Examination of the Relationship between Pharmacist Confidence and Knowledge in Adult Vancomycin Therapy Management at the Kingston General Hospital

Pharmacy Resident Investigator: Megan Zalewski, RPh, BScComp, BScPhm
Principal Investigator: Susan McKenna, RPh, BScH, BScPhm, BCPS

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Kingston General Hospital pharmacists who volunteered to participate in the Confidence Survey and Knowledge Assessment Test.

Kingston General Hospital Quality and Safety Clinical Lead Pharmacists and Infectious Diseases Pharmacist for their assistance in refining the Knowledge Domains, Confidence Survey, and Knowledge Assessment Test.
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Abstract

Background: The primary purpose of this research project was to examine the relationship between pharmacist self-assessment of confidence and ability to provide sound recommendations for vancomycin therapy management. Secondarily, it sought to evaluate how experience, practice and formal training correlates with confidence in this clinical area. Pharmacists require both comprehension and confidence to translate knowledge into safe, effective patient care.

Methods: The project was conducted at the Kingston General Hospital (KGH) prospectively in three phases. In Phase One, the Vancomycin Management Knowledge Domains (KD), a corresponding confidence and practice characterization survey, and a Knowledge Assessment Test (KAT) were created. Institutional pharmacist leaders vetted and approved the KDs and Confidence Survey by consensus. In Phase Two, the KAT was piloted in a group of pharmacist leaders, and feedback incorporated. In Phase Three, eligible pharmacists who had provided written informed consent completed the Confidence Survey and wrote the KAT. The primary outcome measure was correlation of overall Confidence Scores (CS) with KAT scores. Secondary outcome measures were median overall CSs analyzed according to years of experience, frequency of interventions, and completion of residency program. Additionally, KAT scores were analyzed according to KD.

Results: The overall median CS and KAT scores were 73% and 75%, respectively, in the 22 participants (Spearman co-efficient for correlation \( \rho = 0.21 \)). Median CS was statistically significantly higher in pharmacists performing ten or more interventions per month (84.5% vs 64.2%, \( p<0.05 \)), but not different in those with a pharmacy residency (73.5% vs. 72.3%, NS) or those with five or more years of experience (74.8% vs. 72.3%, NS). With respect to the KAT, pharmacists scored the highest on questions regarding administration of vancomycin and appropriateness of therapy, and scored the lowest on the two questions pertaining to vancomycin dosing subsequent to level analysis.

Conclusion: KGH pharmacist self-reported confidence levels in vancomycin management in adults were moderately high, and were weakly positively correlated to scores on a written knowledge assessment test. Confidence was most strongly associated with frequency of vancomycin interventions performed; supporting the importance of experiential practice to build and maintain confidence.

Key words: Competency, confidence, vancomycin, therapeutic drug monitoring

Word count = 341; Manuscript text = 3,487
Background and Rationale

The primary purpose of this project was to examine the relationship between pharmacist self-assessment of confidence and ability to provide sound recommendations for vancomycin therapy management. Pharmacy Services at Kingston General Hospital (KGH) identified the development of administrative policies permitting pharmacists to adapt medication orders for therapeutic drug monitoring (TDM) as a priority clinical tactic for 2016-2017; aligning with the KGH strategic direction to “transform the patient experience through a relentless focus on quality, safety and service”. [1] Eventual development of a medical directive for pharmacists to manage vancomycin therapy independently will necessitate the assurance that pharmacists can confidently provide accurate recommendations to other healthcare practitioners.

Since trough vancomycin serum levels outside of therapeutic range have been associated with toxicity, inadequate clinical response, and the promotion of resistant pathogens, ensuring pharmacists are knowledgeable about vancomycin management is both a quality and safety initiative. [2,3,4] In addition to reducing uncomfortable phlebotomy for patients, increasing the efficiency of monitoring optimizes resource utilization associated with blood collection, specimen analysis, and interpretation of results. Hospitals in the United States with pharmacist-managed TDM of aminoglycoside or vancomycin therapy have demonstrated significantly less laboratory and drug expenditures, and shorter lengths of stay compared to those without. [5] A subset of vancomycin adverse reactions are administration-related, such as red neck syndrome; pharmacists can prevent unnecessary changes in antibiotic therapy by recognizing a reaction as infusion-related and promoting subsequent administration at slowed infusion rates. [6] As leaders in medication management, it is imperative that pharmacists convey both knowledge and confidence when making recommendations in an area with hospital-wide impact.

At KGH, pharmacists are expected to ensure appropriate dosing and monitoring of vancomycin and secondarily to interpret serum drug levels skillfully. [7] Written requests for pharmacist-led TDM of vancomycin on patient charts are increasingly common; however, there is no standardized approach at KGH to evaluate or validate a pharmacist’s competency to perform such a complex task. In 2016, KGH Pharmacy Administration determined that a knowledge assessment test on managing vancomycin therapy would be incorporated into performance review requirements for selected clinical pharmacists (V. Briggs, personal communication, October 27th, 2016). Evaluating the level of such knowledge is important because mismanagement can lead to patient harm; harm potentially preventable by additional pharmacist training, supervision and guidance. The American College of Clinical Pharmacy suggests recognizing the limit of ones’
own knowledge base is an important step in the development of a mature clinician. [8] Additionally, a low self-confidence in a skill an individual is performing has been identified in knowledge translation literature as a barrier to implementation of evidence. [9] Therefore, healthcare practitioners require both knowledge and confidence to execute the safest and most effective evidence-based medicine.

Evaluating competence can be done through written or verbal tests, simulations, observations, or any combination of these methods. [8] Directly observing pharmacists gathering information, making recommendations and creating follow up plans to assess competence requires significant resources. Since a literature review failed to identify an established method of competency evaluation for vancomycin management, it is reasonable to begin with construction of a written knowledge assessment test employing input from institutional pharmacy leaders to evaluate knowledge; a subset of competence.

