REDUCING THE PERCENTAGE OF ANTIBIOTIC PRESCRIPTIONS WITH PRESCRIBING ERRORS RELATED TO RENAL-DOSE ADJUSTMENT IN THE ORTHOPAEDIC WARD, HOSPITAL MELAKA

Wong Shien Woan[1], Loh Lai Yee[1], Low Seow Huey[2], Nur Diniah Shaharum[1], Tan Pei Xing[1]

[1] Pharmacy Department, Hospital Melaka, Ministry of Health Malaysia

[2] Pharmacy Department, Hospital Kuala Lumpur, Ministry of Health Malaysia

Corresponding Author: Wong Shien Woan
Email: wongshienwoan@moh.gov.my

Abstract

Prescribing antibiotics with the appropriate dose according to the patients' renal profile is crucial due to the variability of pharmacokinetics and pharmacodynamics. Failing to adjust the antibiotics dosage according to patients' renal profile is considered a prescribing error, and may lead to treatment ineffectiveness or toxicity. A verification study conducted in the orthopaedic ward, *Hospital Melaka*, from November 23, to December 27, 2020, revealed that 9.1% of prescriptions had prescribing errors involving antibiotics requiring renal-dose adjustment. This quality improvement study aimed to achieve zero percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment in the orthopaedic ward in *Hospital Melaka*, within a year. A self-administered questionnaire was developed and distributed among 40 healthcare professionals to identify contributing factors. Through Pareto analysis, three major contributing factors to the prescribing errors involved antibiotics requiring renal-dose adjustment, incomplete local drug policy, and different practices among doctors. Two interventional cycles with remedial actions were formulated and implemented from December 2020 to April 2021. The remedial actions developed were the formulation of the Antimicrobial Renal Adjustment quick guide (Am-Read), continuous medical education for doctors and pharmacists, and amendments to the prescriptions column. Data were collected using data collection forms throughout the study period. The Achievable Benefit Not Achieved was reduced from 9.1% to 5.9% post remedial actions Cycle 1, then to 2.9% post remedial actions Cycle 2. In Cycle 2, the prescribing error was detected early during the screening stage by a pharmacist. We believed that the remedial actions implemented in the study could further reduce the prescribing error to zero and could be replicated in other healthcare settings.

KEYWORDS: Antibiotics, renal-dose adjustment, prescribing error, quality improvement study

Problem

Medication error (ME) is defined as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is controlled by healthcare professionals, patients, or consumers (1,2). At *Hospital Melaka*, reported ME cases showed an upward trend, surging from 1,061 in 2017 to 2,184 in 2019. Prescribing errors were the most predominant type, accounting for over 90% of all reported MEs in 2019. Prescribing error refers to any ME initiated during the prescribing process, including incorrect medications, incorrect dose (over- or under-therapeutic dosing), wrong frequency, inappropriate route of administration and inappropriate dosage form (3).

Antibiotics, such as intravenous amoxicillin/clavulanate for diabetic foot infections, are routinely used in orthopaedic wards. Appropriate dosing and frequency are crucial for safety and efficacy, as individual pharmacokinetics and pharmacodynamics vary. In patients with kidney impairment, antibiotics eliminated by the kidneys carry a significant risk of accumulation and toxicity if regimens are not properly adjusted. Getachew et al. (4) demonstrated that 51% of prescriptions requiring dose adjustments including antibiotics such as ceftazidime, vancomycin, and co-trimoxazole were inappropriate. Given that Kateros et al. (5) reported an 8.7% incidence rate of kidney disease among orthopaedic patients, failure to make accurate dose adjustments may causes medication errors.

Hospital Melaka is a state government tertiary facility with 1,091 beds providing diverse clinical specialties. Orthopaedic Department had four adult wards in Block D managed by 14 specialists and 40 medical officers, offering specialty services across operating theatres, outpatient clinics, and inpatient wards. However, unlike medical wards, orthopaedic wards lack dedicated ward pharmacists to provide direct clinical input and interventions during daily rounds. All warded patient medications are handled centrally by the Inpatient Pharmacy Unit, where pharmacists screen prescriptions, dispense drugs, and provide drug information. There were 12 pharmacists at the Satellite 5 Inpatient Pharmacy manage prescriptions across 21 wards, including orthopaedics. Consequently, prescribing errors can only be identified after prescriptions reach the pharmacy.

Pharmacists in Satellite 5 had observed a significant number of prescribing errors specifically involving antibiotics requiring renal-dose adjustment in orthopaedic patients. A verification study conducted in the orthopaedic ward, from November 23, to December 27, 2020, revealed that 9.1% of prescriptions have prescribing errors involving antibiotics requiring renal-dose adjustment. Therefore, this study aimed to reduce the percentage of prescribing errors involving antibiotics requiring renal-dose adjustment in the orthopaedic wards of *Hospital Melaka* to 0.0% within one year.

Background

Medication safety is one of the most crucial aspects of patient safety. Globally, medication-related harm accounts for more than half of the overall preventable harm in medical care, which costs approximately EURO4.5 – 21.8 billion (~MYR21.2 - 102.7 billion, as of August 2026) in Europe annually (1). A study in England estimated that there were 237 million MEs yearly, of which 66 million were potentially clinically significant. These MEs were estimated to incur GBP98,462,582 (~MYR505 million) to the healthcare system and cause 1,708 deaths per annum (6).

In Malaysia, the number of nationwide MEs reported to the Ministry of Health has been rising, from 26,056 in 2017 to 47,251 in 2019 (7). A meta-analysis in Africa reported 13.7% of MEs involved inappropriate drug dose adjustment among renal impairment patients (8). A study in a tertiary hospital in India reported 45.9% MEs out of 427 cases, with prescribing errors being the most frequent MEs (70.4%), and approximately 16.0% of the reported prescribing errors involved patients from orthopaedic surgery disciplines (9).

The antibiotic group was found to be one of the common ME-related pharmacological groups, which resulted in significant morbidity and mortality among patients. More than 50% of prescribing errors involved the wrong doses, in which

the antibiotic group recorded the highest risk of ME at 79.6% (9,10). The death-related rate associated with ME of antibiotics was recorded at 7.5% (11). Likewise, a local study reported that the anti-infective group is one of the most common categories involved in MEs, in which the anti-infective group consists of a quarter of the reported MEs and 19.5% of the actual MEs (12).

Generally, MEs can be attributed to factors related to healthcare professional staff, healthcare system, the working environment, tasks and technology, and others (13,14). Yatim et al. (12) showed that the contributing factors to ME were mainly staff factors (79.4%), including inexperienced personnel, lack of knowledge, or distraction. Besides, tasks and technology, which consisted of failure to adhere to work procedure, incomplete information, illegible prescriptions, and wrong labelling, were reported as other main attributing factors of MEs.

