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Original article

Awareness, perception, and barriers of healthcare providers toward the revised consensus guideline for therapeutic monitoring of vancomycin

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ABSTRACT

Background: A revised consensus guideline published in 2020 recommended transitioning vancomycin monitoring to the area under the concentration–time curve over 24 h to minimum inhibitory concentration (AUC_{24}/MIC). The decision to transition to AUC_{24}/MIC monitoring or to continue trough-based monitoring is made at the institutional level and is influenced by several factors, including healthcare providers and system-related factors. Changing current practices is expected to be difficult, and it is important to understand healthcare providers' perceptions and potential barriers before the transition. This study assessed the awareness and perception of physicians and pharmacists toward the revised guideline and identified barriers to their implementation in Kuwait.

Methods: A cross-sectional survey that employed a self-administered questionnaire was used. A random sample of physicians (n = 390), clinical microbiologists (n = 37), and clinical pharmacists (n = 48) across six Kuwaiti public hospitals were surveyed. Descriptive and comparative statistical analyses were performed. Factors associated with awareness and perceptions among the participants were identified.

Results: The response rate was 85.3% (n = 431). Participants had a high (median = 75%) awareness score for the updated vancomycin guideline, as well as a positive perception (median = 5). The main factor identified to affect the awareness and perception of participants following the group analysis was the years of experience. The main barriers identified were a lack of training to perform vancomycin AUC_{24} calculations, a lack of accurate documentation sample time, and a long turnaround time for serum levels, which might hinder the implementation of the updated guideline.

Conclusion: Physicians, clinical microbiologists, and pharmacists working in Kuwait public hospitals were aware of the 2020 vancomycin monitoring guidelines with positive perceptions. Participants agreed on the several barriers to transitioning to the AUC_{24}/MIC approach, which should be considered by stakeholders before implementation.

1. Introduction

Vancomycin has been used in clinical practice for over five decades; however, clinicians continue to face challenges in prescribing and monitoring (Reuter et al., 2022). Therefore, the clinical guideline has been frequently updated over time by several professional societies (Rybak et al., 2009, He et al., 2020, Rybak et al., 2020, Matsumoto et al., 2022). Vancomycin is traditionally monitored by trough concentrations (Rybak et al., 2009). Together, the American Society of Health-System Pharmacists, Infectious Diseases Society of America, Pediatric Infectious Diseases Society, and Society of Infectious Diseases Pharmacists published an updated vancomycin monitoring consensus guideline in 2020 and recommended transitioning to the area under the concentration–time curve over 24 h to minimum inhibitory concentration (AUC_{24}/MIC) monitoring (Rybak et al., 2020). Less than a quarter of academic medical centers in the United States have implemented AUC_{24}/MIC-based vancomycin monitoring until 2019 (Kufel et al., 2019, Bradley et al., 2021).

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Vancomycin monitoring is a routine service provided by the biochemistry laboratory at all hospitals within the Kuwait Ministry of Health. The pharmacy profession currently remains in its infancy in Kuwait; hence, physicians are recommending vancomycin dosing and requesting and interpreting vancomycin levels. To our best knowledge, no hospital in Kuwait has yet transitioned AUC_{24}/MIC monitoring. To date, only one study has assessed the perception of pharmacists toward vancomycin monitoring following the introduction of the AUC_{24}/MIC dosing and monitoring approach (Gregory et al., 2021). Pharmacists perceive that vancomycin AUC_{24}/MIC monitoring has improved patient safety while maintaining clinical benefits, thereby justifying the challenges and additional time required for monitoring. Institutional barriers were acknowledged to AUC_{24}/MIC-guided dosing implementation, and additional effort is required to enable the transition from trough-based to AUC_{24}/MIC-based strategies (Reuter et al., 2022). The following challenges were encountered during or after implementation for institutions that have implemented AUC_{24}/MIC-based monitoring: pharmacist and/or provider unfamiliarity, time allocation, training requirements, unclear benefit of AUC_{24}/MIC-based monitoring, logistical issues, and errors in the collection of vancomycin serum concentrations (Kufel et al., 2019).

