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An audit of antibiotic prescriptions: an antimicrobial stewardship pre-implementation study at a tertiary care public hospital

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Objective: To audit the prescribing of antibiotics at a tertiary-level public hospital, in preparation for the implementation of an antimicrobial stewardship programme.

Methods: A retrospective audit of antibiotic prescriptions for the period April 2020 to June 2020 was conducted to ascertain appropriate antibiotic prescribing based on a set of process measures, which included whether cultures were taken before the initiation of empirical antibiotics, the duration of antibiotic therapy, de-escalation to a narrower spectrum antibiotic, the concurrent use of four or more antibiotics, documented indication for antibiotic use, and parenteral to oral conversion. Statistics were calculated using Stata (Version 17).

Results: A total of 380 patient medical charts were reviewed. It was noted that there were no standalone antibiotic charts, and antibiotics were prescribed alongside other medication in one prescription record. There was non-compliance to one or more of the process measures in two-thirds of antibiotic prescriptions audited. Excessive duration of therapy was evident in 3.16% (12) prescriptions. There were 18 (4.74%) instances in which de-escalation to a narrower spectrum antibiotic based on susceptibility results did not occur. Only a small proportion of patients were switched from parenteral to oral antibiotics ($n=12$, 3.16%). Some of the additional findings included redundant antibiotic coverage ($n=137$, 36.05%) and prescription of an antibiotic that did not align with the susceptibility results ($n=98$, 25.79%).

Conclusions: Inappropriate antibiotic prescribing did occur in some cases. The results from this pre-implementation study highlight the importance of introducing antimicrobial stewardship interventions with process and outcome measures.

Introduction

The development of antibiotics is one of the most revolutionary discoveries in the history of medicine. Antibiotics have enhanced healthcare delivery and increased life expectancy by allowing for advanced medical practices, including surgery and organ transplants, and reducing morbidity and mortality.[1] Contrary to these advantages, resistant pathogens develop due to inappropriate antibiotic use. Antimicrobial resistance (AMR) is an increasing global threat to public health systems.[2,3] Failure to prioritize the management of AMR causes an upsurge in mortality and lengthier hospital stays as infections caused by drug-resistant resistant pathogens lead to higher rates of adverse clinical outcomes. Furthermore, this increases expenditure due to resource utilization and more costly treatment options.[4]

Many countries, including South Africa, are in the process of developing and implementing National Action Plans on AMR, central to which is antimicrobial stewardship (AMS).[5] With a limited number of drugs in the drug developmental pipeline, the current focus should be on using existing antibiotics efficaciously to preserve effectiveness.[6,7] AMS promotes appropriate antimicrobial prescribing to enhance patient outcomes, maintain patient safety, reduce antimicrobial costs, and limit the occurrence of resistant pathogens.[5] Many hospitals in low- and middle-income countries (LMICs) have various areas in which antibiotic prescribing can be improved; however, the challenge of limited resources precludes the simultaneous implementation of several changes.[3]

Performing a retrospective audit on patient medical charts assesses appropriate antibiotic prescribing and identifies prescribing

Table 1. List of process measures with corresponding definitions[5,9]

Process measure	Definition	Source (via Meditech)
Cultures are taken before the initiation of empirical antibiotics	Patients who are initiated on empirical antibiotics and cultures are taken within 48 h before or on the initiation of therapy.	Patient medical chart Microbiology laboratory results
Duration of antibiotic therapy	The duration of antibiotic treatment complied with the appropriate length of therapy as recommended in relevant treatment guidelines.	Patient medical chart Clinical notes
Opportunities for de-escalation	De-escalation to a narrower spectrum antibiotic based on susceptibility data.	Patient medical chart Microbiology laboratory results Clinical notes
Documented indication for antibiotic use	Requires the need for antibiotic therapy/indication to be written for the patient.	Clinical notes
Conversion from parenteral to oral administration	The practice of converting from a parenteral to an effective oral formulation of antimicrobial.	Patient medical chart Clinical notes

patterns. This is an ideal starting point for recognizing priority areas that should be focused on when introducing ASPs.[3,5] Consistent auditing of antibiotic prescribing can be used to evaluate the success of any interventions and provide feedback to prescribers on the quality and quantity of antibiotics prescribed.[5]