The medication use process involves prescribing, dispensing, administration, and monitoring. Prescribing was shown to be one of the important stages, accounting to 51.0% of all MEs reported in the Ministry of Health Malaysia (3). The contributing factors of prescribing errors are usually multifactorial, consisting of inadequate knowledge of the drug, skills-based slips, inadequate training or experience, fatigue, stress, high workload for the prescriber, inadequate or poor access to patient information, inadequate communication between healthcare professionals, reluctance or fear to question senior colleagues, over-trusting the specialists, improper selection from a computer operator list, pre-printed medication orders, noise working environment, distraction and frequent interruption of prescriber, no or ambiguous guidelines and protocols (13,15-17).

A study conducted at a tertiary hospital in Ipoh found that the prescribing process accounted for 97.4% of all MEs (12). Apart from prescribing, medication administering and dispensing processes were demonstrated to cause 46.2% and 23.1% of all actual MEs, respectively (12).

Multiple strategies to reduce the incidence of prescribing error have been advocated, including the implementation of a ME reporting system (18); the application of error-detecting tools; organising continuous education on medication safety (19); creating a framework for action aimed at healthcare professionals to facilitate improvements in prescribing, dispensing, administration, and monitoring practices; developing guidance and tools to fill the knowledge gap of healthcare professionals; raising awareness among staff regarding medication safety; establishing of electronic medical records providing real-time patients' information, laboratory investigations, and medication profiles; adopting computerised order entry which enables prompt warnings on drug overdose, allergy, drug interaction as well as involving pharmacists for dose calculation and drug administration (20–22).

A comparison of the effectiveness of various interventions in reducing ME was done. Meta-analyses showed that prescribing errors were reduced by pharmacist-led medication reconciliation, computerised medication reconciliation, medication reconciliation by trained mentors, computerised physician order entry as a single intervention, pharmacist partnership, and prescriber education (23,24). The combination of these strategies has also successfully reduced the prescribing or administration of ME, including the combination of prescriber education and pharmacist-led medication reconciliation (23). Grimes et al. (25) also assessed the effectiveness of pharmacist-led medication reconciliation and pharmacist partnership in acute medical units and found a lower prescribing error rate.

Measurement

This quality improvement study was conducted in one orthopaedic ward (Ward D4) and Satellite 5 Inpatient Pharmacy at *Hospital Melaka* from November 2020 to April 2021. In this study, injectables and oral antibiotic prescriptions for patients aged 18 years and above who were admitted to the orthopaedic ward of *Hospital Melaka* that reached Satellite 5 Inpatient Pharmacy during office hours were screened by pharmacists. Prescriptions of antibiotics that were given as 'STAT' doses and antibiotics that did not need renal-dose adjustment at the point of prescribing were excluded.

The 'renal-dose adjustment' in this study refers to the antibiotic dose adjustment for patients with any severity of kidney impairment. Some examples of these antibiotics include amoxicillin-clavulanate, meropenem, and piperacillin-tazobactam. In this study, the patients' latest serum creatinine (SCr) prior to antibiotics initiation was assessed via the 'I-lab system'. The latest SCr level, the patient's body weight, age, and gender will be used to calculate the patient's creatinine clearance (CrCl). Based on the calculated CrCl, the prescribed antibiotic dose will be checked using references such as Malaysia National Antibiotic Guideline 2019, Micromedex Drug Reference, or UpToDate.

Any of the following scenarios was considered as a prescribing error: 1) a normal dose was prescribed to patients with renal impairment; 2) a renal-adjusted dose was prescribed to patients with normal renal function; and 3) an inappropriate renal-adjusted dose was prescribed. For example, IV amoxicillin-clavulanate 1.2g TDS was prescribed to a patient with CrCl 20ml/min, in which the correct dose should be 1.2g STAT, then 600mg BD. The percentage of prescriptions with prescribing errors reported in this study included all prescriptions with errors initiated by the prescriber and detected either during the screening process or counter-checking by pharmacists.

The percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment was used as the indicator for improvement. The percentage was calculated using the formula below:

$$\textit{Percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment} = \frac{\textit{Number of prescriptions of antibiotics requiring renal-dose adjustment, with ≥1 prescribing error}}{\textit{Number of prescriptions of antibiotics requiring renal-dose adjustment}} \times 100$$

For example: (1) If ten antibiotic prescriptions requiring renal-dose adjustment are screened, and two prescribing errors are detected in two prescriptions, then the percentage of prescriptions with prescribing errors is 20% (2). If ten antibiotic prescriptions requiring renal-dose adjustment are screened, and two prescribing errors are detected from one prescription, then the percentage of prescriptions with prescribing errors is 10% (4). In view of the possible harm of a wrong dose of antibiotics requiring renal dose adjustment, our group consensus was to set the standard at zero percentage of prescriptions with prescribing errors. The standard for the study aligns with Goal 3 of the Malaysian Patient Safety Goals 2.0 that set zero number of MEs resulting in severe damage or death for medication safety (2).

A brainstorming session was conducted among five pharmacists and a doctor to identify all the possible contributing factors leading to the prescribing error. Then, a self-administered questionnaire consisting of the possible contributing factors was developed. The questionnaire was reviewed by a senior pharmacist and the head of unit of the Inpatient Pharmacy. A total of 40 healthcare professionals, including 33 pharmacists and seven doctors, were approached to respond to the self-administered questionnaire. Each responder could choose more than one contributing factor. Subsequently, the data were converted into a Pareto chart to identify the major factors causing the prescribing errors involving antibiotics requiring renal-dose adjustment.

A dedicated pharmacist with four years of working experience at Satellite 5 Inpatient Pharmacy was chosen as the data collector. Data collection form (Appendix 1) was used throughout the study to collect data on all the critical steps involved. Part A of the data collection form consists of information regarding prescriptions for antibiotics requiring renal-adjusted doses. Part B of the data collection form comprised the following information: whether the ME reached the patient; the outcome of the ME; the contributing factors of the ME; the process by which the ME occurs; and the staff involved in the ME.

Two pharmacists were involved in the data management. One pharmacist was responsible for data entry and the other for data analysis. Microsoft Excel was used for data storage and analysis in a local computer. The file was kept confidential and with restricted access. The data were tabulated, and the categorical data were presented in percentages.

Initial Assessment of the Problem

The process of care, from prescribing to dispensing antibiotics, is shown in Figure 1. The critical steps where prescribing errors commonly happen and are not being detected before reaching the patient (identified with asterisks) include: (1) antibiotics prescribing by the doctor; (2) prescription screening by the pharmacist; (3) prescription counter-checking by the pharmacist.