Psychology literature describes a theory of cognitive bias in the relationship between confidence and knowledge known as the Dunning-Kruger effect. [10] The theory suggests those less skilled tend to overestimate their ability more than those who are more skilled due to an inability to recognize their limitations. When managing vancomycin, a lack of knowledge may be deemed more unsafe if paired with overconfidence. The study of confidence as it relates to knowledge was inspired by a pilot study by Phillips et al. examining pharmacists’ preparedness to provide advice on the clinical use of vancomycin. [11] Intuitively, the confidence of a practicing clinical pharmacist is expected to increase with years of experience. Similarly, as repetition is essential to the development of practice skills, the frequency of vancomycin interventions is postulated to favorably influence confidence level. The additional structured and rigorous training of a pharmacy residency program with emphasis on providing evidence-based care is also expected to have a favorable influence on confidence. This project sought to evaluate how knowledge, experience, practice and formal training influenced a pharmacist’s confidence in vancomycin therapy management at a tertiary care institution.
Purpose
The purpose of this project was to examine the relationship between pharmacist self-assessment of confidence and ability to provide sound recommendations for vancomycin therapy management.

Objectives
Primary objective:
The primary objective of this project was to determine how self-reported confidence in vancomycin therapy management correlates to knowledge in KGH pharmacists, as measured by a multiple-choice written test.

Secondary objectives:
The secondary objectives of this project were:
1) To determine how years of experience as a hospital pharmacist, self-reported frequency of vancomycin interventions, and completion of a pharmacy residency program relates to self-reported confidence of vancomycin therapy management.
2) To determine how pharmacists’ KAT scores vary by Knowledge Domain scores.
Definitions:

Knowledge Domains:
A list of criteria considered required of pharmacists to competently practice safe and effective adult vancomycin therapy management (Appendix A).

Confidence Survey:
A list of questions that collects the self-reported confidence level in each of the six Knowledge Domains (Appendix B).

Knowledge Assessment Test (KAT):
A set of 12 multiple-choice questions inspired by the Knowledge Domains and corresponding criteria. Each multiple-choice question has a possible 4 answers to choose from, but only one best answer per question (Appendix D).

Pharmacy Leader Group
A group comprised of the four Quality and Safety Clinical Lead Pharmacists of KGH.

Pharmacy Administration
KGH Pharmacy Services Director and Pharmacy Manager, Clinical Practice.
Methods

This study had a prospective three phase design and was conducted at Kingston General Hospital (KGH); a 456-bed tertiary care teaching hospital located in Kingston, Ontario.

Study Population

Inclusion criteria:

Staff pharmacists and pharmacy residents employed at KGH between January 1st and April 31st, 2017 who performed vancomycin therapeutic drug monitoring (TDM) and provided regimen recommendations as part of usual clinical practice were eligible.

Exclusion criteria:

Pharmacists contributing to the creation of the Confidence Survey and Knowledge Assessment Test were excluded from participation, and further pharmacist exclusions were permitted at the discretion of KGH Pharmacy Administration.

Study Design

Phase 1: Creation of Knowledge Domains, Confidence Survey and Knowledge Assessment Test (KAT)

First drafts of the Knowledge Domains, the Confidence Survey and the KAT were created by the research team comprised of pharmacy resident investigator (MZ), and pharmacist preceptor (SM). The Knowledge Domains and Confidence Survey were circulated to the Pharmacy Leader Group. Revisions secondary to feedback were incorporated and the final versions approved by consensus (Appendix A, Appendix B).

Phase 2: Pilot Testing

The draft KAT was piloted by the Pharmacy Leader Group and an Antimicrobial Stewardship/Infectious Diseases pharmacist. The pilot group wrote the KAT, independently, in a controlled environment with unlimited time and unrestricted access to internet resources, paper resources, and a calculator. Immediately afterward, the group compared their responses to the research team’s answer key and discussion was encouraged to gather feedback on content and complexity. Questions were subsequently revised accordingly and all present were asked to keep the details surrounding the KAT confidential.
Phase 3: Execution

Confidence Survey

KGH pharmacists meeting inclusion criteria were invited through email to participate in the Confidence Survey through the SurveyMonkey™ website. Pharmacists were provided an information letter and consent form for participation; no incentives were offered to complete the survey (Appendix C). Reminder emails were sent at 9 and 14 days from the original email. The first page of the Confidence Survey collected self-reported information on pharmacists’ years of experience, frequency of vancomycin interventions performed, and completion of a pharmacy residency program (Appendix B). Number of years of hospital experience and average monthly number of interventions were collected as ordinal data to prevent potential identification of individual pharmacists. Questions on the second page of the Confidence Survey were structured as statements of confidence in the six Knowledge Domains (Appendix B). Pharmacists moved an interactive slider along a visual analogue scale (VAS) from “Not confident” to “Very confident” to record their answer, for which the SurveyMonkey™ website generated a corresponding value between 0 and 100. Each pharmacist had six VAS scores; the mean value of the six scores was labeled their “overall confidence score”. As pharmacists submitted the survey, the resident investigator (MZ) assigned each pharmacist a sequential study number to later match results with the knowledge assessment test scores.

Knowledge Assessment Test (KAT)

Eligible KGH pharmacists, as identified by Pharmacy Administration, were notified through email of KAT testing opportunities in a KGH computer laboratory. Pharmacists completed the KAT questions on paper, independently, in a controlled environment with unlimited time and unrestricted access to internet resources, paper resources, and a calculator. Study investigators requested KAT information be kept confidential until all participants had the opportunity to complete the test.

For each test paper, the pharmacy resident investigator (MZ) removed the pharmacist’s name, initials, and date of completion and recorded their assigned study number on the top right of the first page. The tests were then submitted to the pharmacist preceptor (SM) for marking. Each participant was awarded a score of 1 (correct) or 0 (incorrect) for each Knowledge Assessment question based upon the answer key. Each pharmacist had an “overall knowledge assessment score” which was the percentage of questions answered correctly on the KAT. All questions on the KAT were weighted equally.
Approval and Consent

Project approval was obtained from the Research Ethics Board of Queen’s University in Kingston, the University of Toronto Pharmacy Residency Advisory Committee, and KGH Pharmacy Practice Council prior to implementation. Pharmacists participating in the Confidence Survey provided written informed consent and there were no actual or potential conflicts of interest among the investigators. Pharmacy resident investigator (MZ) provided KGH Pharmacy Administration KAT scores by pharmacist study number and the study number assignment key for future unblinding in a confidential fashion to individual pharmacists upon their request and at Administration’s discretion.
Data analysis

Primary objective

The overall confidence score versus knowledge assessment score, by pharmacist, was displayed as a set of continuous variables in a scatter plot for descriptive analysis. The Spearman correlation coefficient (rho) of the data was calculated in Microsoft Excel 2010 to describe the relationship between the two variables. The non-parametric coefficient was chosen because multiple unspecified factors contribute to both confidence and knowledge, and linearity between variables was unable to be assumed.