A set of pre-defined process measures can be used in antibiotic prescription audits, some of which include a documented indication, stop/review date of therapy, review of therapy after 48 h, compliance with the latest treatment guidelines, duration of therapy, de-escalation of therapy, and parenteral to oral conversion.[5,8,9] Incorporating the WHO AWaRe classification in an audit can provide useful insights into prescribing patterns.[5] The AWaRe classification includes commonly used antibiotics in three groups—Access (lower resistance potential), Watch (higher resistance potential), and Reserve (last-resort options).[5]

This pre-implementation study within a tertiary-level public hospital assessed antibiotic prescribing using patient medical charts, based on selected process measures.

Methods

Ethical clearance

Ethical approval and permission to conduct the study were obtained from the Biomedical Research Ethics Committee (BREC) (BREC/00002530/2021) of the University of KwaZulu-Natal and the Provincial Health and Research Ethics Committee (PHREC), respectively.

Confidentiality

The results were reported with no linked patient identifiers. No individual patient-level data were reported. All results were reported as aggregated total frequencies and percentages.

Study site

This pre-implementation study was conducted at a central tertiary care, referral public hospital in Durban, KwaZulu-Natal (KZN). The 800-bed hospital offers various specialities and has an on-site microbiology laboratory service, which has a website and mobile application where results can be traced. Additionally, the microbiology results are available on-site via the electronic health record system.

Collection of data on antibiotic use

A retrospective antibiotic prescription audit was conducted for the period April to June 2020. Data on antibiotic prescriptions were retrieved from two of the facility's electronic health record systems, Qliksense and Meditech (Version ALS.LIVE615.15F). Information was obtained from various sections and included medications prescribed, microbiology reports, and patient clinical notes [Table S1 (available as Supplementary data at *JAC-AMR* Online)].

A list of process measures (Table 1) was selected based on similar South African and international studies, WHO guidelines for implementing AMS in LMICs, and the South African National Department of Health guidelines on the implementation of the antimicrobial strategy.[5,9–11] Relevant treatment guidelines were used to ascertain the duration of antibiotic therapy and included Hospital Level Standard Treatment Guidelines and Essential Medicines List Fifth Edition (Adults and Paediatric) and South African medicines formulary 12th edition.[12–16]

Appropriateness of prescribing was determined based on compliance with a set of process measures. This included checking if cultures were taken before the initiation of empiric antibiotics, an indication for antibiotic use was documented, the correct antibiotic was selected according to sensitivity results, the antibiotic was used for a suitable duration, and conversion from a parenteral to an effective oral formulation of antibiotics occurred according to the patient's clinical condition as determined by the clinician.

Statistical analysis

Descriptive statistics were calculated for the individual process measures. The percentage of times a combination of process measures occurred together was calculated. A one proportion z-test was then used to determine if the observed percentage differed from the binomial probability of them occurring together by chance. Stata (Version 17) was used for statistical analysis. A 95% confidence interval and statistical significance set at the 5% level was used.

Results

Process measures

A total of 380 patient medical charts were reviewed. There was non-compliance to one or more of the process measures in two-thirds of antibiotic prescriptions audited. The majority of patients were treated in intensive care units ($n = 175$, 46.05%). Several patients underwent specialized surgical procedures ($n = 73$, 19.21%). Some of the common specialties for which patients were admitted included renal (peritoneal dialysis), neurosurgery, cardiology, oncology, gastroenterology, orthopaedics, and urology. Some of the common infections treated involved peritonitis, endocarditis, urinary tract infections, pneumonia, and other infections related to specialized surgical procedures such as wound site sepsis.

