JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

Factors influencing doctors' decisions to prescribe antibiotics to inpatients in public hospitals: a qualitative study

Lai S Kong[1,2], Farida Islahudin[1], Kwee C Koh[3], Leelavathi Muthupalaniappen[4], Wei W Chong[1]

[1] Centre of Quality Management of Medicines, Faculty of Pharmacy, Universiti Kebangsaan Malaysia, Kuala Lumpur 50300, Malaysia
[2] Tuanku Ampuan Najihah Hospital, Ministry of Health, KM 3, Jalan Melang, 72000, Kuala Pilah, Malaysia
[3] Department of Medicine, International Medical University, Kuala Lumpur, Malaysia
[4] Department of Family Medicine, Medical Faculty, Universiti Kebangsaan Malaysia, Kuala Lumpur 50600 Malaysia

Abstract

Introduction: This study aimed to understand the factors that influence doctors' decisions to prescribe antibiotics to inpatients in Malaysian public hospitals and to identify potential targets for quality improvement interventions.

Methodology: A qualitative study was conducted from October 2020 to July 2021 using a semi-structured interview technique with doctors in the internal medicine, surgical, and orthopedic departments of 6 public hospitals in Malaysia. Purposive sampling was applied to select doctors with at least 6 months of working experience, and interviews were conducted until data saturation. The interviews were recorded and transcribed verbatim. Thematic analysis was used to analyze data by generating codes and grouping into main themes and subthemes.

Results: Twenty-two doctors were recruited for interviews, and 5 interrelated themes were generated. The complex decision-making process for prescribing antibiotics involved intra-personal and socio-cultural context of the hospital settings. The prescriber-related factors affecting decision-making included prescribers' competency, attitude, and the influence of other prescribers; and patient-related factors included clinical presentation and medical history. Orthopedic and surgical practices frequently considered surgery-related factors and types and sources of infection. Antibiotic-related factors consisting of pharmacokinetic and pharmacodynamic properties were also determinants. Organization setting-related factors included organizational policies, working environment, and resource availability; and these were mainly described by respondents from limited-resource hospitals.

Conclusions: This study provides valuable insights into the intrinsic and extrinsic factors and barriers that influence doctors' decisions to prescribe antibiotics to inpatients in Malaysian public hospitals. These findings should be considered when developing future interventions aimed at improving antibiotic prescribing practices.

Key words: antibiotics; inpatients; decision-making; hospitals, public; factors.

J Infect Dev Ctries 2025; 19(3):391-403. doi:10.3855/jidc.19891

(Received 21 January 2024 – Accepted 24 August 2024)

Introduction

Antibiotic resistance is a significant public health concern that is responsible for substantial healthcare and economic burden for the community [1,2]. One of the leading causes of antibiotic resistance is the inappropriate use of antibiotics in hospitals due to lack of indication and prolonged use [3]. Studies show that between 25% to 62% of antibiotics prescribed in hospitals are unnecessary or inappropriate [4,5]. Inappropriate use of antibiotics and antibiotic-resistant infections were reported to be associated with increased adverse reactions of antibiotics and higher healthcare expenditure for both patients and the country [6–9].

In general, antibiotic prescribing practices of doctors can be influenced by several factors [10]; including modifying factors such as knowledge, confidence, clinical experience, and seniority [10–14]. Studies have reported low to moderate levels of knowledge among doctors when it comes to prescribing antibiotics [15,16]. However, doctors have reported that they make better decisions in prescribing antibiotics as their clinical experience and confidence increase over time [11]. Additionally, factors such as diagnostic errors or uncertainties, often resulting from a lack of knowledge and experience, fatigue, and cognitive overload, can further affect the decision-making process of doctors, leading to inappropriate antibiotic use [5,11].

In addition to intrinsic factors, the prescribing decisions of doctors may also be influenced by other determinants related to the patient, and the social and cultural aspects of the hospital environment. For example, the patient's condition and clinical characteristics, and peer influence from seniors, may all

influence antibiotic prescribing decisions [11,13,17,18]. Defensive practice among doctors may result in the prescription of antibiotics for uncertain diagnoses due to the fear of missing an infection that could lead to increased mortality or morbidity [17]. Studies have also reported a working culture where not intervening with antibiotics prescribed by other doctors was perceived as a norm to foster good inter-collegial relationships and to maintain one's reputation at work [19].

Several studies on antibiotic prescribing practices have been conducted in primary care settings in Malaysia [20–23]. However, since these studies were quantitative in design, they were unable to provide an in-depth understanding of the various factors and barriers that impact doctors' decisions when it comes to prescribing antibiotics. To our knowledge, limited research has been conducted on appropriate antibiotic prescribing for inpatients among doctors in Malaysian public hospital settings. Antimicrobial prescribing behaviors may also vary as the practice in different hospitals may be influenced by the type of patients admitted, prescribing patterns at the hospital, and available resources [24]. For instance, there are notable differences in the settings between public and private hospitals in Malaysia, with the former having to manage a larger inpatient volume despite being on a smaller financial allocation from the government [25].

Studies on antibiotic prescription practices in various countries have been published. We aimed to evaluate the practice in the Malaysian hospital healthcare settings as it may differ from those in other countries. Understanding the factors influencing antibiotic prescribing decisions is pivotal in planning strategies to implement a more judicious inpatient antibiotic prescribing practice. The aim of this study was to explore the factors and barriers affecting doctors' decision-making processes related to prescribing antibiotics to inpatients in Malaysian public hospitals.

Methodology

Study settings and respondents

An exploratory qualitative study was conducted using a phenomenological research approach. This study involved semi-structured interviews with doctors from 6 public hospitals. Data for this study were collected between 1 October 2020 and 31 July 2021, primarily through online interviews, with only a limited number of face-to-face interviews conducted due to the coronavirus disease 2019 (COVID-19) pandemic.

Purposive maximum variation sampling was applied to capture rich and varied interview data. Doctors from internal medicine, surgical, or orthopedic departments; with different experiences of prescribing antibiotics to inpatients; various lengths of professional service; a reasonable mix of age and gender; and from different public hospital settings (state hospitals, major specialist hospitals, minor specialist hospitals, non-specialist hospitals and university teaching hospitals) were targeted. The three departments were selected because they are the main disciplines involved with the management of different kinds of infections in hospitals. In Malaysia, state hospitals serve as the primary public healthcare facilities within each state. These hospitals, as well as university hospitals, are considered to be well-resourced [26]. They are followed in capacity and resources by major specialist hospitals, and then by minor specialist hospitals, which possess fewer resources in comparison [26]. Non-specialist hospitals are district hospitals that usually operate with limited resources and do not provide in-house specialty services [26].

The recruited respondents were those with a minimum of 6 months of working experience in their respective departments, had regular contact with inpatients, and were actively involved in prescribing antibiotics and managing infections in all types of inpatients, including those who were immunocompromised and severely ill in both the general wards and the intensive care units. House officers were excluded from this study to ensure that the respondents had sufficient clinical experience.