Secondary objectives

Bar graphs were constructed for visual representation of the median overall confidence score by potential influential factors: years as a practicing hospital pharmacist, number of vancomycin recommendations made in a month, and completion of a pharmacy residency program. The median was chosen as a measure of central tendency to minimize the effect of outliers or skewed data. Median confidence scores were evaluated using a Mann-Whitney U test with a two-sided significance of 0.05 for each of the three potential influential factors. [12] For each knowledge domain encompassing two questions of the KAT, pie charts depict the proportion of pharmacists answering 0, 1 or 2 questions correctly.
Results

Study population

In February 2017, twenty-seven KGH pharmacists were invited to participate in the Confidence Survey through the SurveyMonkey™ website. In addition, all KGH pharmacists undertook the Knowledge Assessment Test (KAT) as part of the department’s quality assurance plan, unless excused by Pharmacy Administration. Twenty-two pharmacists met eligibility for inclusion in the study; having completed both the Confidence Survey and KAT, and having provided informed consent (81.5% response rate). Seven (31.8%) pharmacists reported 5 or more years of hospital experience and the same number reported making 10 or more interventions on vancomycin therapy in an average month (Table 1). Nine (40.1%) pharmacists reported completing a pharmacy residency (Table 1).

Study Outcomes

Confidence Scores

Overall confidence scores derived from the Confidence Survey responses ranged from 41% to 92%, with a median of 73% (interquartile range (IQR) 62%-83%). Sixteen of twenty-two (72%) participating pharmacists had an overall confidence score greater than 62%. Median confidence scores by Knowledge Domain are shown in Table 2. Pharmacists registered lowest confidence scores in assessing the appropriateness of vancomycin therapy, and providing advice on maintenance vancomycin level monitoring. The surveyed group was the most confident in providing advice on empiric dosing and administration of vancomycin.

A Mann-Whitney U test indicated that self-reported confidence scores were significantly higher in pharmacists performing greater than 10 interventions per month (Median= 84.5%) compared to pharmacists performing less than 10 interventions per month (Median= 64.2%), U= 19 (p<0.05). There was no statistical difference between median confidence scores in pharmacists with a pharmacy residency (73.5% vs. 72.3%, NS), or those with 5 or more years of experience (74.8% vs. 72.3%, NS).

Knowledge Assessment Scores

Overall KAT scores ranged from 42% to 100%, with median at 75% (IQR 67%-83%). Figure 3 depicts the proportion of pharmacists answering 0, 1 or 2 questions correctly for each Knowledge Domain. Questions regarding administration of vancomycin and appropriateness of therapy were answered correctly at a higher frequency, with 95% of participants correctly
answering both questions of each domain. Pharmacists scored the lowest on the two questions pertaining to vancomycin dosing subsequent to level analysis.

*Correlation between Confidence and Knowledge*

For each pharmacist, overall confidence score was plotted against overall KAT score and Spearman correlation was calculated. The data showed KGH pharmacists’ self-reported confidence levels in vancomycin use management were weakly positively correlated to their knowledge assessment test scores (Spearman co-efficient for correlation $\rho=0.21$). No individuals were identified in the “zones of greatest disconnection”; that is, either highest quartile for self-reported confidence and lowest quartile for KAT score, or highest quartile for KAT score and lowest quartile for confidence (Figure 1). Four individuals in the lowest quartile for KAT were in the second or third quartiles for self-reported confidence. Conversely, three individuals in the highest quartile for KAT scores were in second or third quartile for self-reported confidence (Figure 1).
Discussion

This study set out to explore the association between pharmacists’ self-reported confidence scores and assessed knowledge scores on intravenous vancomycin therapy management in adults. The overall response rate of the confidence survey was 81.5%, and was greater than that reported (73%) by other authors investigating pharmacist self-reported confidence. [11] Self-reported confidence levels were found to be moderately high with sixteen of twenty-two KGH pharmacists having an overall confidence score greater than 62%. In addition, confidence scores were weakly positively correlated to their knowledge assessment test scores in vancomycin use management ($\rho=0.21$).

A pharmacist with an overall confidence score in the highest quartile range and KAT score in the lowest quartile range, or vice versa, was deemed part of a “zones of greatest disconnection”. These areas depict the greatest mismatch in confidence and knowledge. A lack of knowledge in vancomycin management may be deemed more unsafe if paired with overconfidence (Dunning-Kruger effect), however sound knowledge with a lack of confidence may pose a barrier to knowledge translation. Recording no pharmacist in either “zone of greatest disconnection” was encouraging and suggested the pharmacists were reasonably cognizant of their knowledge level when reflecting on confidence level. There were, however, four individuals in the lowest, and three individuals in the highest quartile for knowledge scores that reported confidence scores in the 25 to 75 percentile range. This suggests there remains an opportunity to better synchronize and improve KGH Pharmacists’ confidence and knowledge of vancomycin use management.

Median confidence scores were statistically significantly higher in pharmacists making ten or more interventions per month (84.5% vs 64.2%, $p<0.05$), but there were no differences in those with a pharmacy residency or those with five or more years of experience. Since these findings suggest frequency of interventions may impact confidence, and that confidence may be moderately associated with knowledge, more experiential practice could be used as an intervention to increase pharmacist ability to manage all aspects of vancomycin therapy.