Compliance against the pre-defined process measures was as follows:

(i) Cultures were taken before the initiation of empirical antibiotics in 367 (96.56%) cases.
(ii) An excessive duration of therapy occurred in 12 (3.16%) cases.
(iii) Opportunities for de-escalation to a narrower spectrum antibiotic based on susceptibility results were missed in 18 (4.74%) cases.
(iv) The indication for antibiotic use was documented in 329 (86.58%) of patient medical charts.
(v) Conversion from parenteral to oral administration occurred in 12 (3.16%) cases.

Additional findings from the antibiotic prescription audit

Several additional findings involving inappropriate antibiotic prescribing were observed during the antibiotic prescription audit (Table S2).

Microbiology and antibiotic susceptibility testing

Microbial culture and susceptibility testing to guide antibiotic therapy is practiced at the facility. One of the most frequently occurring findings was the prescribing of an antibiotic that did not align with the susceptibility results ($n=98$, 25.79%). This can be explained as using an antibiotic that has an effect on the bacterial organism but is not the most suitable option for therapy as per the susceptibility results. In some instances, it was noted that the more suitable options, based on susceptibility results, were delayed in being initiated ($n=18$, 4.74%).

Antibiotic therapy was continued following negative culture results in 63 (16.58%) cases. On the other hand, it was noted that antibiotic therapy was not continued in some cases despite culture results showing bacterial growth ($n=28$, 7.37%). In these cases, the reason for discontinuation was not recorded. There were a few instances where empiric therapy was continued without microbiologically significant results ($n=13$, 3.42%). This was where culture results showed the growth of a bacterial species, for example, staphylococcal species, which may be considered a contaminant or a commensal organism. These types of culture results along with mixed growth cultures do not warrant antibiotic therapy; therefore, the decision to continue antibiotics by the clinician was based on the clinical response of the patients. There were three (0.79%) cases in which a reserve antibiotic was used where culture results did not warrant its use.

Redundant/duplicate/multiple antibiotic cover

There were 137 (36.05%) instances of redundant antibiotic coverage. This can be defined as the intentional or unintentional prescribing of antibiotics with overlapping or duplicate spectra in terms of Gram-negative, Gram-positive, and anaerobic cover, on the same calendar day for at least two consecutive days.[9] This study identified redundant combinations in three categories.

(i) Redundant Gram-negative coverage: concurrent administration of two or more of any of the following drugs in or between groups: cephalosporins (ceftriaxone, ceftazidime, and cefotaxime), fluoroquinolones (ciprofloxacin and levofloxacin), β-lactam plus β-lactamase-inhibitor (amoxicillin/clavulanate and piperacillin/tazobactam), aminoglycosides (amikacin and gentamycin), carbapenems (meropenem and imipenem), and tigecycline.[9]
(ii) Redundant Gram-positive coverage: concurrent administration of two or more of any of the following drugs in or between groups: β-lactams (amoxicillin, cefazolin, and cloxacillin), tigecycline, clindamycin, linezolid, and glycopeptides (vancomycin and teicoplanin).[9]
(iii) Redundant anaerobe coverage: the concurrent administration of two or more of any of the following drugs in or between groups: metronidazole, β-lactam plus β-lactamase-inhibitor (amoxicillin/clavulanate and piperacillin/tazobactam), carbapenems (meropenem and imipenem), moxifloxacin, clindamycin, cefoxitin, and tigecycline.[9]

There were two (0.53%) cases in which more than four antibiotics were prescribed concurrently in a patient.

In a few cases ($n=17$, 4.47%), patients were infected with multiple bacterial organisms and one or more of the isolates were also multi-drug resistant, which complicated antibiotic therapy. In two (0.53%) of these cases, the bacteria were resistant to a last-resort antibiotic, colistin. Some of these cases were defined by the clinician, within the medical record notes, as complicated, persistent, or ongoing cases of infection. It was noted that the use of multiple antibiotics commonly occurred in these cases ($n=17$, 4.47%). This differed from the use of four antibiotics concurrently, as it was not defined by the antibiotics being used for two consecutive days but rather spread over many days and involved changing/adding on antibiotics based on the patient's clinical condition during their hospital stay.