Few studies have assessed the preparedness, awareness, confidence, perception, and barriers of healthcare professionals (HCPs) toward vancomycin dosing and monitoring (Newham et al., 2015, Phillips et al., 2016, Phillips et al., 2017, Chan et al., 2018, Kufel et al., 2019, Gregory et al., 2021). Few studies have assessed the barriers to adhering to and implementing vancomycin dosing and monitoring guidelines (Newham et al., 2015, Chan et al., 2018, Kufel et al., 2019). The majority of available evidence was published before the new guideline and thus focused on trough-based monitoring (Newham et al., 2015, Phillips et al., 2016, Phillips et al., 2017, Chan et al., 2018). These studies were conducted in the United Kingdom, Australia, and North America, and none were conducted in the Middle East and North Africa region, including Kuwait. Additionally, none of these studies assessed the awareness and perception of the 2020 vancomycin monitoring guideline. Most of the studies separately assessed the barriers, confidence, knowledge, preparedness, perception, or implementation, and not altogether in one study. Moreover, these studies targeted only pharmacists and/or junior doctors (Newham et al., 2015, Phillips et al., 2016, Phillips et al., 2017, Chan et al., 2018, Gregory et al., 2021), with no information on the awareness and perception of physicians. Understanding HCPs' perception and awareness and any perceived barriers facing them with the plan to transition to vancomycin AUC_{24}/MIC monitoring is important without going into details about the science behind trough- vs AUC_{24}/MIC-based monitoring which is beyond the scope of this study. Therefore, the current study aimed to assess the awareness and perception of physicians and pharmacists toward the revised consensus guideline for therapeutic monitoring of vancomycin and to understand barriers to its implementation in Kuwait.

2. Material and Methods

2.1. Study design and population

This descriptive, cross-sectional survey was conducted in Kuwait, which is a Middle-Eastern country with an area of 17,820 km^2 and an estimated population of 4,328,500 people (The World Bank's Development Data Group, 2022). This study obtained ethical approval from the Ministry of Health Ethical Committee (Ethics approval number: 1124/2021).

2.2. Target population and inclusion and exclusion criteria

The Ministry of Health in Kuwait has divided the country into seven healthcare districts: Farwaniya, Ahmadi, Sabah, Asemah, Jahra, Hawali, and Mubarak Alkabeer, with a total capacity of approximately 7000 beds. Each district has a general hospital and several primary care centers and specialized clinics that are responsible for providing health services to approximately 400,000 people. All hospitals provide similar healthcare services.

The target population was physicians and pharmacists working in six public hospitals in Kuwait. Mubarak Alkabeer district was excluded because it was designated for coronavirus disease 2019 (COVID-19) cases only during the study duration. The inclusion criteria were clinical microbiologists, clinical pharmacists, and physicians working in the medical department, intensive care unit, and pediatric department. The exclusion criteria were medical/pharmacy students and physicians/pharmacists working in the surgical department or dispensary.

2.3. Sample size calculation

The sample size was based on the assumption of 50% responses to most of the main questions because there are no previous similar studies from Kuwait. The Raosoft sample size online calculator, with a margin of error of 5%, a confidence interval of 95%, and a target population size of 1735 physicians in the six hospitals in Kuwait was used to determine the sample size (Raosoft 2004). The minimum sample size estimated for the study was 315 physicians. A larger sample size of 390 physicians was randomly selected from the public hospitals in Kuwait assuming a response rate of 80%. They were randomly selected from the six hospitals using stratified and systematic random sampling according to the methodology described by the World Health Organization (World Health Organization. Action Program on Essential and Vaccines 1993). All clinical microbiologists (n = 37) and clinical pharmacists (n = 48) were included.

2.4. Questionnaire development

A literature search revealed no similar studies and several publications with different aims to examine the impact of vancomycin educational programs and qualitative research were found. Hence, the questionnaire was adopted from available studies (Phillips et al., 2016, Phillips et al., 2017, Bond et al., 2018, Chan et al., 2018). Modifications were made to replace trough-based with AUC_{24}/MIC-based monitoring. The questionnaire contained both closed-ended and open-ended questions. Questionnaire piloting was conducted to test the validity and clarity of the questions and whether they created a positive impression that motivated people to respond following the development stage. The questionnaire was piloted with 15 physicians and 6 pharmacists, which recommended no changes. The questionnaire comprised four domains with a total of 24 questions, as set out in the Supplementary Material. The first domain was participants' demographics and other characteristics, and the second domain was participants' awareness, including questions related to the revised consensus guideline for therapeutic monitoring of vancomycin. The third and fourth domains were about participants' perceptions and barriers, respectively. Participants responded using a five-point Likert scale that ranged from "strongly agree" to "agree," "neutral," "disagree," and "strongly disagree.".