In qualitative research, the sample size is not predetermined, but is determined by the scope of the study and the amount and quality of information obtained from each respondent to reach data saturation. Typically, a sample size of 20 to 30 respondents is sufficient [27,28]. To ensure that data saturation was reached, interviews were conducted until no more new codes or themes emerged from the analysis [28].

Instrument

A semi-structured topic guide was used to facilitate the interviews. The topic guide was developed from a review of literature [13,17,18,29,30] and based on the "four moments of antibiotic decision making" framework by the Agency for Healthcare Research and Quality [31]. This structured framework was proposed to improve antibiotic decision-making by doctors during critical time periods when doctors prescribe antibiotics to inpatients, starting from the diagnosis of an infection until the completion of the antibiotic treatment course [31].

The interview guide consisted of open-ended questions related to three main aspects which were factors influencing doctors' decision-making processes during inpatient antibiotic prescribing, barriers to appropriate inpatient antibiotic prescribing, and recommendations for improving antibiotic prescribing practices. The interview guide was reviewed and validated by an expert panel of two experienced qualitative healthcare researchers, a family medicine specialist, and an infectious disease (ID) consultant. It was then piloted on two respondents to assess its validity, feasibility, and burden. Minor changes to the interview guide were made based on the findings from the pilot study before it was used for actual data collection.

Ethical considerations

Ethical approval for this study was obtained from the Universiti Kebangsaan Malaysia Research Ethics Committee (reference number: UKM PPI/111/8/JEP2018-717) and the Medical Research and Ethical Committee (reference number: KKM/NIHSEC/P20-359 (6)).

Data collection

Potential respondents from the selected hospital were identified with the help of representative doctors from the departments. The identified respondents were contacted and briefed regarding the study before getting their consent to participate in the study. Written consent was taken from respondents who were interviewed face-to-face, while verbal consent was taken from those who joined through online interview. Each interview was conducted on a one-to-one basis, and no third person was present. Respondents were prompted during the interviews if further clarity was required to ensure accurate and reflective answers related to the topic. No personal identifiable data was collected, and respondents' anonymity and confidentiality were ensured throughout the study. The interviews were conducted in English by a trained qualitative researcher (LSK). The interviews were recorded for transcribing purposes and field notes were taken during the interviews. The interviews lasted between 22 to 62 minutes; and the average duration was 37 minutes.

Data analysis

The recorded interviews were transcribed verbatim and ATLAS.ti software version 9.0 [32] was used to assist in the organization and coding of the data. Data was analyzed using a thematic analysis method, where themes were identified through a systematic coding process. Initial codes were applied to the interview transcripts, then further refined and grouped into categories representing the subthemes and the main themes [33]. Emerging themes and subthemes were continually refined, tested, and revised using a constant comparison approach [34]. To ensure data

Table 1. Characteristics of respondents (n = 22).

Respondent number	Gender	Hospital	Current Position	Current Department	Total working experience, excluding housemanship (years)	Total working experience in current department (years)
1	Female	Major specialist hospital	Medical officer	Internal Medicine	0.5	0.5
2	Female	Major specialist hospital	Medical officer	Internal Medicine	5	5
3	Female	Major specialist hospital	Medical officer	Internal Medicine	3.5	3.5
4	Female	Major specialist hospital	Medical officer	Internal Medicine	2	2
5	Male	Major specialist hospital	Specialist	Internal Medicine	9	9
6	Female	State hospital	Specialist	Internal Medicine	7	7
7	Male	State hospital	Medical officer	Internal Medicine	5	5
8	Male	State hospital	Medical officer	Internal Medicine	4	4
9	Female	State hospital	Medical officer	Internal Medicine	5	5
10	Male	Major specialist hospital	Specialist	Internal Medicine	5.5	1.5
11	Male	Major specialist hospital	Medical officer	Internal Medicine	5.5	1.5
12	Male	Major specialist hospital	Medical officer	Orthopedic	8	8
13	Male	State hospital	Specialist	Surgical	9	9
14	Male	Major specialist hospital	Medical officer	Internal Medicine	9	4
15	Male	University hospital	Registrar	Internal Medicine	7.5	5
16	Male	University hospital	Specialist	Surgical	11	11
17	Male	University hospital	Specialist	Internal Medicine	10	10
18	Male	University hospital	Registrar	Orthopedic	4.5	4.5
19	Male	Non-specialist hospital	Medical officer	Non-medical multidisciplinary*	4	4
20	Female	Non-specialist hospital	Medical officer	Internal Medicine	4	2
21	Female	Minor specialist hospital	Medical officer	Non-medical multidisciplinary*	4	4
22	Male	Minor specialist hospital	Medical officer	Internal Medicine	4	2

*Non-medical multidisciplinary department: doctors in this department manage inpatients other than in internal medicine, including orthopedic and surgical inpatients.

triangulation, field notes taken by the interviewer-researcher during and after the interviews were also considered during data analysis [35]. Investigator triangulation was applied, with two researchers (LSK and WWC) independently checking the data for consistency and reliability of coding and themes generated [35]. The consensus and opinions of all research team members were used to finalize the themes.

Results

A total of 22 respondents participated in this study, and the characteristics of each respondent are shown in Table 1.

The factors and barriers influencing doctors' decision-making in inpatient antibiotic prescribing are presented in Figure 1. Five interrelated themes, categorized as intrinsic and extrinsic factors, were generated. These included prescriber-related factors, patient-related factors, antibiotic-related factors, infection-related factors, and organization setting-related factors. Some of the factors also acted as barriers to appropriate inpatient antibiotic prescribing.

Theme 1: Prescriber-related factors and barriers

Theme 1 included competency, awareness, attitude, fear, and influence from other prescribers. The respondents reported that competency in diagnosing infections, deciding which cultures and laboratory parameters to request, and selecting appropriate antibiotics for managing infections were required for their decision-making. This was particularly important for those working in resource-limited district hospitals without in-house specialists. The respondents believed that competency could be gained through personal knowledge, work experience, formal ID training, and exposure to different infection cases by combining the hospital antimicrobial stewardship (AMS) teams. Hence, incompetency due to lack of experience was perceived as a common barrier for most junior doctors.

"I think lack of experience… this happens to a lot of junior doctors. So, when they are not very sure [about] the primary diagnosis; then, they will just treat everything."— respondent 10, internal medicine department, major specialist hospital, 5.5 years of work experience.