Antibiotic prescribing starts when the doctors prescribe the drug for the treatment or prophylaxis of infection (if the patient is undergoing an operation with high-risk contamination). The choice of antibiotics will be based on the type of infection, site of infection, and patient comorbidity. At the same time, the dose of antibiotics will be decided based on references such as Malaysia National Antibiotics Guidelines 2019, Micromedex Drug Reference, or UpToDate. For some of the antibiotics that are excreted renally, such as IV piperacillin-tazobactam, the dose should be reduced in patients with renal impairment. After the prescription is endorsed, it will be sent to the Satellite 5 Inpatient Pharmacy by the ward nurses. In the pharmacy, the pharmacists will screen through the prescription. A query will be made to the prescriber if the prescription needs clarification. The process will be followed by medication filling, labelling, and counter-checking before it is dispensed and collected by the nurses for antibiotic administration to patients.

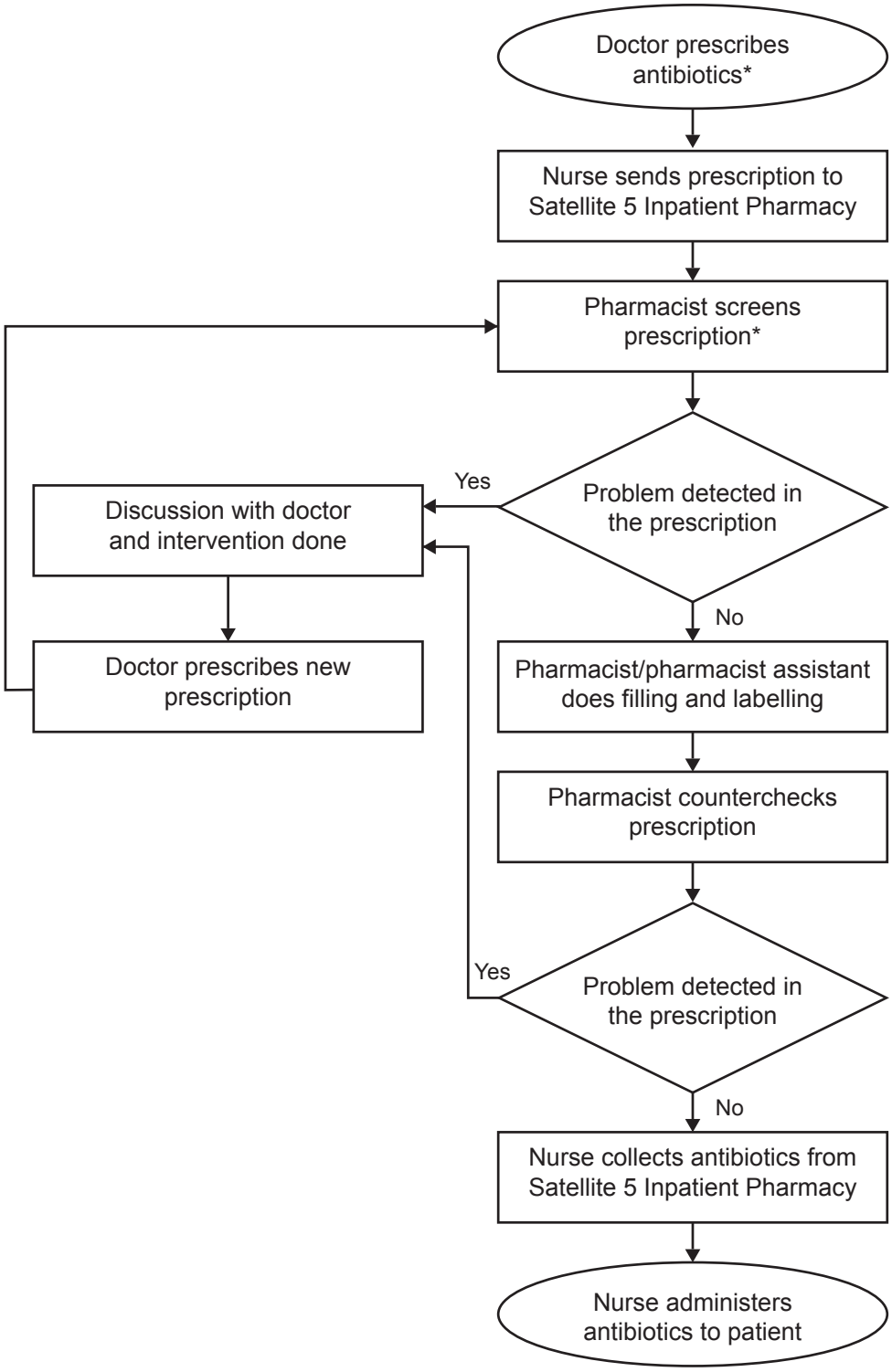
The Model of Good Care (MOGC), as outlined in Table 1, highlights the critical steps in the care process, from prescribing to dispensing antibiotics. During the verification study, 55 prescriptions with antibiotics involving renal-dose adjustment were screened. A total of five prescribing errors were detected therefore resulting in 9.1% of the prescribing errors. The Achievable Benefit Not Achieved (ABNA) was 9.1%. The verification study highlighted that none of the prescribers wrote or indicated the patients' calculated CrCl or the dialysis status on the prescription. Besides, only 70.9% of the prescriptions screened by pharmacists were checked on the patients' renal status. This indicated poor awareness or knowledge among doctors and pharmacists regarding the importance of checking patients' renal status before prescribing antibiotics and screening antibiotic prescriptions.

A few contributing factors were identified during the brainstorming session, as demonstrated in Figure 2. There were five presumed factors to contribute to the high percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment, which include: different practices among doctors, non-adherence to SOP (Standard Operating Procedure), incomplete local prescribing policy and failure to include patient renal status in prescription, lack of awareness and knowledge among doctor and pharmacist and unclear prescription.

A Pareto analysis of the data from the survey administered among pharmacists and doctor was then carried out to identify the main contributing factors as per Figure 3. The three major contributing factors to the high percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment, including: (A) lack of awareness and knowledge among doctors and pharmacists; (B) incomplete local prescribing policy and failure to include patient renal status in prescription; and (C) different practices among doctors.

Before this quality improvement study, doctors and pharmacists lacked awareness that certain antibiotics required dose adjustments based on patients' renal profiles, which may lead to medication errors. The low awareness among doctors and pharmacists was due to inexperienced personnel and a lack of educational programmes to increase awareness and knowledge among the healthcare personnel.