2.5. Data collection

Data were collected anonymously and randomly via self-administered questionnaires from March to August 2021, and both

paper and electronic questionnaires were prepared to provide selection flexibility. Participants were assured of confidentiality and provided written consent for study participation. A follow-up reminder was sent through e-mail or WhatsApp either the next day or after 2 days.

2.6. Statistical analysis

Microsoft Excel and GraphPad Prism 9 software were used for descriptive and comparative statistical analyses. The rank upgrade for physicians and pharmacists is based on years of working experience. Therefore, further analysis used years of experience. Age and years of experience were also presented as categorical variables by dividing them into two groups: ≤40 and >40 years of age and ≤ 10 and >10 years of experience. Country of qualification was divided into Kuwait, or abroad (Middle East, United Kingdom, United States, etc.). Responses were presented as percentages (95% confidence intervals [CI]), medians (Interquartile range [IQR]), and means (standard deviation [SD]).

Correct answers regarding questions related to participants' awareness were labeled as "aware," and "wrong" and "do not know" answers were labeled as "unaware." The total percentage of awareness was estimated by summing awareness questions and dividing them by 4 (the maximum score) and multiplying by 100. Respondents' perceptions toward prescribing and monitoring vancomycin were presented as percentages, means (SD), and medians (IQR) with a Likert scale rating. The overall perception score was reported as a mean (SD) and a median (IQR). The perception score was categorized into negative (0–3) and positive (4–5). Shapiro–Wilk and Kolmogorov–Smirnov tests were used to determine the not normally distributed awareness and perception scores. The Pearson correlation was used to assess correlation between age and years of experience (Figure S1). Therefore, years of experience and profession were the factors assessed for association with awareness and perception toward vancomycin dosing and monitoring. The Mann–Whitney test was used to evaluate the differences in the overall scores between two groups of independent variables (years of experience). The Kruskal–Wallis test was used to evaluate the difference in the overall scores between more than two groups of independent variables (profession: "physician," "clinical microbiologist," or "pharmacist"). The significance level was set at p-values of ≤ 0.05.

3. Results

3.1. Participant characteristics

Of the 505 practitioners approached for enrollment, 431 agreed to participate with an overall response rate of 85.3% (355 [84.5%] physicians, 35 [94.6%] clinical microbiologists, and 41 [85.4%] pharmacists). Table 1 presents the participant demographics and professional information. The participants' median age (IQR) was 39.0 (36) years (mean [SD]: 39.8 [9.37]), and more than half were under 40 years of age (n = 246, 57.1%). The median years of experience (IQR) was 11 years (29.5) (mean [SD]: 11.6 [6.95]), with approximately half (n = 224, 52%) having > 10 years of experience. The majority of the participants were from medical departments (n = 191; 44.3%).

3.2. Participants' awareness

The median (IQR) total awareness score for the updated vancomycin dosing and monitoring guideline was high, at 75% (100) (mean [SD]: 67.3 [36.0]), with two-thirds of the respondents being aware of the updated guideline (n = 272; 63.1%). Table 2 summarizes the results of awareness statements for each question. Approximately two-thirds of participants (65.7%; 95% CI = 61.1–69.9) were aware of the new recommendations to transition to AUC_{24}/MIC vancomycin monitoring. Similarly, 65.0% (95% CI = 60.3–69.3) knew that the vancomycin guideline was updated to help optimize efficacy and minimize toxicity, and were aware of when a vancomycin loading dose is not recommended (60.3%; 95% CI = 55.6–64.8). Additionally, 78.4.6% (95% CI = 74.3–82.0) were aware of the recommended sample times for vancomycin monitoring. Participants who had ≤ 10 years of experience (p < 0.0001) had lower awareness (Table 4). Clinical microbiolo-

Table 1
Participant characteristics.