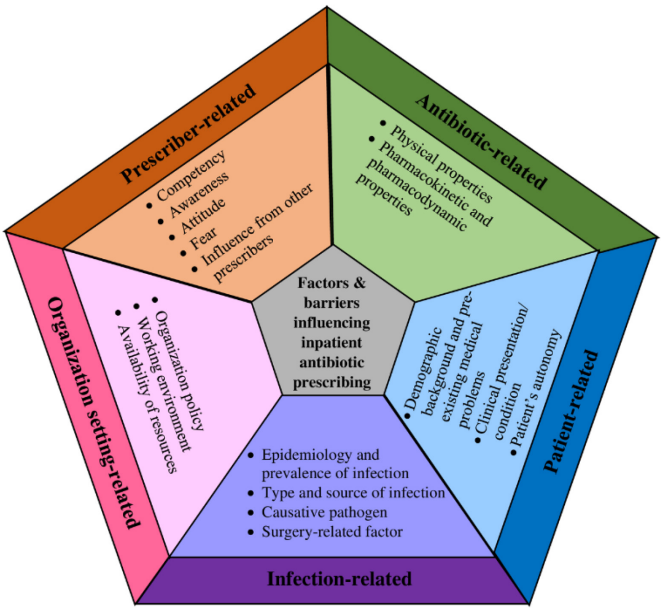
The respondents believed that, awareness and concern about antibiotic resistance led to a more cautious approach to initiating antibiotics and regular review of the need to continue antibiotics based on culture results. Positive attitudes, such as self-confidence and self-initiative toward learning about ID, were also perceived to affect the decision-making processes, as they were related to their competency. Conversely, negative attitudes, such as a lack of initiative to learn, a lack of sense of accountability in tracing cultures (especially on weekends), and resistance from non-ID consultants to follow advice from ID experts were seen as barriers to appropriate antibiotic prescribing.

Fear of patient complaints and deterioration of patients' condition were also reported to cause unnecessary antibiotics to be prescribed as a form of defensive medicine.

"I think, because of preventive (defensive) medicine, we always think please, please do everything so [that] the patient is not deteriorating..." — respondent 17, internal medicine department, university hospital, 10 years of work experience

The respondents described the influences of other prescribers, such as ID experts and seniors or colleagues, in the antibiotic prescribing decisions in their daily work. Some of these influences, including expert opinions provided by ID specialists, helped ensure that antibiotic prescriptions were appropriate and adhered to guidelines or protocols. However, the respondents reported feeling pressure to follow the "normal practice" and not change antibiotics initiated by others, even if they were deemed inappropriate, in order to be accepted and recognized by their colleagues and seniors. This was due to long-standing issues of senior-junior hierarchy and the need to preserve inter-collegial relationships within and between departments.

Figure 1. Factors and barriers influencing doctors' prescribing decision on antibiotics.



In cases where different opinions were provided by different specialists from different disciplines, the decision to change antibiotics would usually be in the hands of the primary team managing the patient.

"There are many times that I will see a patient seen by other colleagues and they started straight away with Tazocin (piperacillin/tazobactam). So… we have to continue… but sometimes I tend to step down the antibiotics, if the patient is not really ill… But, sometimes, even I faced the challenges especially in trying to step down the antibiotics or even stopping the antibiotics when it is unnecessary (patient is under different treating teams)." — respondent 15, internal medicine department, university hospital, 7.5 years of work experience.

Theme 2: Patient-related factors and barriers

Theme 2 included patient's demographic background and pre-existing medical problems, patient's clinical presentations or conditions, and patient's autonomy. The respondents reported that the patients' demographic factors, such as age, pregnancy, and exposure risk; based on the patient's activity or lifestyle would be taken into consideration when diagnosing infections and selecting antibiotics. For example, they described that they would consider covering for melioidosis caused by *Burkholderia pseudomallei* which is found in soil, in patients who were involved in gardening; or they might consider covering for leptospirosis in patients who have visited waterfalls or gone jungle trekking. In the case of patients from special groups, extra caution would be considered by them in deciding on antibiotics, such as selecting antibiotics that are known to be safe for pregnant patients, using broader spectrum antibiotics for immunocompromised patients, adjusting the dosage or selecting alternative antibiotics for patients with existing renal or hepatic impairments, and selecting antibiotics that require less frequent administration for patients needing conservation of intravenous access.

"You want to prescribe end-stage renal disease patient who has very minimal line IV (intravenous) cloxacillin four-hourly… you're going to cause thrombophlebitis by just giving cloxa. It (the branula) can probably last 2 days... So, in this kind of situation, I will choose to use cefazolin (once-daily renal dose)." — respondent 9, internal medicine department, state hospital, 5 years of work experience.

In addition, the respondents highlighted the importance of considering a patient's pre-existing medical problems, such as underlying medical conditions, previous history of allergies and adverse effects, and prior diagnoses and cultures, when making decisions about antibiotic treatment. Although previous culture results and antibiotic histories were generally perceived as helpful in decision-making, they were less so for patients with a recent history of multiple admissions and exposure to various antibiotics, as this could pose challenges in promptly determining the appropriate antibiotic treatment. Respondents also noted that the COVID-19 pandemic presented new challenges to the timely initiation of appropriate antibiotic treatment, because COVID-19 needed to be ruled out before any blood sample could be drawn or processed, which led to delayed diagnosis and treatment.

"If a patient is admitted for… let's say pneumonia, we usually have to label the patient as severe acute respiratory infection, SARI, first. So, meaning to rule out COVID. So, because of this, the investigations that can be processed is very limited. Usually, microbiology won't process blood culture. This causes a lot of delay in giving the appropriate antibiotic." — respondent 10, internal medicine department, major specialist hospital, 5.5 years of work experience

Patients' clinical presentations and conditions were also key factors considered by respondents when deciding on antibiotics. They described that patients who are critically ill or with deteriorating conditions, such as septic shock, would be prescribed with broader spectrum antibiotics compared to stable patients without shock. Patients responding well to antibiotics would have their treatment continued or de-escalated, depending on laboratory investigations and cultures.

"So, it always depends on the condition of the patient… whether the patient is in shock, not in shock. So, in the initial phase, we have got no culture [and] sensitivities; so, we normally start with the empirical wide (broad) spectrum antibiotics." — respondent 8, internal medicine department, state hospital, 4 years of work experience.

Patients' autonomy in receiving treatment was also reported to influence the prescribing of appropriate antibiotics. For example, patients who refused intravenous antibiotics or requested discharge against medical advice might be prescribed oral antibiotics instead, which could have an impact on treatment outcomes.

"For example, the patient requested to be discharged earlier or discharge at own risk (AOR), and we had to discharge with oral antibiotics which might further reduce the effectiveness in our treatment." — respondent 7, internal medicine department, state hospital, 5 years of work experience

Theme 3: Antibiotic-related factors and barriers

These factors include physical properties, and pharmacokinetic and pharmacodynamic properties. The respondents expressed their consideration of the physical properties of antibiotics when treating patients with renal impairment and fluid restriction. This includes the volume of post-dilution and frequency of administration, particularly when multiple choices of antibiotics can provide the same pathogen coverage.

"Let's say, BSI (blood stream infection), for example. So, some patients (with renal impairment and fluid restriction), we are (usually) giving cloxacillin… but because of volume (risk of fluid overload), if there's available choice of cefazolin, they'll use the cefazolin because of (the) frequency that can be OD (once daily) rather than the cloxacillin which can be QID (quarter in die or four times a day)." — respondent 6, internal medicine department, state hospital, 7 years of work experience

The respondents mentioned converting patients from intravenous to oral antibiotics once their clinical condition improved, provided the bioavailability of the oral antibiotic was similar to the intravenous form. Besides choosing the appropriate antibiotics, respondents would also consider the pharmacokinetic and pharmacodynamic properties of the antibiotics, such as penetration to the infection site, optimal dose, and bioavailability; to ensure successful treatment of the infection.