Pharmacists were found to be most confident in providing advice on administration of vancomycin, and least confident in assessing appropriateness of vancomycin therapy. Interestingly, knowledge test questions inspired by these two knowledge domains were answered correctly at the highest frequency. Participants also performed well on knowledge test questions regarding empiric dosing of vancomycin. When advising on administration, assessing appropriateness of therapy, or determining empiric dosing, there exist institutional guidelines for pharmacists to follow, which may explain the high frequency of correct answers in these domains.
Pharmacists had the lowest knowledge scores on the two questions pertaining to vancomycin level analysis; a practice for which there are no written institutional guidelines to reference. Answering these questions required multifactorial analysis; consideration of timing of the level and preceding doses, and fluctuating patient pharmacokinetic and pharmacodynamic factors. Creating algorithms to support and guide pharmacists when making dosing and monitoring interventions after serum level analysis may improve confidence and thus performance in this domain.

The classification of the knowledge scores by domain may allow pharmacy leaders to tailor future teaching efforts to focus more on level analysis and subsequent dosing recommendations to ensure competency is met in the area pharmacists had the most difficulty. The knowledge domains can serve as a cornerstone to the future development of competency-based training and evaluation of vancomycin therapy management for KGH pharmacists. Establishing competence will be required prior to implementation of a medical directive for pharmacists to manage vancomycin therapy independently. Furthermore, results of the confidence survey and knowledge assessment test will provide benchmark data against which to compare future assessments of vancomycin use management. They may be used in before-and-after comparison studies to assess the effectiveness of an intervention such as a teaching module or increased supervised experiential practice. The ultimate goal is to increase all pharmacists’ confidence and knowledge scores irrespective of baseline; this is akin to “Moving the Mountain” in quality of care as described by the Ontario College of Pharmacists. [13]

There are limitations to consider when interpreting the results of this study. The study used a written multiple-choice knowledge test as a surrogate for comprehensive competency assessment in vancomycin management. Due to the complexity of analysis required when assessing vancomycin serum levels, it was impossible to fully evaluate higher-order reasoning skills on a multiple-choice test. Plus, any misleading or missing information in a question may have led to misinterpretation by pharmacists and variability in answers. In the future, using direct observation of clinical practice in addition to the KAT may allow a pharmacist to provide reasoning behind their thought-process for the evaluator. While this method of evaluation may be ideal, it is recognized to be extremely resource intensive. Furthermore, since the knowledge assessment test was not validated, results should be interpreted with caution as no “passing grade” was established.

The single center, small population size, and nature of the study proved to be limiting factors. Firstly, it restricts generalizability to other groups of pharmacists, and secondly, certain secondary endpoints were restricted to collection and analysis of ordinal data to maintain
anonymity of participants. If years of experience or number of vancomycin interventions per month were expressed as continuous data, further analysis of their association with confidence level may have been performed and led to more focused recommendations for future action.

External confounding factors in addition to those studied may have influenced pharmacist confidence and knowledge. Examples include: other formalized training such as a doctorate of pharmacy, clinical area of practice, and recent feedback or education on vancomycin use management. Since only pharmacists volunteering to participate in the confidence survey were eligible for the study, there may be a voluntary response bias wherein only pharmacists above a certain level of confidence would have agreed to participate. Under representing less confident pharmacists may have skewed the results. Pharmacists may have also discussed KAT questions since there were multiple sittings days apart, affecting the results.
**Conclusion**

Hospital providers rely on pharmacists to provide expert advice on administration, dosing and monitoring of intravenous vancomycin. Pharmacists must possess the knowledge and corresponding confidence level to effectively make recommendations for optimal use. This study in a tertiary teaching hospital found pharmacist self-reported confidence levels in vancomycin management in adults to be moderately high, and weakly positively correlated to knowledge, as measured by a written multiple-choice test. No evidence of the potentially unsafe combination of high confidence and low knowledge was detected. The knowledge test data collected serves as a baseline for this institution, and the study identifies opportunities for improvement; particularly in vancomycin level interpretation and subsequent recommendations. The results of the knowledge test should be interpreted with caution, as a larger multi-center study with a validated test would be required to determine if these findings are reproducible. Determining the most effective teaching method to increase both pharmacist knowledge and confidence in vancomycin management, and generating an effective evaluation method of this complex process are potential areas for future study. Investigating pharmacist confidence and knowledge in managing vancomycin therapy in varying populations such as pediatric patients or adults undergoing renal replacement therapy may also be a valuable extension of this research.
References

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6) Bruniera FR et al. The use of vancomycin with its therapeutic and adverse effects: a review. *European Review for Medical and Pharmacological Sciences*. 2015:19(1) 694-700
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14) Crader MF. Development of Antimicrobial Competencies and Training for Staff Hospital Pharmacists. *Hospital Pharmacy*. 2014;49(1) 32-40


17) Tran TT et al. Unique pharmacist competency program at community-based, teaching hospitals. *Journal of Hospital Administration*. 2013;2(3) 119-25
## Tables

Table 1: Hospital pharmacist practice characterization survey (n = 22)

<table>
<thead>
<tr>
<th></th>
<th>Pharmacists, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years of experience</strong></td>
<td></td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>15 (68.2)</td>
</tr>
<tr>
<td>5 or more years</td>
<td>7 (31.8)</td>
</tr>
<tr>
<td><strong>Number of Interventions</strong></td>
<td></td>
</tr>
<tr>
<td>Less than 10 interventions per month</td>
<td>15 (68.2)</td>
</tr>
<tr>
<td>10 or more interventions per month</td>
<td>7 (31.8)</td>
</tr>
<tr>
<td><strong>Pharmacy Residency Program</strong></td>
<td></td>
</tr>
<tr>
<td>Not completed</td>
<td>13 (59.1)</td>
</tr>
<tr>
<td>Completed</td>
<td>9 (40.1)</td>
</tr>
</tbody>
</table>
Table 2: Median Confidence Scores by Knowledge Domain

<table>
<thead>
<tr>
<th>Knowledge Domain*</th>
<th>Median Overall Confidence Score (%)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1: Appropriateness of therapy</td>
<td>68.5</td>
</tr>
<tr>
<td>D2: Empiric Dosing</td>
<td>75</td>
</tr>
<tr>
<td>D3: Empiric Monitoring</td>
<td>74.5</td>
</tr>
<tr>
<td>D4: Dosing subsequent to level analysis</td>
<td>74</td>
</tr>
<tr>
<td>D5: Maintenance Monitoring</td>
<td>71.5</td>
</tr>
<tr>
<td>D6: Administration</td>
<td>75</td>
</tr>
</tbody>
</table>

* Refer to Appendix A for Knowledge Domain criteria

** Refer to Appendix B for Confidence Survey questions
Figures

Figure 1: Pharmacist confidence versus knowledge in adult vancomycin therapy management (n=22).