Medical record notes

Patient clinical notes did not contain sufficient information to analyse antibiotic prescribing thoroughly in 44 (11.58%) cases. This included missing information on the indication for antibiotic therapy, the reason for the type of antibiotic selected if the susceptibility results stated otherwise, the reason for insufficient or excessive duration beyond which guidelines state, the continued administration of antibiotics when culture results were negative, and the reason for multiple antibiotics used contrary to the culture results.

There were some cases in which the patient's clinical notes did not reconcile with the antibiotics administered ($n=13$, 3.42%), specifically the name of antibiotics and/or duration of therapy mentioned in the clinical notes were different from what was administered.

Process measures and/or additional findings occurring together in combination

The percentage of times findings from the antibiotic audit occurred together in combination was examined (Table S3). Statistical tests were used to determine if this observed percentage differed from the probability of these findings occurring together by chance with no significance. It was observed that the prescribing of an antibiotic that did not align with the susceptibility results was one of the most commonly occurring findings in

Table 2. Process measures and additional findings that were observed to frequently occur together

Process measures and additional findings occurring together in combination		*n* (%)	*P* value	Confidence interval (%)	Exact probability (%)
The prescribing of an antibiotic that did not align with the susceptibility results	+ De-escalation to a narrower spectrum antibiotic based on susceptibility results did not occur	12 (3.16)	$P<0.001$*	1.4–4.9	0.88
	+ The delayed initiation of a more suitable antibiotic based on susceptibility results	10 (2.63)	$P=0.012$	1.0–4.2	1.22
	+ Prescription of multiple antibiotics by changing/adding on antibiotics	11 (2.89)	$P=0.001$*	1.5–5.1	1.15
Antibiotic therapy was continued after culture results were negative for any bacterial growth	+ Antibiotics were used for an excessive duration of therapy	10 (2.63)	$P<0.001$*	1.0–4.2	0.52
The indication for antibiotic use was not documented	+ The patient's clinical notes do not contain sufficient information to analyse antibiotic prescribing thoroughly	13 (3.42)	$P=0.003$*	1.6–5.2	1.55
	+ Antibiotic therapy was continued after culture results were negative for any bacterial growth	9 (2.37)	$P=0.85$	0.8–3.9	2.23
Antibiotic therapy was not continued after culture results showed the presence of bacterial growth	+ The patient's clinical notes do not contain sufficient information to analyse antibiotic prescribing thoroughly	9 (2.37)	$P=0.0013$*	0.8–3.9	0.85

*Statistically significant, $P \leq 0.005$.

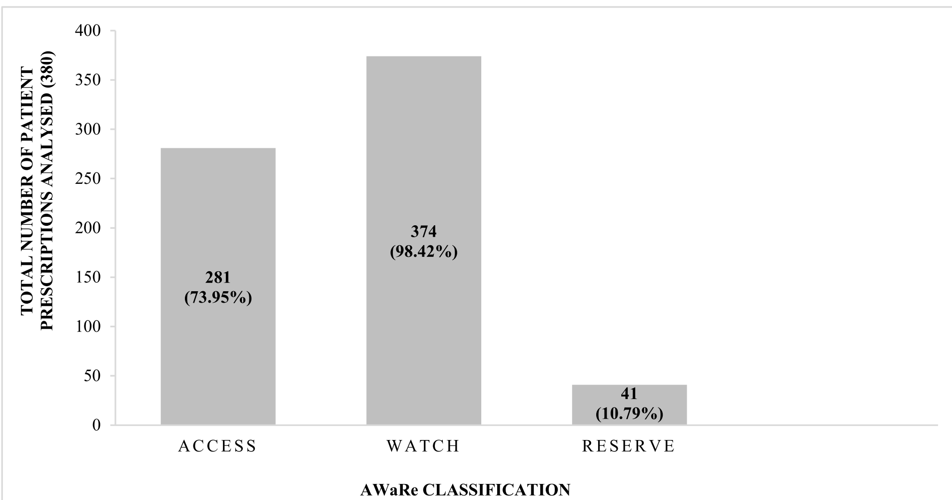

Figure 1. Frequency of antibiotic use according to the AWaRe classification.

combination with other findings of non-compliance and showed statistical significance. A summary of these and additional findings in combination are represented in Table 2.