"For example, a patient with meningoencephalitis... Whatever cultures that we send will show a certain sensitivity towards a range of antibiotics, but we need to take into account the choice of antibiotics because you need the antibiotics to be able to cross the blood-brain barrier effectively to treat the patient." — respondent 14, internal medicine department, major specialist hospital, 9 years of work experience

Theme 4: infection-related factors and barriers

This theme included epidemiology and prevalence of infection, types and sources of infection, causative pathogens, and surgery-related factors. The respondents acknowledged that local endemicity of certain infections, such as melioidosis and recent local outbreaks of certain infections in the ward or hospital would prompt them to prescribe antibiotics to treat these common infections unless proven otherwise.

Before deciding to replace an antibiotic that was deemed ineffective for a patient, respondents would consider the type and source of the infection, including the natural history, diagnosis, and severity of the infection. For example, in the case of melioidosis, it may take longer for fever to resolve even if the patient is responding well to the antibiotics. As such, the escalation of antibiotics from ceftazidime to carbapenem may not be necessary. Additionally, respondents from the orthopedic department considered factors such as the condition of wounds in response to antibiotics, the risks of wound contamination from different environments, and the severity of the infection.

"Usually what we look at is the condition of the wound. Is it granulating well? Is there slough? Is there a new development of pus or not? Is the surrounding erythematous? All these will let us know if the patient is responding well to the antibiotics [or not]." — respondent 18, orthopedic department, university hospital, 4.5 years of work experience

"So, if let's say it's open fracture… open fracture on a tar road and open fracture in the drain [are] two different things, you know… The wound can be infected by certain specific bacteria… some anaerobes… so our antibiotic selection may be different." — respondent 18, orthopedic department, university hospital, 4.5 years of work experience

Before the release of culture reports, respondents described that they would decide on antibiotics based on the possible causative pathogens to be covered. Once the culture results are released, they would check on the sensitivity and significance of the culture before changing antibiotics.

"You see... the wound may look a bit greenish; the discharge is a bit greenish… there's a typical smell, you know that this is definitely Pseudomonas. Tazocin (piperacillin/tazobactam) is started. So, once you send the culture and sensitivity, and it comes back to be Pseudomonas, then we will change accordingly. [But] It very depends on the culture. If it's a swab culture we take in the ward, then there's a high chance of contaminants. If you take a deep tissue culture in the operating theatre, and it grows something, then we definitely will trust that more than anything else, you know..." — respondent 18, orthopedic department, university hospital, 4.5 years of work experience.

However, respondents were facing challenges with cultures that showed no growth despite patients' clinical conditions indicating the presence of an infection. In such cases, they would rely on their clinical judgment and continue administering antibiotics rather than discontinuing them.

"The yield (of positive culture) is very low, it doesn't correlate with clinical findings that we are looking at the patient… patient looks very septic, it

should be something growing but most of time [there] is no growth on culture... so, that point of time, we usually don't trust the culture… we just treat according to the clinical examination …" — respondent 17, internal medicine department, university hospital, 10 years of work experience

Both orthopedic and surgical respondents reported that surgery-related factors, such as the timing, type, and duration of surgery, influenced their decisions regarding antibiotic prescribing. For example, emergency or repetitive surgery was perceived to be important for certain severe local infections because it could prevent the systemic spread of infection and deterioration of the patient's condition. However, the timing of surgery was determined by the patient's clinical condition, and unstable patients may not undergo surgery even when it was indicated, due to the need to balance the risks and benefits of surgery for the patient's clinical outcome.

"It's based on the patient's condition and [whether] the patient is fit for surgery or not. So, most of the common cases happen, patients with severe sepsis, severe infections… Sometimes [the] patient might be having a heart attack as well, MI (myocardial infarction); then there's a… in between a life-saving procedure and the infection control, there's a need to be balanced." — respondent 12, orthopedic hospital, major specialist hospital, 8 years of work experience.

The respondents also described that the duration of surgery determined the risk of patients getting surgical wound infections, resulting in a longer duration or change of antibiotics.

"The surgery time (duration) will affect the duration of antibiotics as well… Because the more time you take about the surgery, the more contamination. Even though you are doing [the surgery in] OT (operation theatre); [it] doesn't mean that there is no contamination. There's still 1 or 2 percent infection rate there… So, time (duration) of surgery; if it is shorter, then, duration of antibiotic will be shorter... vice versa." — respondent 12, orthopedic hospital, major specialist hospital, 8 years of work experience

Theme 5: organization setting-related factors and barriers

This theme included organization policies, working environment, and availability of resources. AMS policies were perceived to play an essential role in ensuring the appropriateness of antibiotic prescribing practices in a hospital, especially with broad-spectrum antibiotics. The respondents commented that AMS-related strategies of restriction and pre-authorization of antibiotics, regular audits, and antibiotic rounds by AMS teams had affected their decision-making process, leading to justified and less unnecessary antibiotic use. However, respondents from resource-limited hospitals without in-house specialists described undesirable issues with antibiotic restriction and pre-authorization leading to delayed initiation of appropriate broad-spectrum antibiotics. This happened because of the perceived lengthy procedure to get the visiting specialists' approval to start the restricted antibiotic.

"For example, if I think my diagnosis [for the patient] is going to be nosocomial infection, I would want to start Tazocin (piperacillin/tazobactam). But limitations are I cannot [do that] because I have to call my specialist and discuss [it first]." — respondent 22, internal medicine department, minor specialist hospital, 4 years of work experience.

Regarding working environments, the importance of a multidisciplinary approach was frequently highlighted by the respondents. A healthy working environment with good inter-collegial and inter-professional collaboration, including with pharmacists, nurses, laboratory staff, radiology staff, and record unit staff; could accelerate the decision-making process in prescribing appropriate antibiotics. In addition, the engagement of nurses and ward pharmacists in rounds was perceived as crucial by respondents to ensure smoother decision-making.

"That's why we need the teamwork. For example, if [it's] only [the] MO (medical officer) who needs to trace everything, then of course, it will be difficult." — respondent 9, internal medicine department, state hospital, 5 years of work experience

"The presence of pharmacists there during ward round is very important because they really make a difference in the way that we prescribe. Most of the pharmacists actually really follow the national antibiotic guidelines… you know, the personal preference is not a good way to choose antibiotics." — respondent 5, internal medicine department, major specialist hospital, 9 years of working experience.

The respondents reported that effective communication was vital in promoting inter-collegial and inter-professional collaboration, as it could minimize misunderstandings and optimize patients' clinical outcomes.