- ■ = study participant
- ★ Two participants had a confidence score of 58% and knowledge score of 64%

Interquartile range for overall Confidence Survey score = 62-83%.

Interquartile range for overall Knowledge Assessment Test score = 67-83%.
Figure 2: Median confidence scores by years of hospital experience, frequency of vancomycin interventions, and completion of pharmacy residency program (n=22)

NS = non-significant difference
Figure 3: Proportion of pharmacists with correct responses on Knowledge Assessment Test by Knowledge Domain (two questions per domain, n=22)
Appendices

Appendix A: Vancomycin therapy management Knowledge Domains

<table>
<thead>
<tr>
<th>Knowledge Domain</th>
<th>Criteria</th>
</tr>
</thead>
</table>
| D1: Appropriateness of therapy               | ▪ Assesses patient’s indication for vancomycin.  
▪ Recognizes vancomycin’s spectrum of antimicrobial activity and describes its place in therapy.                                               |
| D2: Empiric Dosing                            | ▪ Recommends vancomycin empiric dosing regimen appropriate for the clinical condition and patient characteristics such as age, weight, organ function, and concomitant drug therapy. |
| D3: Empiric Monitoring                        | ▪ Recommends vancomycin serum level monitoring to maximize efficiency, minimize patient morbidity, and promote efficient use of resources.                                                            |
| D4: Dosing subsequent to level analysis       | ▪ Obtains all pertinent information prior to making vancomycin recommendation.  
▪ Correctly interprets concentration measurements based on sample time, dosage history, desired target range, and patient response.  
▪ Recommends vancomycin regimen changes to maximize drug efficacy, safety and efficient use of resources, while considering vancomycin’s pharmacodynamic and pharmacokinetic parameters. |
| D5: Maintenance Monitoring                    | ▪ Orders vancomycin therapy monitoring parameters appropriately.  
▪ Integrates consideration of patient morbidity and resource use when recommending vancomycin monitoring plan.                                                                                      |
| D6: Administration                            | ▪ Promotes safe reconstitution, dilution and administration of intravenous vancomycin.  
▪ Recognizes adverse effect(s) associated with administration rate.                                                                                                                                     |

1 Knowledge Domains adapted from:


## Page 1

1. How many years have you been a practicing hospital pharmacist?  
(Please round to the nearest half year, including all part time or full time work, excluding pregnancy and parental leave or extended leave lasting greater than 1 month).  
   a) Less than 5 years  
   b) 5 years or more

2. How many recommendations on vancomycin use management do you make in an average month for ADULT patients?  
(Consider verbal and written recommendations on initiation of vancomycin therapy, therapy modifications, monitoring, administration and discontinuation)  
   a) Less than 10 recommendations in a month  
   b) 10 or more recommendations in a month

3. Have you completed a pharmacy residency?  
   a) Yes  
   b) No (Includes those currently undergoing the pharmacy residency program at KGH)

## Page 2

<table>
<thead>
<tr>
<th>The following questions were answered using an interactive slider along a visual analogue scale from “Not confident” to “Very confident”</th>
<th>Corresponding Knowledge Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. How confident do you feel assessing appropriateness of vancomycin indication in adult patients?</td>
<td>D1</td>
</tr>
<tr>
<td>5. How confident do you feel recommending empiric dosing of vancomycin in adult patients?</td>
<td>D2</td>
</tr>
<tr>
<td>6. How confident do you feel recommending empiric monitoring of vancomycin in adult patients?</td>
<td>D3</td>
</tr>
<tr>
<td>7. How confident do you feel recommending vancomycin regimen changes subsequent to serum level analysis in adult patients?</td>
<td>D4</td>
</tr>
<tr>
<td>8. How confident do you feel recommending a monitoring plan for ongoing vancomycin therapy following regimen adjustment in adult patients?</td>
<td>D5</td>
</tr>
<tr>
<td>9. How confident do you feel recommending vancomycin administration parameters in adult patients to nurses?</td>
<td>D6</td>
</tr>
</tbody>
</table>

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4. How confident do you feel assessing appropriateness of IV vancomycin indication in adult patients?
Appendix C: Information letter and consent form

Information Letter and Consent Form to Participants (i.e. Pharmacists)

On Research Project Entitled:

Examination of the Relationship between Pharmacist Confidence and Knowledge in Vancomycin Therapy Management at Kingston General Hospital

__________(Date)

Dear Pharmacist:

You are invited to participate in a research study conducted by Megan Zalewski, Pharmacy Resident, Kingston General Hospital and Susan McKenna, Pharmacist, Kingston General Hospital. The objective of this research study is to determine how self-reported confidence in vancomycin therapy management relates to knowledge, as measured by a multiple choice test, in KGH pharmacists.

If you decide to volunteer and participate, you will be asked to complete a 5-minute online questionnaire. Participation in this study is voluntary. You may withdraw from this study at any point in time by notifying Pharmacy Resident Investigator, Megan Zalewski, with no associated penalty. There are no known or anticipated risks from participating in this study or for withdrawing from the study. Research findings from this pilot study will be presented through poster presentation at Canadian Society of Hospital Pharmacists (CSHP) – Ontario Branch-sponsored Kingston/Ottawa Residency Night June 2017, and published if the opportunity is available through pharmacy journals, oral or poster presentations at conferences, such as the annual Canadian Pharmacists’ Association (CPhA) Conference. If you have any questions regarding this study, please feel free to discuss them with Megan Zalewski, Pharmacy Resident investigator at 613-549-6666 Ext 3922 or zalewskm@kgh.kari.net, Susan McKenna, Principal investigator at 613-549-6666 Ext 6286, or Veronique Briggs, Pharmacy Resident Program Director, at 613-549-6666 Ext 4334.