Variable	Physicians (n = 355)	Pharmacists (n = 41)	Clinical microbiologists (n = 35)	Total (n = 431)
Sex				
Male (%)	219 (61.7%)	6 (14.6%)	7 (20%)	232 (53.8%)
Female (%)	136 (38.3%)	35 (85.4%)	28 (80%)	199 (46.2%)
Age (years)				
≤40 (%)	189 (53.2%)	39 (95.1%)	18 (51.4%)	246 (57.1%)
>40 (%)	166 (46.8%)	2 (4.9%)	17 (48.6%)	185 (42.9%)
Nationality				
Kuwaiti (%)	174 (49.0%)	37 (90.2%)	20 (57.1%)	231 (53.6%)
Non-Kuwaiti (%)	181 (51.0%)	4 (9.8%)	15 (42.9%)	200 (46.4%)
Years of experience				
≤10 years (%)	153 (43.1%)	36 (87.8%)	18 (51.4%)	207 (48%)
>10 years (%)	202 (56.9%)	5 (12.2%)	17 (48.6%)	224 (52%)
Country of Qualification				
Kuwait (%)	141 (39.7%)	15 (36.6%)	20 (57.1%)	176 (40.8%)
Abroad (%)	214 (60.3%)	26 (63.4%)	15 (42.9%)	255 (59.2%)
Specialties				
Pediatrics (%)	104 (29.3%)	6 (14.6%)	–	110 (25.5%)
Medical (%)	173 (48.7%)	18 (43.9%)	–	191 (44.3%)
Intensive Care Unit (%)	78 (22.0%)	12 (29.3%)	–	90 (20.9%)
others (%)	0	5 (12.2%)	–	40 (9.28%)
Rank				
Consultant/Head Specialist Pharmacist (%)	71 (20.0%)	1 (2.4%)	4 (11.4%)	76 (17.6%)
Senior Specialist/Specialist Pharmacist (%)	50 (14.1%)	0	5 (14.3%)	55 (12.8%)
Specialist/Senior Pharmacist (%)	110 (31.0%)	11 (26.8%)	17 (48.6%)	138 (32.0%)
Registrar/Pharmacist (%)	108 (30.4%)	27 (65.9%)	8 (22.9%)	143 (33.2%)
Resident/Junior Pharmacist (%)	16 (4.5%)	2 (4.9%)	1 (2.9%)	19 (4.4%)

Table 2
Participants' awareness of the updated vancomycin dosing and monitoring guidelines.

Awareness item	Frequency	Percentage
What does the revised consensus guideline for therapeutic monitoring of vancomycin published in 2020 recommend? (For adult and pediatric patients)		
A. Continue trough-guided dosing and monitoring	60	13.9%
B. Move to peak-guided dosing and monitoring	22	5.1%
C. Move to AUC_{24}/MIC-guided dosing and monitoring	283	65.7%
D. I do not know	66	15.3%
What is the recommended vancomycin target to optimize efficacy and minimize toxicity, as recommended by the revised consensus guideline for therapeutic monitoring of vancomycin 2020 (assuming MIC of $\leq$ 1 mg/L)?		
A. Trough concentration of 15–20 mg/L	68	15.8%
B. Trough concentration of 15–25 mg/L	24	5.6%
C. AUC_{24}/MIC of $\geq$ 400 mg.h/L	280	65.0%
D. I do not know	59	13.7%
When is a vancomycin loading dose NOT recommended?		
A. Patients with critical illnesses	18	4.2%
B. Stable patients with non-serious methicillin resistant *Staphylococcus areus* infection	259	60.1%
C. Require renal replacement therapy	62	14.4%
D. I do not know	92	21.3%
What are the recommended vancomycin sample times by the revised consensus guideline for therapeutic monitoring of vancomycin? (A and C are correct)		
A. Trough only	63	14.6%
B. Peak only	18	4.2%
C. Peak and trough concentrations	275	63.8%
D. I do not know	75	17.4%

gists had lower awareness compared with physicians and pharmacists (0.0286).

3.3. Participants' perception

The total perception was positive, with a median score of 5 (5) (mean [SD]: 4.29 [1.17]), and 81.0% (n = 349) of participants had overall positive perceptions of $\geq$ 4. Table 3 presents participants' responses to perception items. Most participants (91.6%; 95% CI = 88.7–93.9) agreed that pharmacists should be required to have some knowledge of vancomycin AUC_{24}/MIC dosing and monitoring. A total of 88.6% (95% CI = 85.3–91.3) of participants agreed that vancomycin AUC_{24}/MIC dosing and monitoring should be applied in their clinical practice. Participants with $\leq$ 10 years of experience had negative perceptions toward the updated vancomycin guideline (p = 0.0002) (Table 4).

3.4. Perceived barriers

Table 5 shows participants' responses to the perceived barriers to the transition to AUC_{24}/MIC monitoring. Lack of training to perform vancomycin AUC_{24} calculations was the highest barrier reported by responders (n = 355; 91%). Approximately two-thirds of participants agreed that a lack of accurate documentation sample time was the second perceived barrier. More than half of the participants (55%; n = 237) agreed that long turnaround times for serum levels might hinder the implementation of the updated guideline.