"If I think the patient [referred by other departments] requires the [change of] antibiotic immediately, I will call in the MO (medical officer) and have a discussion. If they disagree, then, they probably will call their specialist or consultant… So, it's always a discussion [between doctors from different

departments]. We will do things as per our terms, but we will definitely take in everyone's consideration." — respondent 9, internal medicine department, state hospital, 5 years of work experience.

In addition, the respondents frequently mentioned that the availability of resources was a critical factor in their decision to prescribe appropriate antibiotics. This included access to antibiotics, relevant expertise, diagnostic tests, laboratory services, readily accessible reference sources, and electronic medical systems. The respondents noted that this was particularly challenging in public hospitals with limited resources, where they had to optimize the use of available resources to ensure the best possible outcomes for their patient. Sometimes they needed to prescribe antibiotics based on availability. For example, one respondent reported that limited antibiotic choices in rural hospitals could delay the prompt initiation of antibiotics that would need to be accessed from other distant hospitals.

Based on previous experience in other hospitals, readily accessible online reference sources were reported by one respondent to facilitate decision-making, as doctors could check the appropriate guidelines anywhere, anytime. The respondents also highlighted the importance of having relevant expertise such as in-house specialists, ID specialists, ward pharmacists, clinical microbiologists, radiology teams, and AMS teams. In smaller hospitals with limited resources, complicated cases or cases requiring surgeries may need to be referred to larger hospitals for further management, and there might be prolonged antibiotic use if there was a delay in patient acceptance and transfer.

"Before when I was in Hospital W, of course it's easier because the ID (specialist) is there (in-house). So, if you have anything, you can consult [him] any time, day, morning, night, any day, every day." — respondent 4, internal medicine department, major specialist hospital, 2 years of work experience.

"In smaller hospitals, when you would like to refer cases for surgery… because of lack of human resources (in-house surgeons)… So, we cannot (operate to) rapidly remove the source of infection as expected… so we might continue antibiotics longer while waiting for them (surgeons) to do something…" — respondent 17, internal medicine department, university hospital, 10 years of work experience.

The availability of radiology and laboratory services, as well as electronic medical systems, was perceived to affect antibiotic prescribing decisions. The lack of such resources was perceived as a barrier in limited-resource public hospitals where services are often outsourced to larger hospitals.

"Here (limited-resource hospital), if there's a growth, they (laboratory staffs) will send to another hospital [to further culture]. They only give us the preliminary report (Gram-stained organism). Once it goes to the other hospital (to further culture), then only we get the final formal report (culture and sensitivity). So, in that way, there is a slight delay, yeah, to escalate the antibiotic" — respondent 22, internal medicine department, minor specialist hospital, 4 years of work experience.

Discussion

To our knowledge, this is the first qualitative study to provide an in-depth overview focusing on the factors and barriers influencing doctors' decisions to prescribe antibiotics to inpatients in different public hospital settings in Malaysia. Findings from this study demonstrate that prescribing antibiotics is a complex process that is influenced by both intrinsic and extrinsic factors, which may be interrelated, either directly or indirectly. Notably, doctors in resource-limited hospitals appeared to experience more barriers in prescribing appropriate antibiotics than those in larger hospitals with more expertise and resources. These findings can help to facilitate quality improvement strategies aimed at promoting more rational antibiotic prescribing practices and enhancing AMS programs in Malaysia.

Findings from this study demonstrated that patient-related factors were not the only factors influencing doctors' decision-making processes for prescribing antibiotics to inpatients. Intrinsic factors, such as prescriber-related factors were also commonly reported, consistent with previous studies [36–41]. The respondents were aware of the importance of antibiotic resistance and the need to streamline antibiotics based on cultures, in line with other studies [19,42,43]. Nonetheless, some respondents acknowledged that irrational antibiotic prescribing can happen due to lack of prescriber competency, negative attitudes, and fear of patient complaints or deterioration. These individual factors can be addressed by implementing and including AMS strategies in hospital policies, such as regular antibiotic usage monitoring by pharmacists along with audits and feedback to doctors, and continuous medical education [43,44].

This study also found that socio-cultural contexts such as senior-junior hierarchy, professional hierarchy, and non-interference of others' prescribing; influenced respondents' decision-making, as reported in previous

studies [17,19,24,30,37–41]. Doctors may passively adhere to the prescribing norms in their hospitals due to fear of criticism, individual responsibility for patients' deterioration, and the desire to maintain a positive relationship with colleagues [18,19,24,45]. Effective inter-collegial and inter-professional communications, regular review of selected broad-spectrum antibiotic cases by the multidisciplinary AMS team, and role modelling by senior staff during rounds can help break and improve the prevailing cultures in the hospital [13,18,24,39,46]. Enforcing the best antibiotic prescribing practices through leadership at the department level is crucial when developing hospital policies for quality improvement [30].

The availability of resources was deemed to be an important extrinsic factor by most respondents in this study. Without these resources, appropriate diagnosis and antibiotic prescribing could be delayed, which could impact clinical outcomes of patients. The availability of non-human resources was described to a greater extent in this study as compared to previous overseas studies. A probable reason for this is the differences in healthcare system settings, as different types of public hospitals in Malaysia are equipped with different resources [25]. Smaller district public hospitals may only be equipped with basic resources to serve nearby communities due to geographical limitations, although referrals of complicated cases and outsourcing of laboratory and radiology services can be made to larger resource-rich public hospitals when needed [25]. Outsourcing of laboratories and delays in receiving microbiology reports can lead to prolonged inappropriate antibiotic use, due to increased transfer time and a lack of remote tracing system [14,47]. Effective pooling of resources within hospital networks by state health departments and expanding telecommunication services are recommended to address this issue [48].

In terms of human resources, ID specialists and microbiologists are commonly recognized as essential experts for prescribing antibiotics [14,24]. The unavailability of these experts in certain hospitals was perceived as a common barrier. Remote consultation or teleconference with visiting experts from other hospitals can improve appropriate antibiotic prescribing [48,49]. In addition, the importance of pharmacists in the decision-making process for prescribing antibiotics was highlighted by a few respondents in this study and other studies, highlighting the increasing importance of multidisciplinary collaboration and its acceptance by doctors [14,24,38,39]. Pharmacists play a vital role in being the gatekeeper to antibiotic use by actively and regularly reviewing antibiotic orders, participating in ward rounds, providing telephone advice, and implementing AMS activities to reinforce prudent prescribing of antibiotics to inpatients [39,44].

Interestingly, compared to other studies, antibiotic- and surgery-related factors were frequently reported in this study. The optimization of dosing based on pharmacokinetic and pharmacodynamic concepts has gained much attention in recent years as it maximizes treatment outcomes and minimizes the emergence of antibiotic resistance and healthcare costs [50]. In Malaysia, the public healthcare system is funded by the federal government, and patients pay a minimal fee [25]. Therefore, the selection of antibiotics considers their pharmacokinetic and pharmacodynamic profile and effectiveness to ensure hospital budgets are utilized efficiently to treat more patients. Furthermore, this study found that respondents from different specialties considered different factors when taking decisions on antibiotics. For instance, diagnosis and severity of wound infections and surgery-related factors were commonly considered by respondents from surgical and orthopedic departments. Wound conditions, types of surgery, and timing and duration of surgery, determine the rate of infections, and hence influence the choice and continuation of antibiotics post-surgery [51–54]. Further studies should delve into them, and more studies can be conducted in AMS in wound care.