It is important for you to know that any information that you provide will be kept confidential. All information collected from participants in this study will be aggregated and no individual could be identified from these aggregated results. Data will be analyzed and reported in a manner that does not identify individuals. Participants’ names will not appear in any report, publication or external presentation resulting from this study. Data will only be accessible by the two co-investigators, Pharmacy Director and Clinical Manager.

Data, with no personal identifiers, collected will be securely stored in the Kingston General Hospital, located in Kingston, Ontario, with a secure server environment. As well, data collected will be electronically archived and encrypted.
If you have any questions, or you would like to receive a copy of the results of this study please contact Megan Zalewski at zalewskm@kgh.kari.net directly.

I would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics at Queen’s University, which can be reached at 613-533-6000 Ext 74814 if you have any questions about your rights as participants of this study. The final decision about participating in this study is yours. Thank you for considering participation in this study.

Please return completed consent form (see below) to Megan Zalewski at zalewskm@kgh.kari.net by ____________ (date)
Thank you.

Sincerely,
Megan Zalewski, Pharmacy Resident
Kingston General Hospital
Consent Form to Participants

On Research Project Entitled:

Examination of the Relationship between Pharmacist Confidence and Knowledge in Vancomycin Therapy Management at Kingston General Hospital

I have read the information presented in the Information Letter (above) about a research project entitled “Examination of the Relationship between Pharmacist Confidence and Knowledge in Vancomycin Therapy Management at Kingston General Hospital” conducted by Megan Zalewski, Pharmacy Resident, Kingston General Hospital and Susan McKenna, Pharmacist, Kingston General Hospital. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. I am aware that I may withdraw from the research project without penalty at any time by advising the pharmacy resident investigator, Megan Zalewski, of this decision.

This project has been reviewed by and received ethics clearance through the Office of Research Ethics at Queen’s University. In addition, I was informed that if I have any questions regarding this project, I may contact Megan Zalewski, Susan McKenna or Veronique Briggs.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐ YES ☐ NO

Participant Name (please print): ___________ Participant Signature: _______________

Date: ____________________________

Please return completed consent form to Megan Zalewski at zalewskm@kgh.kari.net by __________ (date). Thank you.
Appendix D: Knowledge Assessment Test Questions

Question 1:

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 89 years</th>
<th>Sex: Female</th>
<th>Weight: 52 kg</th>
<th>Height: 160 cm</th>
<th>Allergies: NKDA</th>
</tr>
</thead>
</table>

**Medication Regimen**
- Currently on IV cefazolin (dosing not applicable for question)
- No vancomycin initiated as of yet

**Lab data**

| Current SCr: 105 mcmol/L | Baseline SCr: 105 mcmol/L | Serum Vancomycin Level: Not applicable for question |

**Diagnosis**
- Thigh abscess (incised and drained) with associated cellulitis

**Cultures**
- Sterile site culture (thigh abscess):
  - *Staphylococcus aureus*
  - Cloxacillin: Resistant
  - Vancomycin: Susceptible

You suggest starting vancomycin in patient KK; what is the best empiric dosing recommendation?

- a) Vancomycin 750 mg IV q48h
- b) Vancomycin 1000 mg IV q24h
- c) Vancomycin 1000 mg IV once then 750 mg IV q12h
- d) Vancomycin 1000 mg IV once then 750 mg IV q48h

Question 2:

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 99 years</th>
<th>Sex: Female</th>
<th>Weight: 45 kg</th>
<th>Height: 150 cm</th>
<th>Allergies: NKDA</th>
</tr>
</thead>
</table>

**Lab data**

| Current SCr: 50 mcmol/L | Baseline SCr: 50 mcmol/L | White blood cell count: 6.5 x 10⁹/L |

**Diagnosis**
- Cystitis

**Cultures**
- Urine culture: *Enterococcus faecium*
  - Ampicillin: Resistant
  - Vancomycin: Susceptible

A resident wants to initiate vancomycin therapy for patient JJ; what is the best empiric dosing recommendation?

- a) Vancomycin 750 mg IV Q48h
- b) Vancomycin 1000 mg IV Q12h
- c) Vancomycin 750 mg IV Q24h
- d) Vancomycin 1000 mg IV once then 750 mg IV Q24h
**Question 3:**

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 75 years</th>
<th>Sex: Male</th>
<th>Weight: 80 kg</th>
<th>Height: 172 cm</th>
<th>Allergies: Penicillin (anaphylaxis)</th>
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<td>CD</td>
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**Medication Regimen**
- Vancomycin 1500 mg IV load initiated today then 1250 mg IV q24h

**Lab data**
- **Current SCr:** 180 mcmol/L (trending down with IV hydration)
- **Baseline SCr:** 80 mcmol/L
- **Serum Vancomycin:** No applicable for question

**Diagnosis**
- Bacteremia in setting of prosthetic hip infection

**Cultures**
- 4 of 4 blood cultures (flagged positive today):
  - *Staphylococcus aureus*
  - Cloxacillin: Susceptible
  - Vancomycin: Susceptible

What is the best time to request the first vancomycin serum monitoring level(s) to ensure adequacy of this empiric regimen?

a) 15 to 30 minutes prior to second dose of 1250 mg and 60 minutes after completion of infusion of third dose of 1250 mg (acknowledging that this is not yet at steady state)

b) 15 to 30 minutes prior to second dose of 1250 mg (acknowledging that this is not yet at steady state)

c) 15 to 30 minutes prior to third dose of 1250 mg as serum level must be drawn at steady state

d) 15 to 30 minutes prior to fourth dose of 1250 mg as serum level must be drawn at steady state

**Question 4:**

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 75 years</th>
<th>Sex: Male</th>
<th>Weight: 80 kg</th>
<th>Height: 172 cm</th>
<th>Allergies: Penicillin (anaphylaxis)</th>
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**Medication Regimen**
- Day 37 of Vancomycin with current dosing regimen of 1250 mg IV q24h
- Planned 42 day course