Prior to this study, the prescribing



*indicates critical steps

Figure 1: Process of care from prescribing to dispensing antibiotics

Table 1: MOGC in reducing prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment in the orthopaedic ward

No.	Proses	Criteria	Standard	Verification (n=55)	Cycle 1 (n=34)	Cycle 2 (n=35)
1.	Doctor prescribes antibiotics	Prescribe to the right patient	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Prescribe the right antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Prescribe the right route of antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Prescribe the right dose of antibiotics	100%	90.9% (50/55)	94.1% (32/34)	97.1% (34/35)
		Write the patient's calculated CrCl or the dialysis status	100%	0.0% (0/55)	91.2% (31/34)	97.1% (34/35)
2.	Pharmacist screens prescription	Ensure the right patient	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Ensure the right antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Ensure the right route of antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Check the patient's CrCl or the dialysis status	100%	70.9% (39/55)	97.1% (33/34)	100% (35/35)
		Ensure the right dose of antibiotics	100%	94.5% (52/55)	97.1% (33/34)	100% (35/35)
3.	Pharmacist counter-checks prescriptions	Ensure the right patient	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Ensure the right antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Ensure the right route of antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Check the patient's CrCl or the dialysis status	100%	100% (55/55)	100% (34/34)	100% (35/35)
		Ensure the right dose of antibiotics	100%	100% (55/55)	100% (34/34)	100% (35/35)

policy was found to have a critical gap. The prescriber was not required to include the patient's renal status. Therefore, the Satellite 5 Inpatient Pharmacist, who screened the prescription unable to determine whether a patient has renal impairment, and consequently undermine the possibility for ME. The lack of a standardised local reference to guide doctors on the renal dosing of antibiotics has been another cause for ME. Doctors may refer to different references based on their previous working experiences and trainings. The other two smaller proportions of contributing factors include non-adherence to SOP (11.5%) and unclear prescription (0.0%).

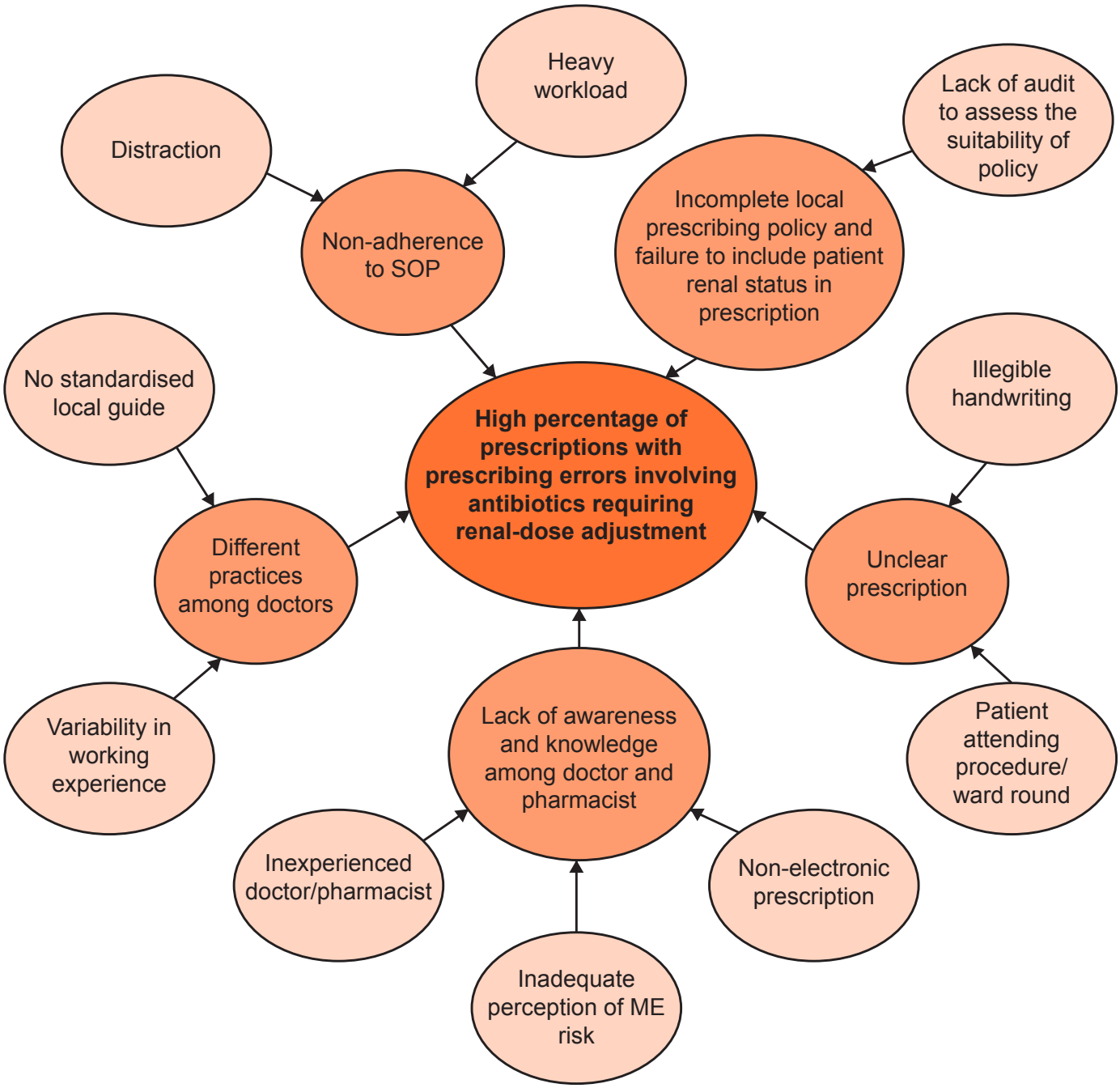


Figure 2: Problem analysis chart of the high percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment

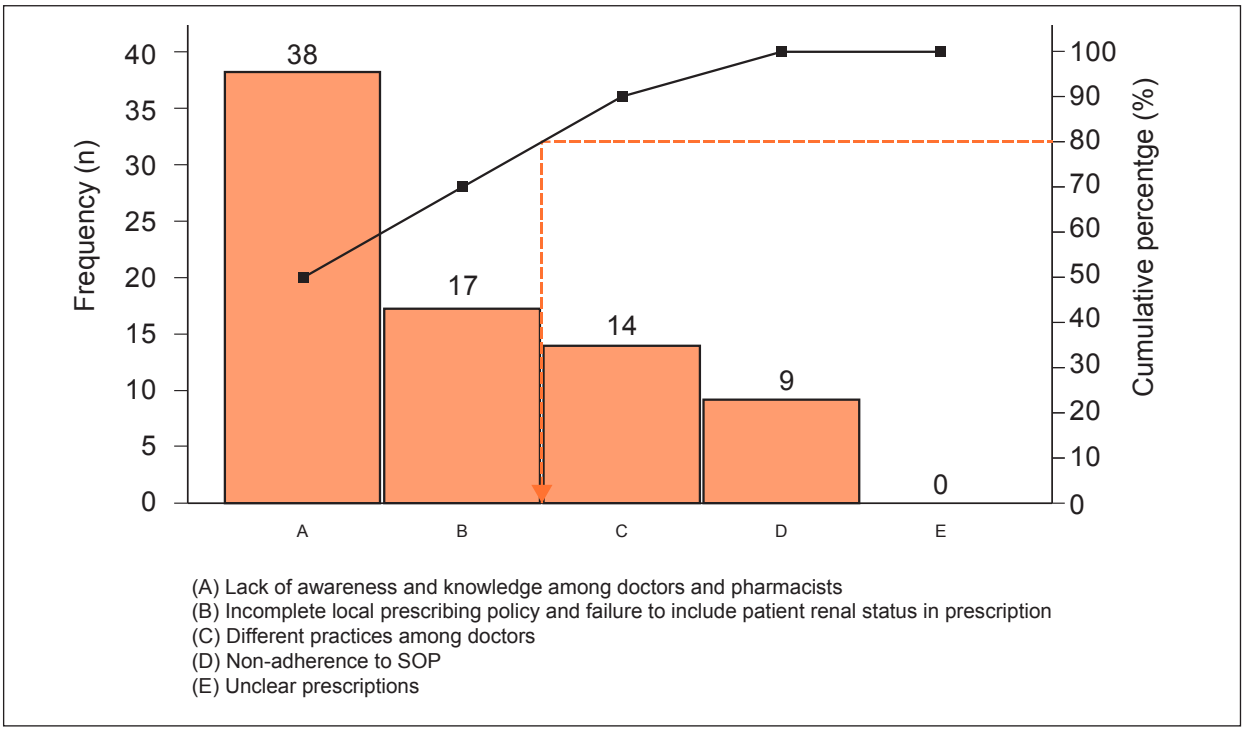


Figure 3: Contributing factors to the high percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment

Strategy

Following the identification of the contributing factors, there were two intervention cycles with five remedial actions implemented to reduce the percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment in the orthopaedic ward of *Hospital Melaka*. Cycle 1 involved three remedial actions and was implemented from December 2020 to March 2021. During Cycle 1, remedial actions were carried out for eight weeks (December 28, 2020, till February 21, 2021); followed by three weeks of post-remedial data collection (February 22, till March 14, 2021) then two weeks of data analysis (March 15 till March 31, 2021). Subsequently, Cycle 2 involved two remedial actions were conducted in the month of April 2021. During Cycle 2, the remedial actions were implemented for one week (April 1, 2021 till April 7, 2021), followed by three weeks of post-remedial data collection (April 8, 2021 till April 28, 2021). The data collected during the post-remedial periods were analysed to determine the effectiveness of the interventions.

Cycle 1 focused on tackling the issue of inadequate knowledge and awareness among doctors, and incomplete drug policy. The first remedial action for Cycle 1 was taken by developing an Antimicrobials Renal Adjustment quick guide (Am-Read) (Appendix 2) based on the National Antimicrobial Guidelines 2019, Micromedex and UpToDate to tackle inadequate or varying references used by doctors. Am-Read listed all the antibiotic doses for normal kidney function and adjusted the dose based on the patients' CrCl. It was then distributed to the orthopaedic ward and placed in every patient's medication file. The second remedial action was done by amending the inpatient prescriptions by adding a temporary column for renal profile-related data which were the patient's latest CrCl and dialysis status. A stamp chop with two columns 'CrCl' and 'PD/HD/No' was made and it was stamped on all the empty medication charts. Then, the medication charts were distributed to the orthopaedic ward. Continuous medical education via virtual sessions with doctors and nurses was carried out as the third remedial action to create awareness regarding the importance of renal-dose adjustment for antibiotics. The availability of an Am-Read quick guide in every patient's medication file was notified

during the session. Doctors were informed of the necessity of filling in the patients' latest CrCl and dialysis status upon prescribing.

Although the three remedial actions in Cycle 1 showed improvement in overcoming the contributing factors, the ABNA achieved in Cycle 1 was 5.9% (Figure 4). It was noticed that there was a lack of knowledge and awareness among the pharmacists, besides the doctors. Many of the Am-Read quick guides that were placed in the patients' medication files during the remedial action, were noticed to be misplaced.

Hence, the fourth and fifth remedial actions in Cycle 2 involved providing education sessions to pharmacists and doctors and the redistribution of the Am-Read quick guide. Both the pharmacists working in Satellite 5 Inpatient Pharmacy and the doctors in the orthopaedic ward had received the education session that emphasised the importance of checking through patients' renal profiles and to use the Am-Read quick guide upon prescribing and screening. The Am-Read quick guide that was found missing from the patient's medication file also got replaced. Moreover, the Am-Read quick guide was also placed on the Satellite 5 Inpatient Pharmacy notice board. After the remedial actions in Cycle 2 were done, the reported prescriptions with prescribing errors were reduced to 2.9% with the ABNA achieved in Cycle 2 was 2.9%.

Results

During the verification study, 5 out 55 (9.1%) antibiotic prescriptions screened were detected to have prescribing errors. Three of the prescribing errors involved wrong frequency at which the first dose was served but the second dose was managed to be corrected. Another prescribing error involved wrong dose while the third prescribing error involved both wrong dose and frequency. In the post-remedial actions of Cycle 1, it was found that two out of 34 (5.9%) antibiotic prescriptions screened had prescribing error. One of the prescribing errors involved wrong frequency of antibiotic while the other prescribing error involved wrong dose of antibiotic. After post-remedial actions of Cycle 2, one prescribing error was detected out of 35 prescriptions (2.9%). The prescribing error involved wrong frequency but was detected at the very early stage during initial pharmacist screening, which was a near-miss error. The ABNA showed a reduction in the percentage of prescriptions with prescribing errors detected i.e., from 9.1% during verification study, to 5.9% in