Antibiotics prescribed according to the AWaRe groups

Most of the patient medical charts within the study contained two or more prescribed antibiotics. Therefore, most patients received antibiotics concurrently from the Access and Watch groups, Watch and Reserve groups, or Access, Watch, and Reserve groups. The results for the 380 patient medical charts reviewed are displayed in Figure 1. Antibiotics in the Watch group were most frequently prescribed. This included antibiotics such as meropenem, piperacillin/tazobactam, and vancomycin. The Reserve group of antibiotics was prescribed the least and included colistin ($n=37$, 9.74%), linezolid ($n=2$, 0.53%), and tigecycline ($n=1$, 0.26%). The Access group of antibiotics prescribed included amikacin ($n=147$, 38.68%), amoxicillin/clavulanic acid ($n=121$, 31.84%), cloxacillin ($n=19$, 5.00%), cefazolin ($n=55$, 14.47%), clindamycin ($n=7$, 1.84%), metronidazole ($n=42$, 11.05%), flucloxacillin ($n=7$, 1.84%), benzylpenicillin ($n=9$, 2.37%), gentamycin ($n=40$, 10.53%), sulfamethoxazole/trimethoprim ($n=35$, 9.21%), nitrofurantoin ($n=2$, 0.53%), amoxicillin ($n=1$, 0.26%), chloramphenicol ($n=6$, 1.58%), phenoxymethylpenicillin ($n=4$, 1.05%), doxycycline ($n=1$, 0.26%), ampicillin ($n=9$, 2.37%), and cephalexin ($n=1$, 0.26%).

Antibiotic administration patterns

Out of the 380 patient charts reviewed, there were 75 (19.74%) occurrences in which antibiotics were not administered consistently. The reasons for missed administration, if stated, consisted of the antibiotic being out of stock, the patient not being in the room, or not having an IV line.

Discussion

The results from this study indicate that the facility is mostly compliant with the process measures assessed, with room for improvement in certain aspects including redundant/duplicate antibiotic prescriptions, parenteral to oral switch, and a requirement for prompt reviewing of the prescribed antibiotics once culture results have become available. This is essential as it can prevent the use of unnecessary or incorrect antibiotics, thereby reducing the chances of developing further resistance.

Process measures and additional findings from the antibiotic audit

Cultures taken before the initiation of empirical antibiotics

One of the core AMS practices includes taking an appropriate culture before initiating the first antibiotic dose.[17] To their advantage, the facility has an on-site microbiology laboratory. This ensures the timeous receipt of samples, followed by good turnaround times in the availability of results for guiding antibiotic therapy.

In a majority of the cases, cultures were taken before antibiotic initiation. Not obtaining culture results before antibiotic initiation precludes certainty on the presence of a bacterial infection and identification of the causative organism. Additionally, other studies have suggested that taking blood cultures after antibiotic initiation results in a loss of sensitivity, thereby decreasing the ability of the blood culture to precisely indicate which organism(s) to target.[18] It is imperative that cultures be taken before the initiation of antibiotics while ensuring that antibiotic treatment is not delayed.

Opportunities for de-escalation

The results showed that there was good adherence to this process measure. One of the goals of an ASP is to achieve reduced antibiotic consumption, particularly broad-spectrum antibiotics, without compromising patient outcomes.[5] The most significant concern for the overuse of broad-spectrum antibiotics is selection for resistance.[19] The injudicious use of broad-spectrum antibiotics has been shown to result in altering the makeup of the host microbiome, even when used for short treatment durations.[19] Prescribers need to be aware of the potential immediate and long-term harm of broad-spectrum therapy.