The findings from this study dictate a wide range of factors and barriers that are interrelated. Implementing suitable AMS strategies according to different factors and barriers in different hospital settings is imperative to improve inpatient antibiotic prescribing among doctors [17,19]. However, the restrictive and persuasive strategies and educational interventions in AMS may not promise behavioral changes in humans, because behavior change is complex and influenced by numerous factors interacting at multiple levels [41,55,56]. Nevertheless, the application of behavioral science has an emerging role in optimizing prudent antibiotic use in AMS [38,55,57]. Policy changes and translation into better antibiotic prescribing practices may include creating a prescribing norm of managing antibiotic resistance as everyone's responsibility, and positive role modeling and enabling trust to raise questions and challenge others [13]. Changing existing behaviors and working cultures among the doctors may not be easy, but the desired behaviors can be cultivated among future doctors through instilling the thought of acknowledging the engagement of multidisciplinary collaboration in the decision-making for judicious antibiotic prescribing during undergraduate and

postgraduate training programs [57]. Additionally, incorporating conceptual framework into clinical practice, such as the "four moments of antibiotic decision making", can assist doctors in recognizing problems and guide them with potential solutions through adaptive change model [56]. The framework uses a structured stepwise approach composed of four critical moments of antibiotic decision-making, starting from the diagnosis of infection until the completion of antibiotics dosage [31]. Similarly, to help translate knowledge into behavior and close the gap between intentions and actions, introducing implementational intention of "if-then" plans to doctors may be effective in changing their behavior [58]. Some examples of implementational intention to ensure appropriate inpatient antibiotic prescribing are: "If I have prescribed broad spectrum antibiotics, then I should review the culture results after 72 hours to decide the need to de-escalate them"; "If an antibiotic initiated by others is not justifiable, then I should discuss with them and do necessary changes"; and "If an antibiotic is prescribed for a patient, then I should check or decide the duration".

There are a few strengths in this study. The respondents were recruited based on different clinical backgrounds and various working experiences in different Malaysian public hospital settings, to ensure diversity and richness of the data. The inclusion of surgeons in this study provided additional interesting and valuable findings, which to our knowledge, were not frequently reported in previous studies. One-to-one interviews instead of focused group discussions, were conducted to avoid the possible impact of senior-junior hierarchy issues and to delve in depth into the scope. A limitation of this study is that the respondents were recruited from only 6 public hospitals in 3 states in West Malaysia. Thus, the findings from this study may not be generalized to the entire doctor population in public hospitals. In addition, doctors from private hospitals were not included in this study because there could be a possibility of differences in cultural and social context. Future studies can be expanded to include doctors nationwide including East Malaysia and private hospitals, to get a more comprehensive insight into this topic.

Conclusions

This study provides valuable insights into various factors and barriers, including intrinsic and extrinsic factors, that influence doctors' decision-making process when prescribing antibiotics to inpatients in Malaysian public hospitals. The complex interactions between the themes suggest that behavioral change is required to improve appropriate inpatient antibiotic prescribing practices. Therefore, the findings from this study should be considered in conjunction with the application of behavioral science in designing targeted approaches for quality improvement interventions.

Acknowledgements

We would like to thank the Director General of Health, Malaysia, for the permission to publish this paper. We also wish to thank all the respondents for their time in the study and express our gratitude to all the involved hospitals for the support from their hospital directors to complete this study during the COVID-19 pandemic.

Authors' contributions

Conceptualization: WWC, LSK; methodology, LSK, WWC, FI, LM, KCK; validation: LSK, WWC, FI, LM, KCK; formal analysis: LSK, WWC, FI, LM, KCK; investigation: LSK, WWC; writing — original draft: LSK.; writing — review and editing: WWC, FI, LM, KCK; supervision: WWC; funding acquisition: WWC.

Funding

The study was supported by the Transdisciplinary Research Grant Scheme (TRGS), grant number (TRGS/1/2022/UKM/02/8/2), funded by the Ministry of Higher Education (MOHE), Malaysia; and the Dana Cabaran Perdana (DCP), grant number (DCP-2017-003/5), Universiti Kebangsaan Malaysia.

Corresponding author

Wei Wen Chong, PhD.
Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz,
50300 Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, Malaysia.
Tel: +60-3-9289-7118
Fax: +603-2698 3271
Email: weiwen@ukm.edu.my

Conflict of interests

No conflict of interests is declared.

References

1. World Health Organization (2019) New report calls for urgent action to avert antimicrobial resistance crisis. Available: https://www.who.int/news-room/detail/29-04-2019-new-report-calls-for-urgent-action-to-avert-antimicrobial-resistance-crisis. Accessed: 20 January 2025.
2. Roberts RR, Hota B, Ahmad I, Scott II RD, Foster SD, Abbasi F, Schabowski S, Kampe LM, Ciavarella GG, Supino M, Naples J, Cordell R, Levy SB, Weinstein RA (2009) Hospital and societal costs of antimicrobial resistant infections in a Chicago teaching hospital: implications for antibiotic