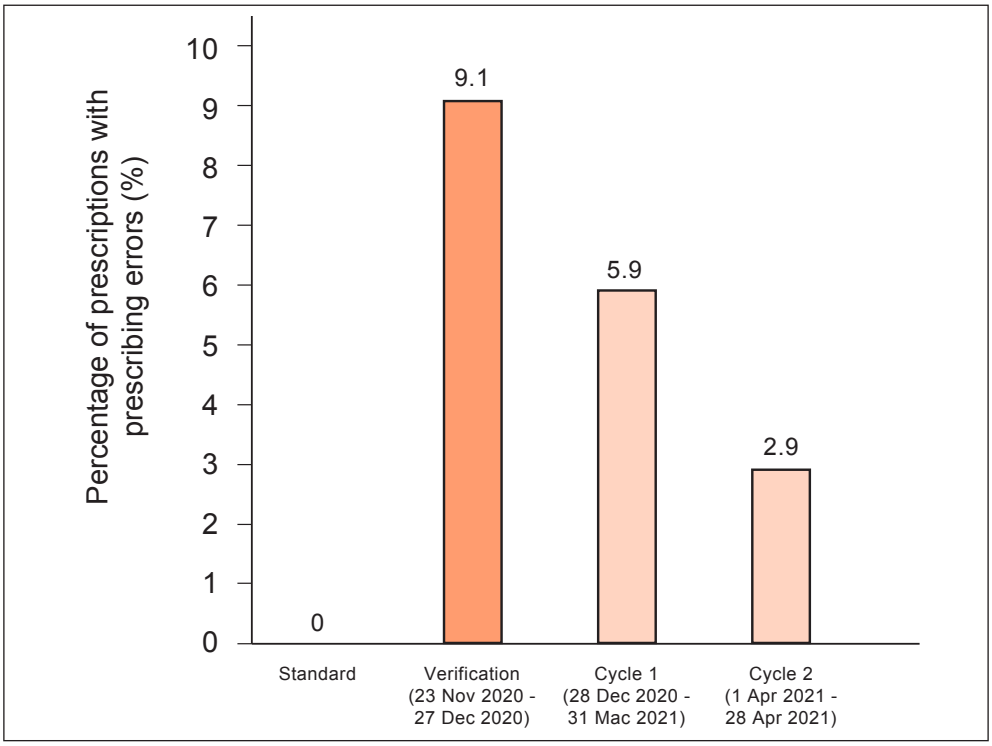


Figure 4: Achievement of the indicator by cycles

Cycle 1, and to 2.9% in Cycle 2. Even though the standard set is yet to be achieved, the remedial actions implemented were shown to be effective in reducing the percentage of prescribing error as the error was managed to be detected at the initial screening stage by pharmacist in Cycle 2.

From this study, we identified the lack of renal-profile information in the prescription. Therefore, we added a temporary column on the prescription, requiring the doctor to fill up the patients' renal profile (CrCl or dialysis status). Through these strategies, the awareness among prescribers to fill up the renal-profile information improved from 0.0% during verification study to 91.2% during Cycle 1 and 97.1% during Cycle 2. The effectiveness of this strategy was proposed to the management level, in order for a permanent addition of a renal-status column in the inpatient prescription.

Lessons and Limitations

Several lessons were learned from this study. Firstly, it is important to raise the awareness of doctors and pharmacists on the need for renal-dose adjustment of certain antibiotics in renally-impaired patients. Hence, a scheduled continuous education session should be done to ensure all the healthcare providers are updated and well-equipped with the latest antibiotic dosage adjustment knowledge. This session, also should emphasise healthcare professionals on adherence to SOP so that prescribing errors can be prevented.

However, this study findings are limited due to the sample collection from the orthopaedic ward in *Hospital Melaka*. The sample size collected was small. The COVID-19 pandemic wave has posed a huge challenge for the study in terms of implementing and evaluating the effectiveness of the proposed remedial actions. Before the pandemic, four orthopaedic wards were in Block D of *Hospital Melaka*. Three wards were shut down and changed to COVID-19 wards, leaving only one orthopaedic ward with 30 beds daily, continuing the service since early 2020.

On top of that, the manpower during the pandemic was affected with constant changes in ward staff rotation involving housemen and medical officers. As the orthopaedic wards were shifted to COVID-19 wards, the housemen initially under orthopaedic rotation relocated to other postings while the medical officers were reassigned as frontliners. It was challenging to deliver the education session to all the orthopaedic ward staff members simultaneously. Thus, our study resorts to a virtual education session. However, those who had attended our education session may not remain in the same ward. In the second cycle, the issue was overcome by conducting a physical education session at Ward D4.

In addition, during the ward relocation, it was noticed that the Am-Read quick guide attached to the patients' medication files, as well as the stamped inpatient medication prescription, were missing. We have to inspect regularly and redistribute both materials as necessary. To ensure the patients' CrCl and dialysis status were consistently available on the inpatient medication prescriptions, a practical and low-cost stamp was designed to be applied to every prescription in the orthopaedic ward.

Lastly, our study only focused on detecting prescribing errors, particularly the dosage and frequency. The study design was unable to screen for medication's administration or any omission errors. Both types of MEs can only be detected if a designated ward pharmacist is assigned to the ward to inspect from time to time.

Despite the limitations, we identified the factors contributing to a high percentage of prescribing errors and formulated remedial actions that were cost-saving. This is the pioneer project in *Hospital Melaka* in reducing the percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment, and successfully won the first prize during poster presentation at the state level. The collective efforts of the team members in this study should be acknowledged.

Conclusion and the Next Steps

This study reduced the percentage of prescriptions with prescribing errors involving antibiotics requiring renal-dose adjustment from 9.1% in the verification study to 5.9% in Cycle 1 and then to 2.9% in Cycle 2 through the remedial actions formulated and implemented. We believed that the remedial actions implemented

in the study could be replicated in other healthcare settings, including wards of different disciplines, government clinics, and hospitals. This is because the Am-Read quick guide developed in this study includes the antibiotics commonly prescribed in oral and injectable forms. It can be expanded to include other antimicrobials, such as antifungal and antiviral, as well as further details on the hemodynamic status of the patient. Most importantly, it should be reviewed regularly to keep it up to date and distributed to all healthcare providers to reduce ME. In addition, a standardised prescription form with additional columns for CrCl and dialysis status for all wards in *Hospital Melaka* and eventually nationwide can be made available.

Acknowledgements

The authors would like to thank the Director General of Health Malaysia for his permission to publish this work. The authors would also like to thank the hospital director, department head and staff of *Hospital Melaka* for supporting this study.

Conflict of Interest

The authors declare that there was no conflict of interest.

Funding

This study received no specific grants from any funding agencies from the public, commercial or non-profit sectors.