Documented indication for antibiotic

One of the recommendations to assess AMS compliance is monitoring the completion of indicators on an antibiotic prescription chart.[17] This includes the documentation of a diagnosis and indication for antibiotic treatment.[17] Despite the advanced electronic medical record system at the facility, there is an absence of a standalone antibiotic prescription chart. Having this chart will help all healthcare professionals (HCPs) involved in patient care to identify an indication for antibiotic therapy promptly. Documenting the antibiotic indication has beneficial effects on the quality of patient care through improved antibiotic prescribing and enhancing communication between HCPs at the point of care transitions.[20]

Duration of antibiotic therapy

The duration of therapy should ideally be reviewed every 48–72 h, as the majority of bacterial infections require 7 days or less of antibiotic treatment. The results from this study showed that excessive duration of therapy was found in only a small minority of patients (3.16%). Unnecessary exposure to antibiotics can lead to adverse effects. Moreover, the excessive use of an antibiotic may further promote the selection of AMR.[17] Despite good results from the study presented here, compliance can be further improved. Basic initiatives such as support to review antibiotic therapy that has exceeded in duration can be provided through feedback by pharmacists during the dispensing process or ward rounds/chart reviews.[17]

Conversion of parenteral to oral administration

The results highlight a key finding: only a very small proportion of patients were switched from parenteral to oral antibiotics. The prolonged use of parenteral antibiotics can result in unnecessary intravenous exposure, thus increasing the chances of complications such as bloodstream infections.[5,21] The conversion from parenteral to oral antibiotics can advantageously reduce the length of hospital stay and healthcare costs, as the patient can complete their antibiotic therapy at home.[5,21]

This intervention may, however, meet with possible opposition from prescribers.[5] A qualitative study of hospital doctors' accounts of what influences their clinical practice identified possible reasons for hesitance to convert from parenteral to oral dosage forms. These include the following: concern about receiving complaints if patients' expectations were unmet; hierarchy of the medical team structure limited opportunities for parenteral to oral switch; and parenteral antibiotics were perceived as more potent. The latter reason was acknowledged by the doctors as not necessarily being evidence based.[22]

Redundant/duplicate/multiple antibiotic cover

The prevention of redundant antibiotic therapy is considered a first-tier or 'low-hanging fruit' intervention for AMS quality improvement.[17] In this study, duplicate spectrum of activity occurred in just over 35% of patients; therefore, focus should be placed on improving compliance for this aspect of prescribing. The common occurrence of redundant antibiotic cover can substantially increase the likelihood of AMR and adverse events.[5] The results from a study that assessed redundant anaerobic antimicrobial prescriptions did not identify the reason for such prescriptions, although it was suggested that it could be attributed to a lack of knowledge on anaerobic cover with β-lactams.[23] Conducting an audit and feedback intervention for redundant antibiotic therapy requires efficiently trained staff who can review and provide expert advice on antibiotic therapy. This intervention can be performed by pharmacists in the process of reviewing a prescription, as expertise in antimicrobials is often the domain of pharmacists.[5]

The review of a prescription of more than four antibiotics concurrently for a patient is also considered a first-tier AMS intervention.[17] To maintain compliance with this process measure, it is essential to continually review antibiotic prescriptions to reduce redundant antibiotic cover.[17] This can be achieved by comparatively simple means through pharmacist-led initiatives. A South African study by Brink *et al*.[9] on AMS implementation in resource-limited settings documented 739 (9%) pharmacist-led interventions for the use of more than four antibiotics simultaneously.[9]

Medical record notes

The names and/or duration of antibiotic therapy in the clinical notes did not reconcile with the antibiotics administered in some cases. This could indicate poor recording of clinical notes or a possible change in the antibiotic used that was not recorded in the clinical notes.