stewardship. Clin Infect Dis 49: 1175–1184. doi: 10.1086/605630.
3. Prestinaci F, Pezzotti P, Pantosti A (2015) Antimicrobial resistance: a global multifaceted phenomenon. Pathog Glob Health 109: 309–318. doi: 10.1179/2047773215Y.0000000030.
4. Harrison PF, Lederberg J (1998) Antimicrobial resistance: issues and options. In Harrison PF, Lederberg J, editors. The National Academy of Sciences. 128 p.
5. Filice GA, Drekonja DM, Thurn JR, Hamann GM, Masoud BT, Johnson JR (2015) Diagnostic errors that lead to inappropriate antimicrobial use. Infect Control Hosp Epidemiol 36: 949–956. doi: 10.1017/ice.2015.113.
6. Cecchini M, Langer J, Slawomirski L (2015) Antimicrobial resistance in G7 countries and beyond: economic issues, policies. Available: https://www.oecd.org/els/health-systems/Antimicrobial-Resistance-in-G7-Countries-and-Beyond.pdf. Accessed: 20 January 2025.
7. Friedman ND, Temkin E, Carmeli Y (2016) The negative impact of antibiotic resistance. Clin Microbiol Infect 22: 416–422. doi: 10.1016/j.cmi.2015.12.002.
8. Tamma PD, Avdic E, Li DX, Dzintars K, Cosgrove SE (2017) Association of adverse events with antibiotic use in hospitalized patients. JAMA Intern Med 177: 1308–1315. doi: 10.1001/jamainternmed.2017.1938.
9. Calderón-Parra J, Muiño-Miguez A, Bendala-Estrada AD, Ramos-Martínez A, Muñez-Rubio E, Fernández Carracedo E, Tejada Montes J, Rubio-Rivas M, Arnalich-Fernandez F, Beato Pérez JL, García Bruñén JM, Del Corral Beamonte E, Pesqueira Fontan PM, Carmona MDM, Fernández-Madera Martínez R, González García A, Salazar Mosteiro C, Tuñón de Almeida C, González Moraleja J, Deodati F, Martín Escalante MD, Asensio Tomás ML, Gómez Huelgas R, Casas Rojo JM, Millán Núñez-Cortés J; SEMI-COVID-19 Network (2021) Inappropriate antibiotic use in the COVID-19 era: factors associated with inappropriate prescribing and secondary complications. Analysis of the registry SEMI-COVID. PLoS One 16: e0251340. doi: 10.1371/journal.pone.0251340.
10. Krockow EM, Colman AM, Chattoe-Brown E, Jenkins DR, Perera N, Mehtar S, Tarrant C (2019) Balancing the risks to individual and society: a systematic review and synthesis of qualitative research on antibiotic prescribing behaviour in hospitals. J Hosp Infect 101: 428–439. doi: 10.1016/j.jhin.2018.08.007.
11. Barlow G, Nathwani D, Myers E, Sullivan F, Stevens N, Duffy R, Davey P (2008) Identifying barriers to the rapid administration of appropriate antibiotics in community-acquired pneumonia. J Antimicrob Chemother 64: 442–451. doi: 10.1093/jac/dkm462.
12. Bjorkman I, Berg J, Roing M, Erntell M, Lundborg CS (2010) Perceptions among Swedish hospital physicians on prescribing of antibiotics and antibiotic resistance. Qual Saf Heal Care 19: e8. doi: 10.1136/qshc.2008.029199.
13. Papoutsi C, Mattick K, Pearson M, Brennan N, Briscoe S, Wong G (2017) Social and professional influences on antimicrobial prescribing for doctors-in-training: a realist review. J Antimicrob Chemother 72: 2418–2430. doi: 10.1093/jac/dkx194.
14. Velasco E, Ziegelmann A, Eckmanns T (2012) Eliciting views on antibiotic prescribing and resistance among hospital and outpatient care physicians in Berlin, Germany: results of a qualitative study. BMJ Open 2: e000398. doi: 10.1136/bmjopen-2011-000398.
15. Tan WL, Siti R, Shahfini I, Zuraidah A (2015) Knowledge, attitude and practice of antibiotics prescribing among medical officers of public health care facilities in the state of Kedah, Malaysia. Med J Malaysia 70: 307–311.
16. Thriemer K, Katuala Y, Batoko B, Alworonga J-P, Devlieger H, Van Geet C, Ngbonda D, Jacobs J (2013) Antibiotic prescribing in DR Congo: a knowledge, attitude and practice survey among medical doctors and students. PLoS One 8: e55495. doi: 10.1371/journal.pone.0055495.
17. Livorsi D, Comer A, Matthias M, And EP, Bair M (2015) Factors influencing antibiotic-prescribing decisions among inpatient physicians: a qualitative investigation. Infect Control Hosp Epidemiol 36: 1065–1072. doi: 10.1017/ice.2015.136.
18. Rodriguesa A, Roque F, Falcão A, Figueiras A, Herdeiro MT (2013) Understanding physician antibiotic prescribing behaviour: a systematic review of qualitative studies. Int J Antimicrob Agents 41: 203–212. doi: 10.1016/j.ijantimicag.2012.09.003.
19. Warreman EB, Lambregts MMC, Wouters RHP, Visser LG, Staats H, van Dijk E, de Boer MGJ (2019) Determinants of in-hospital antibiotic prescription behaviour: a systematic review and formation of a comprehensive framework. Clin Microbiol Infect 25: 538–545. doi: 10.1016/j.cmi.2018.09.006.
20. Ab Rahman N, Teng CL, Sivasampu S (2016) Antibiotic prescribing in public and private practice: a cross-sectional study in primary care clinics in Malaysia. BMC Infect Dis 16: 1–8. doi: 10.1186/s12879-016-1530-2.
21. Teng CL Nurjahan MI, Hashim NA, Punithambigai P, Leong KC, Mihat Ob (2003) Upper respiratory tract infections: to what extent is the management evidence-based? Med J Malaysia 58: 159–166.
22. Teng CL, Leong CL, Aljunid SM, Cheah M (2004) Antibiotic prescription in upper respiratory tract infections. Asia Pac Fam Med 3: 38–45.
23. Teng CL, Khoo EM, Lee V, Zailinawati AH, Mimi O, Chen WS, Nordin S (2011) Antibiotics for URTI and UTI. Prescribing in Malaysian primary care settings. Aust Fam Physician 40: 325–329.
24. Wojcik G, Ring N, McCulloch C, Willis DS, Williams B, Kydonaki K (2021) Understanding the complexities of antibiotic prescribing behaviour in acute hospitals: a systematic review and meta-ethnography. Arch Public Heal 79: 1–19. doi: 10.1186/s13690-021-00624-1.
25. World Health Organization Regional Office for the Western Pacific (2013) Malaysia health system review. Available: https://iris.who.int/bitstream/handle/10665/206911/9789290615842_eng.pdf. Accessed: 20 January 2025.
26. Samsudin S, Sobri Jaafar A, Applanaidu SD, Ali J, Majid R (2016) Are public hospitals in Malaysia efficient? An application of DEA and Tobit analysis. Southeast Asian J Econ 4: 1–20.
27. Dworkin SL (2012) Sample size policy for qualitative studies using in-depth interviews. Arch Sex Behav 41: 1319–1320. doi: 10.1007/s10508-012-0016-6.
28. Vasileiou K, Barnett J, Thorpe S, Young T (2018) Characterising and justifying sample size sufficiency in interview-based studies: systematic analysis of qualitative health research over a 15-year period. BMC Med Res Methodol 18: 1–18. doi: 10.1186/s12874-018-0594-7.
29. Skodvin B, Aase K, Charani E, Holmes A, Smith I (2015) An antimicrobial stewardship program initiative: a qualitative study on prescribing practices among hospital doctors.