References

1. World Health Organization. What is medication error? [Internet]. 2022 [cited 2026 Feb 21]. Available from: https://cdn.who.int/media/docs/librariesprovider2/country-sites/medication-error-wpsd-final.pdf?sfvrsn=e5853e2a_1&download=true

2. Abu Bakar N, Abu Bakar AM. Malaysian patient safety goals 2.0: Guidelines on implementation & surveillance [Internet]. Medical Care Quality Section, Medical Development Division, Ministry of Health Malaysia; 2021 [cited 2026 Feb 21]. Available from: https://patientsafety.moh.gov.my/v2/?page_id=60

3. Abu Bakar N, Abu Bakar AM, Abdul Hamid SBS. Quick guide preventing prescription error [Internet]. Patient Safety Unit, Medical Care Quality Section, Medical Development Division, Ministry of Health Malaysia; 2020 [cited 2026 Feb 21]. Available from: https://jknmelaka.moh.gov.my/hmelaka/images/borang/Preventing%20Prescription%20Error%20-%20KKM%20Guideline%202020.pdf

4. Getachew H, Tadesse Y, Shibeshi W. Drug dosage adjustment in hospitalized patients with renal impairment at Tikur Anbessa specialized hospital, Addis Ababa, Ethiopia. BMC nephrology [Internet]. 2015 Oct 7 [cited 2026 Feb 21];16:158. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26446847

5. Kateros K, Doulgerakis C, Galanakos SP, Sakellariou VI, Papadakis SA, Macheras GA. Analysis of kidney dysfunction in orthopaedic patients. BMC Nephrology [Internet]. 2012 Sep 3 [cited 2026 Feb 21];13(1). Available from: https://link.springer.com/article/10.1186/1471-2369-13-101

6. Elliott RA, Camacho E, Jankovic D, Sculpher MJ, Faria R. Economic analysis of the prevalence and clinical and economic burden of medication error in England. BMJ Quality & Safety [Internet]. 2021 Jan 19 [cited 2026 Feb 21];30(2):96–105. Available from: https://qualitysafety.bmj.com/content/30/2/96

7. Pharmacy programme statistics report 2019 [Internet]. Pharmaceutical Services Programme, Ministry of Health Malaysia; 2019 [cited 2026 Feb 21]. Available from: https://pharmacy.moh.gov.my/en/documents/annual-report-and-statistics-pharmaceutical-services-programme.html

8. Dale D, Asmamaw G, Etiso T, Bussa Z. Prevalence of inappropriate drug dose adjustment and associated factors among inpatients with renal impairment in Africa: A systematic review and meta-analysis. SAGE Open Medicine [Internet]. 2023 Jan [cited 2026 Feb 21];11. Available from: https://journals.sagepub.com/doi/10.1177/20503121221150104

9. Desai M, Patel N, Shah S, Patel P, Gandhi A. A study of medication errors in a tertiary care hospital. Perspectives in Clinical Research [Internet]. 2016 [cited 2026 Feb 21];7(4):168. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5079090/

10. Nguyen HT, Nguyen TD, van den Heuvel ER, Haaijer-Ruskamp FM, Taxis K. Medication errors in Vietnamese hospitals: prevalence, potential outcome and associated factors. Emmert-Streib F, editor. PLOS ONE [Internet]. 2015 Sep 18 [cited 2026 Feb 21];10(9):e0138284. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0138284

11. Phillips J, Beam S, Brinker A, Holquist C, Honig P, Lee LY, et al. Retrospective analysis of mortalities associated with medication errors. American Journal of Health-System Pharmacy [Internet]. 2001 Oct 1 [cited 2026 Feb 21];58(19):1835–41. Available from: https://academic.oup.com/ajhp/article-abstract/58/19/1835/5158382

12. Mohd Yatim MF, Othman NH. A retrospective analysis of medication errors at a tertiary hospital in a Northern State of Malaysia. Malaysian Journal of Pharmaceutical Sciences [Internet]. 2022 Nov 16 [cited 2026 Feb 21];20(2):79–92. Available from: https://www.researchgate.net/publication/365496378_A_Retrospective_Analysis_of_Medication_Errors_at_a_Tertiary_Hospital_in_a_Northern_State_of_Malaysia

13. Tully MP, Ashcroft DM, Dornan T, Lewis PJ, Taylor D, Wass V. The causes of and factors associated with prescribing errors in hospital inpatients. Drug Safety [Internet]. 2009 Oct [cited 2026 Feb 21];32(10):819–36. Available from: https://link.springer.com/article/10.2165/11316560-000000000-00000#citeas

14. Guideline on medication error reporting system [Internet]. 2nd ed. Medication Safety Section, Pharmacy Practice and Development Division, Pharmaceutical Services Programme, Ministry of Health Malaysia ; 2019 [cited 2026 Feb 21]. Available from: https://pharmacy.moh.gov.my/sites/default/files/document-upload/mers-reporting-guideline-manual-form.pdf

15. Anzan M, Alwhaibi M, Almetwazi M, Alhawassi TM. Prescribing errors and associated factors in discharge prescriptions in the emergency department: A prospective cross-sectional study. Orueta JF, editor. PLOS ONE [Internet]. 2021 Jan 12 [cited 2026 Feb 21];16(1):e0245321. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0245321

16. Mahomedradja RF, Schinkel M, Kim, Reumerman MO, Otten J, Tichelaar J, et al. Factors influencing in-hospital prescribing errors: A systematic review. British Journal of Clinical Pharmacology [Internet]. 2021 Jun 1 [cited 2026 Feb 21];89(6). Available from: https://bpspubs.onlinelibrary.wiley.com/doi/10.1111/bcp.15694

17. Sutherland A, Ashcroft DM, Phipps DL. Exploring the human factors of prescribing errors in paediatric intensive care units. Archives of Disease in Childhood [Internet]. 2019 Feb 8 [cited 2026 Feb 21];104(6):588–95. Available from: https://adc.bmj.com/content/104/6/588

18. Abuelsoud NN. Improving medication safety through implementation of medication error reporting systems in different medical specialities. Journal of Pharmacy Practice and Research [Internet]. 2018 Dec [cited 2026 Feb 21];48(6):537–42. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/jppr.1453

19. Mutair AA, Alhumaid S, Shamsan A, Zaidi ARZ, Mohaini MA, Al Mutairi A, et al. The effective strategies to avoid medication errors and improving reporting systems. Medicines [Internet]. 2021 [cited 2026 Feb 21];8(9):46. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC8468915/

20. Chui MA, Pohjanoksa-Mäntylä M, Snyder ME. Improving medication safety in varied health systems. Research in Social and Administrative Pharmacy [Internet]. 2019 Jul [cited 2026 Feb 21];15(7):811–2. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7850231/

21. Tiri B, Bruzzone P, Priante G, Sensi E, Costantini M, Vernelli C, et al. Impact of antimicrobial stewardship interventions on appropriateness of surgical antibiotic prophylaxis: How to improve. Antibiotics [Internet]. 2020 Apr 9 [cited 2026 Feb 21];9(4):168. Available from: https://www.mdpi.com/2079-6382/9/4/168