4. Discussion

The present study shows good awareness and positive perceptions of HCPs (physicians, clincal microbiologits and pharmacists) about the 2020 updated guideline for vancomycin dosing and monitoring. However, several barriers were identified, mainly the need for proper training and system support. HCPs had high awareness of the new recommendations for the transition to AUC_{24}/MIC-based dosing and monitoring, the need for a loading dose in some patient populations, the number of samples required, and the time to measure them. Factors associated with the awareness of HCPs were the years of experience and being clincal microbiologist. Those who had fewer years of experience and were clinical microbiologists were less aware of the changes in the 2020 guideline. Awareness about the 2009 vancomycin dosing and monitoring guideline was studied by Philips et al. (Phillips et al., 2016). The results revealed that pharmacists had high awareness. The present study revealed better awareness in both physicians and pharmacists than in clinical microbiologists. This might be because the guidelines were published during the global COVID-19 pandemic. Moreover, the current study was conducted during the pandemic

Table 3
Participants' perception toward prescribing and monitoring vancomycin.

Perception Item	Response (%) agreed/ strongly agreed	Mean* (SD)	Median* (IQR)
Vancomycin AUC_{24}/MIC dosing and monitoring are relevant to my clinical practice.	329 (76.3%)	4.00 (0.92)	4.0 (4.0)
Pharmacists should be required to have some knowledge of vancomycin AUC_{24}/MIC dosing and monitoring.	395 (91.6%)	4.49 (0.68)	5.0 (4.0)
Vancomycin AUC_{24}/MIC dosing and monitoring should be applied to my clinical practice.	382 (88.6%)	4.19 (0.68)	4.0 (3.0)
Pharmacists should be asked by healthcare professionals for recommendations on the appropriate use of vancomycin AUC_{24}/MIC dosing and monitoring.	381 (88.4%)	4.36 (0.77)	5.0 (4.0)
I should be able to provide information on the appropriate use of vancomycin AUC_{24}/MIC dosing and monitoring.	365 (84.7%)	4.12 (0.68)	4.0 (3.0)

* Responses rated on a Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Table 4
Factors associated with awareness and perception toward vancomycin dosing and monitoring.

Variable	Overall median percentage awareness score (25%, 75% percentile)	Mean rank	*P*-value	Overall median perception score (25%, 75% percentile)	Mean rank	*P*-value
Years of experience						
≥10 years	100 (50, 100)	244.1	<0.0001*	5 (4, 5)	234.6	0.0002*
≤10 years	75 (25, 100)	185.6		5 (3, 5)	195.8	
Profession						
Physician	75 (25, 100)	221.3	0.0286*	5 (4,5)	219.0	0.340
Clinical Microbiologist	50 (25, 100)	165.6		5 (3, 5)	211.4	
Pharmacist	75 (50, 100)	213.3		4 (4, 5)	193.6	

* Significant with *P*-value of ≤ 0.05.

Table 5
Perceived barriers to implementation.

Barrier Item	Frequency (%; 95% CI) agreed/ strongly agreed
Having dedicated phlebotomists for vancomycin blood sampling.	207 (48.0%; 43.3–52.7)
Lack of communication between doctors and nurses was identified as another reason for the collection of inappropriately timed blood samples	146 (33.9%; 29.6–38.5)
Accurate documentation of sample time.	298 (69.1%; 64.6–73.3)
No efficacy data to support use in special populations (e.g.,., dialysis, pediatric patients, neonates).	166 (38.5%; 34.0–43.2)
Long turnaround time for serum levels	237 (54.9%; 50.3–59.6)
No cooperation/lack of support from physicians.	101 (23.4%; 19.7–27.7)
Lack of training to perform vancomycin AUC_{24} calculations.	355 (91.0%; 87.8–93.5)

in 2021. Clinical microbiologists were the main specialty overwhelmed with diagnostic, treatment, and prevention measures during the pandemic and might have not followed up on other non-COVID-19-related updates.