Antimicrob Resist Infect Control 4: 1–8. doi: 10.1186/s13756-015-0065-4.
30. Charani E, Sevdalis N, Kyratsis Y, Drumright L, Shah N, Holmes A (2013) Understanding the determinants of antimicrobial prescribing within hospitals: the role of "prescribing etiquette". Clin Infect Dis 57: 188–196. doi: 10.1093/cid/cit212.
31. Agency for Healthcare and Research Quality (2019) The four moments of antibiotic decision making. Available: https://www.ahrq.gov/sites/default/files/wysiwyg/antibiotic-use/four-moments/poster-three-options.pdf. Accessed: 20 January 2025.
32. ATLAS.ti Scientific Software Development GmbH. (2023) ATLAS.ti Mac (version 9.0.20.0). Qualitative data analysis software. Available: https://atlasti.com.
33. Boyatzis RE (1998) Transforming qualitative information: thematic analysis and code development, 1st edition. Thousand Oaks: Sage Publications 200 p.
34. Silverman D (2006) Interpreting qualitative data: methods for analyzing talk, text and interaction, 3rd edition. Sage Publications 448 p.
35. Donkoh S, Mensah J (2023) Application of triangulation in qualitative research. J Appl Biotechnol Bioeng 10: 6–9. doi: 10.15406/jabb.2023.10.00319.
36. Saliba-Gustafsson EA, Nyberg A, Borg MA, Rosales-Klintz S, Lundborg CS (2021) Barriers and facilitators to prudent antibiotic prescribing for acute respiratory tract infections: a qualitative study with general practitioners in Malta. PLoS One 16: 1–19. doi: 10.1371/journal.pone.0246782.
37. Chan YY, Bin Ibrahim MA, Wong CM, Ooi CK, Chow A (2019) Determinants of antibiotic prescribing for upper respiratory tract infections in an emergency department with good primary care access: a qualitative analysis. Epidemiol Infect 147: 1–7. doi: 10.1017/S095026881800331X.
38. Rawson TM, Charani E, Moore LSP, Hernandez B, Castro-Sánchez E, Herrero P, Georgiou P, Holmes AH (2016) Mapping the decision pathways of acute infection management in secondary care among UK medical physicians: a qualitative study. BMC Med 14: 1–10. doi: 10.1186/s12916-016-0751-y.
39. Hulscher MEJL, Grol RPTM, van der Meer JWM (2010) Antibiotic prescribing in hospitals: a social and behavioural scientific approach. Lancet Infect Dis 10: 167–175. doi: 10.1016/S1473-3099(10)70027-X.
40. Mattick K, Kelly N, Rees C (2014) A window into the lives of junior doctors: narrative interviews exploring antimicrobial prescribing experiences. J Antimicrob Chemother 69: 2274–2283. doi: 10.1093/jac/dku093.
41. Schouten JA, Hulscher MEJL, Natsch S, Kullberg B-J, van der Meer JW, Grol RP (2007) Barriers to optimal antibiotic use for community-acquired pneumonia at hospitals: a qualitative study. Qual Saf Heal Care 16: 143–149. doi: 10.1136/qshc.2005.017327.
42. Zhuo A, Labbate M, Norris JM, Gilbert GL, Ward MP, Bajorek BV, Degeling C, Rowbotham SJ, Dawson A, Nguyen KA, Hill-Cawthorne GA, Sorrell TC, Govendir M, Kesson AM, Iredell JR, Dominey-Howes D (2018) Opportunities and challenges to improving antibiotic prescribing practices through a One Health approach: results of a comparative survey of doctors, dentists and veterinarians in Australia. BMJ Open 8: 1–12. doi: 10.1136/bmjopen-2017-020439.
43. Akhtar A, Khan AH, Zainal H, Ahmad Hassali MA, Ali I, Ming LC (2020) Physicians' perspective on prescribing patterns and knowledge on antimicrobial use and resistance in Penang, Malaysia: a qualitative study. Front Public Health 8: 601961. doi: 10.3389/fpubh.2020.601961.
44. CDC (2019) The core elements of hospital antibiotic stewardship programs: 2019. Atlanta, GA. Available https//www.cdc.gov/antibiotic-use/core-elements/hospital.html. Accessed: 20 January 2025.
45. Broom A, Broom J, Kirby E (2014) Social science and medicine cultures of resistance? A Bourdieusian analysis of doctors' antibiotic prescribing. Soc Sci Med J 110: 81–88. doi: 10.1016/j.socscimed.2014.03.030.
46. Agency for Healthcare Research and Quality (2022) AHRQ safety program for improving antibiotic use. Available: https://www.ahrq.gov/sites/default/files/wysiwyg/antibiotic-use/overall-antibiotic-stewardship-project-final-report.pdf. Accessed: 20 January 2025.
47. Skodvin B, Aase K, Charani E, Holmes A, Smith I (2015) An antimicrobial stewardship program initiative: a qualitative study on prescribing practices among hospital doctors. Antimicrob Resist Infect Control 4: 24. doi: 10.1186/s13756-015-0065-4.
48. Stenehjem E, Hyun DY, Septimus E, Yu KC, Meyer M, Raj D, Srinivasan A (2017) Antibiotic stewardship in small hospitals: barriers and potential solutions. Clin Infect Dis 65: 691–696. doi: 10.1093/cid/cix407.
49. CDC (2020) Implementation of antibiotic stewardship core elements at small and critical access hospitals. Available: https://www.cdc.gov/antibiotic-use/media/pdfs/core-elements-small-critical-508.pdf. Accessed: 20 January 2025.
50. Hoo GSR, Liew YX, Kwa ALH (2017) Optimisation of antimicrobial dosing based on pharmacokinetic and pharmacodynamic principles. Indian J Med Microbiol 35: 340–346. doi: 10.4103/ijmm.IJMM_17_278.
51. BOA & BAPRAS (2020) Standards for the management of open fractures. Available: https://blrs.org.uk/wp-content/uploads/2021/02/BOA-and-BAPRAS-Standards-for-Open-fractures-2020.pdf. Accessed: 20 January 2025.
52. Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, Fish DN, Napolitano LM, Sawyer RG, Slain D, Steinberg JP, Weinstein RA, American Society of Health-System Pharmacists, Infectious Disease Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America (2013) Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Heal Pharm 70: 195–283. doi: 10.2146/ajhp120568.
53. Spagnolo AM, Ottria G, Amicizia D, Perdelli F, Cristina ML (2013) Operating theatre quality and prevention of surgical site infections. J Prev Med Hyg 54: 131–137.
54. Wounds UK (2020) Best practice statement: antimicrobial stewardship strategies for wound management. Available: https://wounds-uk.com/wp-content/uploads/2023/02/d2427e2ff3c9603cbf9afed8fd967cba.pdf. Accessed: 20 January 2025.
55. Lundborg CS, Tamhankar AJ (2014) Understanding and changing human behaviour-antibiotic mainstreaming as an approach to facilitate modification of provider and consumer behaviour. Ups J Med Sci 119: 125–133. doi: 10.3109/03009734.2014.905664.
56. Tamma PD, Miller MA, Cosgrove SE (2019) Rethinking how antibiotics are prescribed: incorporating the 4 moments of antibiotic decision making into clinical practice. JAMA 321: 139–140. doi: 10.1001/jama.2018.19509.
57. Pinder R, Sallis A, Berry D, Chadborn T (2015) Behaviour change and antibiotic prescribing in healthcare settings:

literature review and behavioural analysis. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/774129/Behaviour_Change_for_Antibiotic_Prescribing_-_FINAL.pdf. Accessed: 20 January 2025.

58. Saddawi-Konefka D, Schumacher DJ, Baker KH, Charnin JE, Gollwitzer PM (2016) Changing physician behavior with implementation intentions: closing the gap between intentions and actions. Acad Med 91: 1211–1216. doi: 10.1097/ACM.0000000000001172.