**Lab data**
- **Current SCr:** 130 mcmol/L (stable for past 3 weeks)
- **Baseline SCr:** 80 mcmol/L

**Diagnosis**
- Methicillin susceptible *Staphylococcus aureus* prosthetic hip infection

Patient CD from questions 3/4 is on Day 37 of planned 42 day course of Vancomycin 1250 mg IV q24h. What is the best time to request the next vancomycin serum monitoring level?

a) Vancomycin serum level on Day 42 of therapy to ensure vancomycin has not accumulated over course of previous week.

b) Vancomycin serum level in 3 days to assess for accumulation.

c) Monitor serum creatinine daily, and consider vancomycin regimen adjustment if serum creatinine increases by more than 25%. No further serum monitoring levels required if vancomycin therapeutic course completed on Day 42.

d) No further serum monitoring levels required if vancomycin therapeutic course completed on Day 42.
**Question 5:**

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 80 years</th>
<th>Sex: Male</th>
<th>Weight: 102 kg</th>
<th>Allergies: NKDA</th>
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**Medication Regimen**
- December 3rd is Day 14 of Vancomycin 1500 mg IV q12h
- See below for recently administered doses
  - Dec 1st 0900h: 1500 mg given
  - Dec 1st 2110h: 1500 mg given
  - Dec 2nd 0845h: 1500 mg given
  - Dec 2nd 2230h: 1500 mg given

**Lab data**
- **Current Scr:** 52 mcmol/L
- **Baseline Scr:** 52 mcmol/L
- **Serum Vancomycin:** 17.6 mg/L on day 4 (prior to 7th dose of current regimen). Target level of 15 to 20 mg/L as set by Neurosurgical Service

**Diagnosis**
Ventriculoperitoneal (VP) shunt-related infection

**Cultures**
- Sterile site culture (VP shunt):
  - *Staphylococcus epidermidis*
  - Cloxacillin: Resistant
  - Vancomycin: Susceptible

**Serum vancomycin level at 0500h on December 3rd was 23 mg/L. What is the best course of action at this time with respect to regimen and further level monitoring?**

a) Continue Vancomycin 1500 mg IV q12h and draw vancomycin trough level in 7 days. Draw trough level sooner if serum creatinine increases.

b) Hold 0900h dose on Dec 3 and restart Vancomycin 1500 mg IV q12h at 2100h on December 3.

c) Hold 0900h dose on Dec 3 and draw random vancomycin level at that time instead. Reassess regimen when level reported.

d) Continue Vancomycin 1500 mg IV q12h as scheduled and re-draw vancomycin level prior to 2100h dose on December 4th

**Question 6:**

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 55 years</th>
<th>Sex: Male</th>
<th>Weight: 120 kg</th>
<th>Allergies: Sulfa (reaction unknown)</th>
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**Medication Regimen**
- Day 7 of Vancomycin 1750 mg IV q12h
- Last dose of 1750 mg received May 7th at 0915h
- Further Vancomycin administration HELD after reviewing May 7th 0900h serum vancomycin level result (see below)

**Lab data**
- **Current Scr:** 130 mcmol/L
- **Baseline Scr:** 80 mcmol/L
- **Serum Vancomycin:**
  - May 7 0900h: 50 mg/L
  - May 7 2100h: 52 mg/L
  - May 8 0600h: 27 mg/L

**Diagnosis**
Tricuspid valve infective endocarditis

**Cultures**
- 4 of 4 blood cultures:
  - *Staphylococcus aureus*
  - Cloxacillin: Resistant
  - Vancomycin: Susceptible

Assume no changes in vancomycin volume of distribution and assume serum creatinine levels are at steady state. What is the best course of action at this time?
a) Do not draw any further levels on May 8th; restart less aggressive vancomycin regimen at 1600h.
b) Draw a vancomycin serum level on May 9th at approximately 0600h (with scheduled morning bloodwork). Do not administer any more vancomycin until this level assessed.
c) Allow vancomycin to clear for 8 hours (do not draw any further levels on May 8) and restart previous regimen of vancomycin 1750 mg IV q12h.
d) Draw a “random” vancomycin serum level on May 8 at 1200h to ensure level is below 20 mg/L before restarting vancomycin at less aggressive regimen.

Question 7:

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 65 years</th>
<th>Sex: Female</th>
<th>Weight: 100 kg</th>
<th>Allergies: NKDA</th>
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**Medication Regimen**
- Day 16 of Vancomycin IV.
- No changes occurred to dosing regimen during past week.
- Received Gentamicin IV concomitantly on Days 1 to 14. Now stopped.
- Ongoing diuresis with furosemide for associated heart failure, with furosemide dosing reassessed daily.

**Lab data**

<table>
<thead>
<tr>
<th>Current SCr: 125 mcmol/L</th>
<th>Baseline SCr: 65 mcmol/L</th>
<th>Serum Vancomycin: Trough level on Day 16 (today): 18.8 mg/L (target 15-20 mg/L)</th>
</tr>
</thead>
</table>

**Diagnosis**
- Infective Endocarditis, native valve

**Cultures**
- 4 of 4 blood cultures: *Enterococcus faecium*
  - Ampicillin: Resistant
  - Vancomycin: Susceptible

**Lab data**
- Complete blood count and differential within normal limits on Day 16 of vancomycin therapy

What is best vancomycin therapy monitoring plan with respect to further level monitoring?

a) Recommend PRE dose serum vancomycin on Day 19 of vancomycin therapy. No change to regimen. Serum creatinine daily for next 3 days then reassesses.
b) Recommend PRE dose serum vancomycin level and serum creatinine on Day 23 of vancomycin therapy. No change to regimen.
c) Recommend daily vancomycin and creatinine levels with daily morning bloodwork beginning Day 17 of vancomycin therapy. Based upon level, determine need to give dose that day. Give same dose on Day 16 as was given on Day 15.
d) Recommend PRE dose serum vancomycin level on Day 23 of vancomycin therapy. Serum creatinine daily on Days 17 to 23, then reassess.

