This problem can be controlled via increasing the sessions of CPD for healthcare providers on appropriate antimicrobial treatment, providing local antimicrobial guidelines and consulting with experts on infectious diseases. More studies about local AMR patterns are deemed necessary, and more efforts are warranted to educate clinicians about antimicrobial resistance. We highly encourage each hospital to generate their internal policy or guidelines to guide and restrict antimicrobials’ overuse to combat AMR.

Author Contributions: Conceptualization, M.A.B., H.A. (Hassan Alsultan), T.A., H.A. (Hussain Alaithan), M.A.I., A.A., S.A., A.A.E., and A.A.A.; methodology, M.A.B., A.A., S.A., A.A.E., H.A. (Hassan Alsultan), M.A.I., K.A.E.-F., Y.M., A.A.A., and K.M.F.; software, M.A.B., M.A.I., and K.A.E.-F.; validation, M.A.B., A.A., M.A.I., K.A.E.-F., and Y.M.; formal analysis, M.A.B., M.A.I., and K.A.E.-F.; investigation, M.A.B., S.A., H.A. (Hassan Alsultan), T.A., H.A. (Hussain Alaithan), and A.A.A.; resources, M.A.B., A.A., S.A., and K.M.F.; data curation, M.A.B., M.A.I., and A.A.A.; writing—original draft preparation, M.A.B., A.A., S.A., A.A.E., H.A. (Hassan Alsultan), T.A., H.A. (Hussain Alaithan), and M.A.I.; writing—review and editing, M.A.B., A.A., S.A., and A.A.E.; visualization, M.A.B., A.A., S.A., and A.A.E.; supervision, M.A.B., A.A., S.A., and K.M.F.; project administration, M.A.B., S.A., and K.M.F.; funding acquisition, M.A.B., S.A., and A.A.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Deanship of Scientific Research at Princess Nourah bint Abdulrahman University through the Fast-track Research Funding Program.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Imam Abdulrahman Bin Faisal University (IRB-UGS-2019-5-088).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data will be available upon request.

Acknowledgments: In this section, you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support, or donations in kind (e.g., materials used for experiments).

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Ki, V.; Rotstein, C. Bacterial Skin and Soft Tissue Infections in Adults: A Review of Their Epidemiology, Pathogenesis, Diagnosis, Treatment and Site of Care. Can. J. Infect. Dis. Med. Microbiol. 2008, 19, 173–184. [CrossRef]
2. Al-Harthi, S.E.; Khan, L.M.; Abed, H.H.; Alkreathy, H.M.; Ali, A.S. Appraisal of Antimicrobial Prescribing Practices of Governmental and Non-Governmental Dentists for Hospitals in the Western Region of Saudi Arabia. *Saudi Med. J.* 2013, 34, 1262–1269.

3. Blomberg, B. Antimicrobial Resistance in Developing Countries. *Tidsskr. Nor. Laegeforening* 2008, 128, 2462–2466.

4. Alshammari, T.M.; Larrat, E.P.; Morrill, H.J.; Caffrey, A.R.; Quilliam, B.J.; LaPlante, K.L. The Risk of Hepatotoxicity with Fluoroquinolones: A National Case-Control Safety Study. *Am. J. Heal. Syst. Pharm.* 2014, 71, 37–43. [CrossRef]

5. Quiros, R.E.; Bardossy, A.C.; Angeleri, P.; Zurita, J.; Espinoza, W.R.A.; Carneiro, M.; Guerra, S.; Medina, J.; Luquerna, X.C.; Guerra, A.; et al. Antimicrobial Stewardship Programs in Adult Intensive Care Units in Latin America: Implementation, Assessments, and Impact on Outcomes. *Infect. Control. Hosp. Epidemiol.* 2021, 1–10. [CrossRef]