We found that HCPs had positive perceptions toward vancomycin AUC_{24}/MIC dosing and monitoring and supported their application in clinical practice. The majority of participants expressed positive perceptions that pharmacists should have some knowledge and should provide information on the appropriate use of vancomycin AUC_{24}/MIC dosing and monitoring. A positive impact was found by involving pharmacists in vancomycin monitoring, with an increased number of patients achieving targets and reduced risk of nephrotoxicity (Masuda et al., 2015, Joseph et al., 2021). Practicing clinical pharmacits is currently limited in Kuwait (48 at study time). Therefore, other professions, especially physicians remain required to know about vancomycin and its dosing and monitoring. Those with < 10 years of experience had negative perceptions toward the guideline, and the reasons should be explored.

The present study identified several barriers that should be considered when planning to implement vancomycin AUC_{24}/MIC-based dosing and monitoring. A major barrier was the lack of training to perform vancomycin AUC_{24} calculations, which was also reported by Kufel et al. (Kufel et al., 2019). AUC_{24} calculations can be performed using Bayesian software or pharmacokinetic equations. Both approaches require training, which is not required for the trough-based approach (Rybak et al., 2020). A recent study revealed more vancomycin level utilization than pharmacokinetic equations using Bayesian software (Alsowaida et al. 2022). Discussion about the difference in AUC_{24} calculation approaches is beyond the scope of the current study. Health institutions in the United States of America require credentialing or training before pharmacists can perform vancomycin therapeutic drug monitoring (TDM) (Kufel et al., 2019). Other important barriers that need attention from institutions are the lack of accurate documentation for sample time and the long turnaround time for serum levels. These barriers were reported for both vancomycin trough-and AUC_{24}/MIC-based dosing and monitoring approaches (Newham et al., 2015, Kufel et al., 2019). The AUC_{24}/MIC approach is expected to provide more time to perform calculations. A recent survey revealed that 41% of pharmacists disclosed that additional time was required when applying AUC_{24}/MIC monitoring; however, this was accepted due to the potential benefits of lower nephrotoxicity and similar cure rates (Gregory et al., 2021). The decision to transition to AUC_{24}/MIC monitoring or continue trough-based monitoring should be considered by institutions with staffing, capabilities, and patient population needs (Reuter et al., 2022). This is supported by a recent clinical study that revealed poor TDM practices, which reflects an ongoing challenge in daily practice and highlights the need to optimize vancomycin dosing strategies and improve awareness among all HCPs (Van Der Heggen et al., 2021). High levels of engagement, collaboration, effective communication, and strong evidence-based guidelines are necessary to ensure their suitability and sustainability for routine daily practice. Our results support ensuring the existence of appropriate infrastructure to support the effective application of vancomycin dosing and monitoring guidelines, as suggested by previous studies (Newham et al., 2015, Chan et al., 2018).

The current findings can be used by decision-makers in education and policymakers in Kuwait's healthcare systems to design future targeted multifaceted interventions and improve vancomycin dosing and monitoring. Additionally, these findings can be used to develop a national quality improvement program for vancomycin administration. The study results could provide a foundation for designing a future audit and feedback intervention to assess outcomes and continue the quality improvement cycle. Moreover, the results indicate the importance of developing educational strategies on vancomycin monitoring and the AUC_{24}/MIC approach for HCPs through webinars, lectures, or workshops. A recent position statement from the International Association of TDM and Clinical Toxicology highlighted the importance of education among all stakeholders involved in vancomycin TDM for successful implementation (Reuter et al., 2022). Phillips et al. revealed that implementation strategy, including education, clinical

vignettes, and provision of pocket guidelines, improved vancomycin practices and increased practitioners' confidence in prescribing vancomycin (Phillips and Gordon 2015, Phillips et al., 2017).

This study fills a gap in the existing literature by providing useful information on HCPs' awareness and perception of the revised 2020 consensus guidelines for vancomycin TDM and their implications in the Middle-Eastern region. The findings apply to healthcare providers in secondary healthcare settings in Kuwait. This study has its own limitations, including (i) limited generalization of the present findings to all healthcare providers in Kuwait because HCPs working in tertiary and private hospitals, or other HCPs, such as nurses, who play an important role in administering vancomycin and monitoring patients were not included; (ii) the cross-sectional nature of the survey, as it does not reflect any changes in respondents over time; (iii) the consensus guideline was published in the Spring of 2020, and the study was conducted a year after, which may be too soon to ask about awareness; (iv) vancomycin AUC_{24}/MIC dosing and monitoring was the main focus, thus assessing the importance of optimal vancomycin dosing and monitoring in general and the importance of the use of AUC_{24}/MIC for vancomycin monitoring would be beneficial for future studies; (v) this type of research depends on the information provided by respondents, and it is exposed to recall bias because socially desirable behaviors may be overreported or socially undesirable behaviors may be underreported, thus assessing the honesty of the answers or verifying the claims of respondents was not possible in this study, and the anonymous completion of the questionnaires would have minimized over-and under-reporting; (vi) non-response bias cannot be excluded since 14.7% of the contacted HCPs did not submit the survey, which might indicate that they have simply ignored this study after reading the invitation. They may still have different views compared to the study participants. However, our response rate was 85.3% with no missing data.