**Question 8:**

For patient GH of question 7, what is best vancomycin therapy monitoring plan with respect to hematological measurements and patient education?

a) Recommend complete blood count with differential daily. Advise patient to report any symptoms of hearing loss.
b) Recommend complete blood count with differential on Day 23 of vancomycin therapy. Advise patient to report any symptoms of increased urinary frequency as this may be related to cessation of concomitant gentamicin therapy.
c) Recommend complete blood count with differential daily on Days 17 to 23 then reassess. Advise patient to report any infectious symptoms (e.g. fever) as this may be related to cessation of concomitant gentamicin therapy.
d) Recommend complete blood count with differential on Day 23. Advise patient to report any symptoms of ear fullness, ringing or problems with balance.
Question 9:

Patient IJ, an 18 year old male weighing 120 kg is to receive Vancomycin 20 mg/kg IV stat then 15 mg/kg IV q8h. Assume dosing regimen is appropriate for indication and renal function. Assess the following orders for appropriateness of administration, and choose the most correct answer:

a) 1. Vancomycin 1500 mg in 500 mL dextrose 5% IV via peripheral line over 90 minutes once
2. Then, 6 hours later, give Vancomycin 1000 mg in 250 mL dextrose 5% over 60 minutes once
3. Eight hours after administration of 1000 mg dose, start Vancomycin 1750 mg in 500 mL dextrose 5% (at rate of 1000 mg/hour) IV q8h

b) 1. Vancomycin 2500 mg in 250 mL Sodium Chloride 0.9% IV via peripheral line over 2.5 hours once
2. Then, 8 hours later, start Vancomycin 1750 mg in 500 mL dextrose 5% IV via peripheral line over 2 hours q8h

c) 1. Vancomycin 2500 mg in 500 mL dextrose 5% IV via central line over 90 minutes once
2. Then, 8 hours later, start Vancomycin 1750 mg in 250 mL dextrose 5% over 90 minutes IV q8h

d) 1. Vancomycin 1500 mg in 500 mL dextrose 5% IV via central line over 90 minutes once
2. Then, 6 hours later, give Vancomycin 1000 mg in 250 mL dextrose 5% IV over 60 minutes once
3. Twelve hours after administration of 1000 mg dose, start Vancomycin 1750 mg in 500 mL dextrose 5% over 2 hours IV q8h

Question 10:

For patient IJ of question 9, what are the best instructions to provide to the physician with respect to prevention and management of potential infusion-related adverse effects?

a) Infuse vancomycin at maximum IV rate of 1000 mg per hour. If patient reports symptoms of rash during infusion, continue IV vancomycin but reduce rate by half.

b) Infuse vancomycin at maximum IV rate of 1000 mg over 60 minutes. If patient develops rash and hypotension during infusion, stop IV vancomycin and administer epinephrine 0.3 mg IM stat and diphenhydramine 50 mg IV once. Do not rechallenge with vancomycin, and add “vancomycin-induced anaphylaxis” to patient hypersensitivity list.

c) Infuse vancomycin at maximum IV rate of 1000 mg per hour. If patient reports symptoms of rash during infusion, always premedicate with diphenhydramine 50 mg IV 30 min before each subsequent dose.

d) Infuse vancomycin at maximum IV rate of 1000 mg per 60 minutes. If patient reports symptoms of rash during infusion, increase rate to 1000 mg per 30 minutes to hasten vancomycin exposure, thus mast cell destabilization.
Question 11:

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 65 years</th>
<th>Sex: Female</th>
<th>Weight: 63 kg</th>
<th>Height: 165 cm</th>
<th>Allergies: Sulfa (rash)</th>
</tr>
</thead>
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**Medication Regimen**
- Day 3 of Vancomycin 1000 mg IV q12h

**Lab data**
- Current SCr: 73 mcmol/L
- Baseline SCr: 73 mcmol/L
- Serum Vancomycin: 11.5 mg/L (drawn prior to sixth dose)

**Diagnosis**
- Bacteremia, suspected urinary source

**Cultures**
- 2 of 4 blood cultures:
  - *Enterococcus faecalis*
    - Ampicillin: Susceptible
    - Vancomycin: Susceptible

**What is the best course of action with respect to vancomycin therapy?**

a) Recommend increase in vancomycin to 1250 mg IV q12h with goal of achieving target steady state trough level above 15 mg/L.

b) Recommend discontinuation of Vancomycin and initiation of Ampicillin IV

c) Recommend decrease in vancomycin to 750 mg IV q12h with goal of achieving target steady state trough level to lower end of 8 to 15 mg/L range.

d) Recommend continuation of vancomycin regimen and repeat next serum trough level on Day 10 of vancomycin therapy.

Questions 12:

<table>
<thead>
<tr>
<th>Patient Initials</th>
<th>Age: 89 years</th>
<th>Sex: Female</th>
<th>Weight: 52 kg</th>
<th>Height: 160 cm</th>
<th>Allergies: NKDA</th>
</tr>
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<tbody>
<tr>
<td>NM</td>
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</table>

**Medication Regimen**
- Day 2 of Vancomycin 1000 mg IV q12h and Piperacillin/Tazobactam 3.375 grams IV q6h

**Lab data**
- Current SCr: 74 mcmol/L
- Baseline SCr: 60 to 70 mcmol/L
- Serum vancomycin: 25 mg/L (drawn prior to fourth dose of vancomycin therapy on current regimen)

**Diagnosis**
- Ascending cholangitis complicated by E.coli bacteremia

**Cultures**
- 4 of 4 blood cultures:
  - *E.coli*
    - Ampicillin: Susceptible
    - Gentamicin: Susceptible
    - Levofloxacin: Susceptible

**What is the best course of action with respect to vancomycin therapy?**

a) Change to vancomycin 750 mg IV q12h with level prior to fourth dose of new regimen with target trough range 8 to 15 mg/L.

b) Change to vancomycin 750 mg IV q24h with level prior to third dose of new regimen with target trough range 15 to 20 mg/L.

c) Change to vancomycin 750 mg IV q24h with level prior to third dose of new regimen with target trough range 8 to 20 mg/L.

d) Discontinue vancomycin