6. Abushaheen, M.A.; Muzaeed; Fatani, A.J.; Alosaimi, M.; Mansy, W.; George, M.; Acharya, S.; Rathod, S.; Divakar, D.D.; Jhugroo, C.; et al. Antimicrobial resistance, mechanisms and its clinical significance. *Dis. Mon.* 2020, 66, 100971. [CrossRef]

7. Nasr, Z.; Babiker, A.; Elbasheer, M.; Osman, A.; Elazzazy, S.; Wilby, K.J. Practice Implications of an Antimicrobial Stewardship Intervention in a Tertiary Care Teaching Hospital, Qatar. *EMHJ* 2019, 25, 172–180. [CrossRef]

8. Al-Harthi, S.E.; Khan, L.M.; Osman, A.M.; Alim, M.A.; Saadah, O.I.; Almohammadi, A.A.; Khan, F.M.; Kamel, F.O. Perceptions and Knowledge Regarding Antimicrobial Stewardship among Clinicians in Jeddah, Saudi Arabia. *Saudi Med. J.* 2015, 36, 813–820. [CrossRef]

9. Zetts, R.M.; Stoesz, A.; Smith, B.A.; Hyun, D.Y. Outpatient Antibiotic Use and the Need for Increased Antibiotic Stewardship Efforts. *Pediatrics* 2018, 141. [CrossRef]

10. Suafian, G.; Shehadeh, M.; Darwish, D.; Al-Ijel, H.; Youssef, A.; Darwish, R. A Cross-Sectional Study on Knowledge, Attitude and Behavior Related to Antibiotic Use and Resistance among Medical and Non-Medical University Students in Jordan. *AJP* 2012, 6, 763–770. [CrossRef]

11. Saleem, Z.; Saeed, H.; Hassali, M.A.; Godman, B.; Asif, U.; Yousaf, M.; Ahmed, Z.; Riaz, H.; Raza, S.A. Pattern of Inappropriate Antibiotic Use among Hospitalized Patients in Pakistan: A Longitudinal Surveillance and Implications. *Antimicrob. Resist. Infect. Control.* 2019, 8, 188. [CrossRef] [PubMed]

12. Md Rezal, R.S.; Hassali, M.A.; Alrasheedy, A.A.; Saleem, F.; Md Yusof, F.A.; Godman, B. Physicians’ Knowledge, Perceptions and Behaviour towards Antibiotic Prescribing: A Systematic Review of the Literature. *Expert Rev. Anti-Infect. Ther.* 2015, 13, 665–680. [CrossRef]

13. Antibiotic Resistance Threats in the United States. 2013. Available online: https://www.cdc.gov/drugresistance/pdf/ar-threats-2013-508.pdf (accessed on 1 June 2021).

14. Willemsen, I.; Groenhuijzen, A.; Bogaers, D.; Stuurman, A.; Van Keulen, P.; Kluytmans, J. Appropriateness of Antimicrobial Therapy Measured by Repeated Prevalence Surveys. *Antimicrob. Agents Chemother.* 2007, 51, 864–867. [CrossRef] [PubMed]

15. Kapadia, S.N.; Abramson, E.L.; Carter, E.J.; Loo, A.S.; Kaushal, R.; Calfee, D.P.; Simon, M.S. The Expanding Role of Antimicrobial Stewardship Programs in Hospitals in the United States: Lessons Learned from a Multisite Qualitative Study. *Jt. Comm. J. Qual. Patient Saf.* 2018, 44, 68–74. [CrossRef]

16. Aly, M.; Balkhy, H.H. The Prevalence of Antimicrobial Resistance in Clinical Isolates from Gulf Corporation Council Countries. *Antimicrob. Resist. Infect. Control.* 2012, 1, 26. [CrossRef]

17. Karp, B.E.; Tate, H.; Plumblee, J.R.; Dessai, U.; Whichard, J.M.; Thacker, E.L.; Hale, K.R.; Wilson, W.; Friedman, C.R.; Griffin, P.M.; et al. National Antimicrobial Resistance Monitoring System: Two Decades of Advancing Public Health through Integrated Surveillance of Antimicrobial Resistance. *Foodborne Pathog. Dis.* 2017, 14, 545–557. [CrossRef]