5. Conclusions

HCPs working in Kuwaiti public hospitals are aware of the 2020 vancomycin monitoring guidelines and have positive perceptions toward them. Participants agreed on several barriers concerning the transition to the AUC_{24}/MIC approach, which should be considered by stakeholders before implementation. The training was the most frequently identified barrier, and a proper educational approach should be provided to generate competent HCPs. The development and implementation of a training program will fill the existing gap.

Data availability

The data are available from the corresponding author upon reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethics approval statement

Ethical clearance for this study was obtained from the Human Research Ethics Committee of the Ministry of Health, Kuwait (Ethics approval number: 1124/2021).

Authors' contributions

All authors meet the *ICMJE* authorship criteria and have read and approved the final version of the manuscript. SA and AA contributed to the study's conception and design. Material preparation and data collection were performed by NA and ZB. Data analysis was performed by SA. The first draft of the manuscript was written by SA and AA, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsps.2023.04.025.

References

Alsowaida, Y.S., Kubiak, D.W., Dionne, B., Kovacevic, M.P., Pearson, J.C., 2022. Vancomycin area under the concentration-time curve estimation using bayesian modeling versus first-order pharmacokinetic equations: a quasi-experimental study. Antibiotics (Basel) 11 (9).

Bond, S.E., Crowther, S.P., Adhikari, S., Chubaty, A.J., Yu, P., Borchard, J.P., Boutlis, C.S., Yeo, W.W., Miyakis, S., 2018. Evaluating the effect of a web-based e-learning tool for health professional education on clinical vancomycin use: comparative study. JMIR Med. Educ. 4 (1), e5.

Bradley, N., Lee, Y., Sadeia, M., 2021. Assessment of the implementation of AUC dosing and monitoring practices with vancomycin at hospitals across the United States. J. Pharm. Pract. 8971900211012395.

Chan, J.O.S., Baysari, M.T., Carland, J.E., Sandaradura, I., Moran, M., Day, R.O., 2018. Barriers and facilitators of appropriate vancomycin use: prescribing context is key. Eur. J. Clin. Pharmacol. 74 (11), 1523–1529.

Gregory, E.R., Burgess, D.R., Cotner, S.E., VanHoose, J.D., Flannery, A.H., Gardner, B., Autry, E.B., Forster, D.W., Burgess, D.S., Wallace, K.L., 2021. Pharmacist survey: pharmacist perception of vancomycin area under the curve therapeutic drug monitoring. J. Pharm. Pract. 34 (2), 272–278.

He, N., Su, S., Ye, Z., Du, G., He, B., Li, D., Liu, Y., Yang, K., Zhang, X., Zhang, Y., Chen, X., Chen, Y., Chen, Z., Dong, Y., Du, G., Gu, J., Guo, D., Guo, R., Hu, X., Jiao, Z., Li, H., Liu, G., Li, Z., Lv, Y., Lu, W., Miao, L., Qu, J., Sun, T., Tong, R., Wang, L., Wang, M., Wang, R., Wen, A., Wu, J., Wu, X., Xu, Y., Yang, Y., Yang, F., Zhan, S., Zhang, B., Zhang, C., Zhang, H., Zhang, J., Zhang, J., Zhang, J., Zhang, W., Zhao, L., Zhao, L., Zhao, R., Zhao, W., Zhao, Z., Zhou, W., Zeng, X.T., Zhai, S., 2020. Evidence-based guideline for therapeutic drug monitoring of vancomycin: 2020 update by the division of therapeutic drug monitoring, Chinese pharmacological society. Clin. Infect. Dis. 71 (Suppl 4), S363–S371.

Joseph, K., Ramireddy, K., Madison, G., Turco, T., Lui, M., 2021. Outcomes of a pharmacist-driven vancomycin monitoring initiative in a community hospital. J. Clin. Pharm. Ther. 46 (4), 1103–1108.