22. Shea KM, Hobbs AL, Shumake JD, Templet DJ, Padilla-Tolentino E, Mondy KE. Impact of an antiretroviral stewardship strategy on medication error rates. American journal of health-system pharmacy: AJHP: official journal of the American Society of Health-System Pharmacists [Internet]. 2018 Jun 15 [cited 2026 Feb 21];75(12):876–85. Available from: https://pubmed.ncbi.nlm.nih.gov/29720459/

23. Manias E, Kusljic S, Wu A. Interventions to reduce medication errors in adult medical and surgical settings: A systematic review. Therapeutic Advances in Drug Safety [Internet]. 2020 Jan [cited 2026 Feb 21];11(1):1–29. Available from: https://journals.sagepub.com/doi/10.1177/2042098620968309

24. Ciapponi A, Fernandez Nievas SE, Seijo M, Rodríguez MB, Vietto V, García-Perdomo HA, et al. Reducing medication errors for adults in hospital settings. Cochrane Database of Systematic Reviews [Internet]. 2021 Nov 25 [cited 2026 Feb 21];2021(11). Available from: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD009985.pub2/full

25. Grimes TC, Deasy E, Allen A, O'Byrne J, Delaney T, Barragry J, et al. Collaborative pharmaceutical care in an Irish hospital: uncontrolled before-after study. BMJ Quality & Safety [Internet]. 2014 Jul 1 [cited 2026 Feb 21];23(7):574–83. Available from: https://qualitysafety.bmj.com/content/23/7/574.full

Appendix 1: Data Collection Form (Part A: Antibiotic prescriptions screened)

Date of data collection:			**Ward:**	
Remarks: For all ME detected, please fill up Part B with the serial number. Format of the serial number: *yymmdd/ward/no* (e.g. 201123/D4/A2).				
No	Route	Antibiotic required renal-adjusted dose	Medication Error (Yes/No)	Serial number Part B
A1				
A2				
A3				

Data Collection Form (Part B: Medication error form)

ME serial number:			
Date of detecting ME:			
Date of event:			
Medication involved:			
For the questions below, tick (/) in the relevant column			
Location of event	Ward D4		
	Satellite 5 inpatient pharmacy		
In which process the ME occur? (can choose more than 1)	Prescribing		
	Dispensing		
Did the ME reach patient?	Yes		
	No		
ME outcome category	A	Potential error, circumstances/ events have potential to cause incident	
	B	Actual Error - did not reach patient	
	C	Actual Error - caused no harm	
	D	Additional monitoring required - caused no harm	
	E	Additional monitoring required - caused no harm	
	F	Initial/ prolonged hospitalization - caused temporary harm	
	G	Caused permanent harm	
	H	Near death event	
	I	Death	

Contributing factors (Can choose more than 1)			
Staff factor	a	Inexperienced personnel	
	b	Inadequate knowledge	
	c	Distraction	
Medication related	a	Sound alike medication	
	b	Look alike medication	
	c	Look alike packaging	
Work and environment	a	Heavy workload	
	b	Peak hour	
	c	Stock arrangements/ storage problem	
Task and technology	a	Failure to adhere to work procedure	
	b	Use of abbreviations	
	c	Illegible prescriptions	
	d	Patient information/ record unavailable/ inaccurate	
	e	Wrong labeling/ instruction on dispensing envelope or bottle/ container	
	f	Incorrect computer entry	
Others			
Which category made the initial ME?	a	Specialist	
	b	Medical officer	
	c	Houseman medical officer	
	d	Pharmacist	
	e	Provisional Registered Pharmacist	
	f	Nurse	
	g	Nurse trainee	
	h	Pharmacist Assistant	
	i	Others	

Appendix 2: Part of Antimicrobials Renal Adjustment (Am-Read) quick guide

Antimicrobial Renal Adjustment Quick Guide for Adult in Hospital Melaka

<table>
<tr><th>Antibiotics</th><th>Renal Dosage Adjustment</th><th>Ref.</th></tr>
<tr><td>Amoxicillin</td><td>CrCl 10-30 ml/min : 250-500mg BD
CrCl <10 ml/min : 250-500mg OD-BD
HD : 250-500mg OD-BD, serve post HD on HD day
PD : 250-500mg BD</td><td>1</td></tr>
<tr><td></td><td><u>H. pylori eradication therapy (1g BD):</u>
CrCl <30 ml/min or HD : 500mg BD</td><td>8,9</td></tr>
<tr><td>Amoxicillin/ clavulanate (IV)</td><td>CrCl 10-30 ml/min : 1.2g stat, then 600mg BD
CrCl <10 ml/min : 1.2g stat, then 600mg OD
HD : 1.2g stat, then 600mg OD, serve post HD on HD day</td><td>1, 5, 12</td></tr>
<tr><td>Amoxicillin/ clavulanate (PO)</td><td>CrCl 10-30 ml/min : usual dose BD
CrCl <10 ml/min : usual dose OD
HD : usual dose OD, additional dose after HD</td><td>2</td></tr>
<tr><td>Ampicillin</td><td><table><tr><th>CrCl (ml/min)</th><th>Usual dose of 1-2g QID</th><th>Usual dose of 2g 4H</th></tr><tr><td>50 - 129</td><td>1-2g QID</td><td>2g 4H</td></tr><tr><td>30 -49</td><td>1-2g TDS</td><td>2g QID</td></tr><tr><td>15 - 29</td><td>1-2g BD</td><td>2g TDS</td></tr><tr><td>< 15 / HD / PD (serve post HD on HD day)</td><td>1-2g OD</td><td>2g BD</td></tr></table></td><td>1</td></tr>
<tr><td>Ampicillin/ sulbactam (IV)</td><td>CrCl 15-29 ml/min : 1.5-3g BD
CrCl 5-14 ml/min : 1.5-3g OD
HD : 1.5-3g OD-BD, serve post HD on HD day
PD : 1.5g BD, or 3g OD</td><td>1</td></tr>
<tr><td></td><td><u>High dose Sulbactam dose in Acinetobacter sp MDR:</u><table><tr><th>CrCl (ml/min)</th><th>> 50</th><th>20-50</th><th>< 20</th><th>HD</th></tr><tr><td>Sulbactam</td><td>9g/ d</td><td>6g/d</td><td>4g/d</td><td>4g/d</td></tr><tr><td>Ampicillin/ Sulbactam</td><td>9g TDS</td><td>6g TDS</td><td>6g BD</td><td>6g BD</td></tr></table></td><td>3</td></tr>
<tr><td>Ampicillin/ sulbactam (PO)</td><td>CrCl <30 ml/min : should be administered less frequently</td><td>6</td></tr>
</table>