18. Akinsolu, F.T.; Njemieboka, P.O.; Njuguna, D.W.; Ahadji, M.N.; Dezso, D.; Varga, O. Emerging Resistance of Neglected Tropical Diseases: A Scoping Review of the Literature. *Int. J. Environ. Res. Public Health* 2019, 16, 1925. [CrossRef]

19. Vickers, H. International Antibiotic Resistance Crisis. *BMJ* 2011, 342, d3207. [CrossRef]

20. Tonkin-Crine, S.; Yardley, L.; Little, P. Antibiotic prescribing for acute respiratory tract infections in primary care: A systematic review and meta-ethnography. *J. Antimicrob. Chemother.* 2011, 66, 2215–2223. [CrossRef]

21. AlKhamees, O.A.; AlNemer, K.A.; Bin Maneea, M.W.; AlSugair, F.A.; AlEnizi, B.H.; Alharf, A.A. Top 10 Most Used Drugs in the

22. Edgar, T.; Boyd, S.D.; Palamé, M.J. Sustainability for Behaviour Change in the Fight against Antibiotic Resistance: A Social Marketing Framework. *JAC* 2009, 65, 230–237. [CrossRef] [PubMed]

23. Hayat, K.; Rosenthal, M.; Gilliani, A.H.; Chang, J.; Ji, W.; Yang, C.; Jiang, M.; Zhao, M.; Fung, Y. Perspective of Key Healthcare Professionals on Antimicrobial Resistance and Stewardship Programs: A Multicenter Cross-Sectional Study from Pakistan. *Front. Pharmacol.* 2020, 10, 1520. [CrossRef]

24. Labi, A.-K.; Obeng-Nkrumah, N.; Bjerrum, S.; Aryee, N.A.A.; Ofitori-Adjei, Y.A.; Yawson, A.E.; Newman, M.J. Physicians’ Knowledge, Attitudes, and Perceptions Concerning Antibiotic Resistance: A Survey among Clinicians in a Ghanaian Tertiary Care Hospital. *Int. J. Environ. Res. Public Health* 2017, 14, 1152. [CrossRef] [PubMed]
27. Henry, D.; Holloway, K.A. WHO Essential Medicines Policies and Use in Developing and Transitional Countries: An Analysis of Reported Policy Implementation and Medicines Use Surveys. *PLoS Med.* 2014, 11, e1001724.

28. Hassali, M.A.; Kamil, T.K.; Md Yusof, F.A.; Alrasheedy, A.A.; Yusoff, Z.M.; Saleem, F.; Al-Tamimi, S.K.; Wong, Z.Y.; Aljadhey, H.; Godman, B. General Practitioners’ Knowledge, Attitude and Prescribing of Antibiotics for Upper Respiratory Tract Infections in Selangor, Malaysia: Findings and Implications. *Expert Rev. Anti Infect. Ther.* 2015, 13, 511–520. [CrossRef] [PubMed]

29. Costelloe, C.; Metcalfe, C.; Lovering, A.; Mant, D.; Hay, A.D. Effect of Antibiotic Prescribing in Primary Care on Antimicrobial Resistance in Individual Patients: Systematic Review and Meta-Analysis. *BMJ* 2010, 340, c2096. [CrossRef]

30. Yusef, D.; Hayajneh, W.A.; Al-Azzam, S.; Jaradat, S.K.; Gould, I.; Lattyak, E.A.; Lattyak, W.J.; Conway, B.R.; Bond, S.; Conlon-Bingham, G.; et al. Impact of Antimicrobial Stewardship Interventions on Reducing Antifungal Use in Hospitals in Jordan. *Infect. Control. Hosp. Epidemiol.* 2021, 1–2. [CrossRef]