Antibiotics prescribed according to the AWaRe groups

It was observed that the majority of prescribed antibiotics fell within the Watch category. This group of antibiotics has a higher risk of developing resistance and should ideally be monitored.[5,24] The AWaRe classification should be adopted as a stewardship tool in essential medicine lists and national treatment guidelines to encourage narrow-spectrum antibiotic use.[25]

Implementing restriction criteria and pre-authorization for carbapenems can allow for more stringent control of broad-spectrum antibiotic use.[26] In this study, the facility follows a protocol from the KZN Department of Health that states that certain antibiotics require prior approval and microbiology reports before use. These antibiotics fall mainly within the Watch and Reserve category. This practice can be beneficial to resource-limited settings by saving on antibiotic expenditure.[26]

Antibiotic administration patterns

Missed or delayed antibiotic administration can have negative effects on the patient by increasing the risk of treatment failure and selection for resistant bacterial strains.[27] Possible reasons for missed doses are insufficient inventory, poor communication between nurses on change of shifts, and poor communication between nurses and pharmacists when placing antibiotic orders. Antibiotic shortages and insufficient inventory hinder timely access to effective therapy, which can be drivers for the emergence of AMR and excess mortality, especially in LMICs.[28] The implementation of ASPs may not succeed unless antibiotic inventory control and procurement are efficient.[28]

A study identified the roles and challenges of nurses in AMS. One important aspect was the antibiotic ordering between nurses and pharmacists. This involved ensuring that the prescribed antibiotic(s) were ordered from the pharmacy and available at the point of care. It was suggested that antibiotic usage within wards should be analysed to identify an estimated amount of antibiotics required.[29] The study identified the need to develop a nursing handover protocol as guidance to nurses and other multidisciplinary team members to ensure that communication outcomes reach the relevant departments.[29]

Recommendations

In this facility, it was noted that there was no standalone antibiotic chart. The development of a standalone antibiotic chart would ensure that various aspects of the antibiotics prescribed are reviewed with ease. Furthermore, having the clinicians' notes about the patient's antibiotic treatment attached to this chart will make it easier for other HCPs to review therapy, such as the pharmacist at the point of dispensing, and nurses during antibiotic administration.

Results from a previous study conducted at this facility showed that at the time of the study, pharmacists did not participate in ward rounds.[30] The pharmacist should ideally have a significant role in AMS due to their vast knowledge of and influence over the use of antimicrobials.[21] The introduction of pharmacist-led ward rounds as a stepwise approach towards a fully fledged ASP can be beneficial in providing prospective feedback to prescribers on antibiotic therapy.

Previous results from research at this facility showed that further recommendations for an ASP could include building on the existing HAMSC/AMS team (CEO, clinical heads of departments, head of pharmacy services, medical microbiologist, and infectious diseases physician) to include nursing and infection and prevention control representatives. Basic training in optimal antibiotic use can also be offered to all HCPs.[30]

Conclusions

The implementation of a multidisciplinary ASP can be challenging especially in resource-limited settings; therefore, conducting audits to assess antibiotic prescription prior to ASP implementation can be beneficial in developing targeted action plans for AMS initiatives in a stepwise approach towards a fully fledged ASP implementation. Additionally, the process measures/indicators selected for the baseline assessment can play an important role in later evaluating the success of AMS interventions initiated at the facility.

Limitations

The data collection was conducted during the peak of the COVID-19 pandemic, which could have impacted antibiotic prescribing due to a lack of staff, antibiotic stock, and inappropriate antibiotic prescribing in COVID-19 patients due to lack of knowledge and established guidelines to care for patients affected by the pandemic. Due to missing information such as severity of illness and the study being retrospective in nature, the reason for choice of antibiotics prescribed could not be elucidated in some instances. This study identified the prescribing of redundant antibiotic combinations. In prospective intervention studies, this can be identified by consultation with the clinician to ascertain the clinical condition and indication for each case. The limitations above highlight the importance and value of prospective audit and feedback. Prospective audits and feedback can positively impact change in prescribing behaviour. Despite the limitations, this study highlights areas of antibiotic prescribing that can be focused on while strategizing on an AMS action plan.

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Transparency declarations

None to declare.

Author contributions

S.C. conceptualized this project. S.C. and S.Y.E. were involved in the supervision of J.C. J.C. designed the tools, collected data, conducted data analysis, and wrote the original draft of the manuscript. S.C. and S.Y.E. critically reviewed and edited the manuscript. All authors have reviewed the final version of the manuscript.

Supplementary data

Tables S1–S3 are available as Supplementary data at *JAC-AMR* Online.

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