Kufel, W.D., Seabury, R.W., Mogle, B.T., Beccari, M.V., Probst, L.A., Steele, J.M., 2019. Readiness to implement vancomycin monitoring based on area under the concentration-time curve: a cross-sectional survey of a national health consortium. Am. J. Health Syst. Pharm. 76 (12), 889–894.

Masuda, N., Maiguma, T., Komoto, A., Haruki, Y., Sugiyama, T., Kondo, S., Teshima, D., 2015. Impact of pharmacist intervention on preventing nephrotoxicity from vancomycin. Int. J. Clin. Pharmacol. Ther. 53 (4), 284–291.

Matsumoto, K., Oda, K., Shoji, K., Hanai, Y., Takahashi, Y., Fujii, S., Hamada, Y., Kimura, T., Mayumi, T., Ueda, T., Nakajima, K., Takesue, Y., 2022. Clinical Practice guidelines for therapeutic drug monitoring of vancomycin in the framework of model-informed precision dosing: a consensus review by the Japanese society of chemotherapy and the Japanese society of therapeutic drug monitoring. Pharmaceutics 14 (3).

Newham, R., Thomson, A.H., Semple, Y., Dewar, S., Steedman, T., Bennie, M., 2015. Barriers to the safe and effective use of intravenous gentamicin and vancomycin

in Scottish hospitals, and strategies for quality improvement. Eur. J. Hosp. Pharm. 22 (1), 32–37.
Phillips, C.J., Gordon, D.L., 2015. Pharmacist-led implementation of a vancomycin guideline across medical and surgical units: impact on clinical behavior and therapeutic drug monitoring outcomes. Integr. Pharm. Res. Pract. 4, 145–152.
Phillips, C.J., McKinnon, R.A., Woodman, R.J., Gordon, D.L., 2017. Junior doctors' preparedness to prescribe, monitor, and treat patients with the antibiotic vancomycin in an Australian teaching hospital. J. Educ. Eval. Health Prof. 14, 13–110.
Phillips, C.J., Wisdom, A.J., Eaton, V.S., Woodman, R.J., McKinnon, R.A., 2016. The impact of a pilot continuing professional development module on hospital pharmacists' preparedness to provide contemporary advice on the clinical use of vancomycin. Springerplus 5, 331.
Raosoft, 2004. "Raosoft sample size calculator." 2020, from http://www.raosoft.com/samplesize.html.
Reuter, S.E., Stocker, S.L., Alffenaar, J.C., Baldelli, S., Cattaneo, D., Jones, G., Koch, B.C. P., Kocic, D., Mathew, S.K., Molinaro, M., Neely, M., Sandaradura, I., Marriott, D.J. E., 2022. Optimal practice for vancomycin therapeutic drug monitoring: position statement from the anti-infectives committee of the international association of therapeutic drug monitoring and clinical toxicology. Ther. Drug Monit. 44 (1), 121–132.
Rybak, M., Lomaestro, B., Rotschafer, J.C., Moellering Jr., R., Craig, W., Billeter, M., Dalovisio, J.R., Levine, D.P., 2009. Therapeutic monitoring of vancomycin in adult patients: a consensus review of the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, and the Society of Infectious Diseases Pharmacists. Am. J. Health Syst. Pharm. 66 (1), 82–98.
Rybak, M.J., Le, J., Lodise, T.P., Levine, D.P., Bradley, J.S., Liu, C., Mueller, B.A., Pai, M.P., Wong-Beringer, A., Rotschafer, J.C., Rodvold, K.A., Maples, H.D., Lomaestro, B.M., 2020. Therapeutic monitoring of vancomycin for serious methicillin-resistant Staphylococcus aureus infections: A revised consensus guideline and review by the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, the Pediatric Infectious Diseases Society, and the Society of Infectious Diseases Pharmacists. Am. J. Health Syst. Pharm. 77 (11), 835–864.
The World Bank's Development Data Group, 2022. "Population, total - Kuwait." Retrieved 17 Nov. 2022, 2022, from https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KW.
Van Der Heggen, T., Buyle, F.M., Claus, B., Somers, A., Schelstraete, P., De Paepe, P., Vanhaesebrouck, S., De Cock, P., 2021. Vancomycin dosing and therapeutic drug monitoring practices: guidelines versus real-life. Int. J. Clin. Pharm. 43 (5), 1394–1403.
World Health Organization. Action Program on Essential, D. and Vaccines, 1993. How to investigate drug use in health facilities: selected drug use indicators. Geneva, World Health Organization.