

ORIGINAL ARTICLE

An evaluation of knowledge and perception of pharmacology in undergraduate oral hygiene students and recent graduates at a single higher institution in Pretoria

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Abstract

Introduction: Pharmacology is an increasingly important area of study for oral hygienists, as it provides the scientific basis for safe and effective oral healthcare. However, a lack of fundamental understanding of the discipline among clinical graduates can present significant challenges. Oral hygienists require pharmacological training to meet the requirements of their scope of practice. Pharmacology knowledge assists with the diagnosis and treatment of oral conditions and forms the foundation for further clinical competency development. The knowledge and perceptions of pharmacology for pharmacy, nursing and medical students have been well documented; however, little information is present for Bachelor of Oral Hygiene (BOH) students. This paper sets out to evaluate BOH students' and recent graduates' knowledge and perceptions of pharmacology at a single higher institution in Pretoria to identify possible gaps and weaknesses.

Methods: A cross-sectional study design was used to collect data using an online questionnaire. The English-language questionnaire consisted of the self-reported perceptions and knowledge and actual knowledge of pharmacology of undergraduate BOH students and recent graduates. The questionnaire consisted of multiple choice questions, true or false questions and Likert scale questions. Ethics was obtained from the institution's Research Ethics Committee (REC 350/2021).

Results: Overall, the participants perceived the pharmacology module positively and understood its importance. Concerns were raised about insufficient time for studying and that assessments were more aligned to gaining factual knowledge than the development of problem-solving skills. Students rated their knowledge between 57.24% and 69.44%, with BOH III students and graduates having a statistically significant greater self-rated knowledge of antivirals, antifungals and common agents used to treat oral conditions in comparison with BOH I and BOH II students. Overall, BOH students and graduates' actual knowledge was between 45.24% and 66.84%. Although not statistically significant, the total self-rated knowledge of BOH III students and recent graduates tended to be higher than their actual knowledge. Knowledge deficits were evident with some

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pharmacological concepts across the various BOH groups, such as pharmacokinetics, pain, drugs altering dental treatment I: central nervous system drugs, drugs altering dental treatment II: respiratory and endocrine drugs, drugs altering dental treatment III: cardiovascular drugs, drug–drug interactions and common agents used to treat oral conditions.

Conclusion: Self-rated knowledge deficiencies were noted by students and recent graduates for certain pharmacological concepts and were supported by the measurement of their actual knowledge. Further investigation into knowledge deficiencies is needed to guide curriculum review to further strengthen oral hygienists' pharmacological competencies and ensure alignment to their scope of practice.

KEYWORDS

knowledge, oral hygiene, perceptions, pharmacology, self-rated knowledge

1 | INTRODUCTION

Oral hygienists are preventive oral healthcare professionals that provide educational, clinical, and therapeutic services to the public.¹ Their primary focus is the prevention and control of oral diseases and the promotion and improvement of the public's oral health.² As many oral hygienists are responsible for reviewing health histories with patients, knowledge of medications is invaluable in alerting the treating oral hygienist and dentist to situations that could affect the patient's overall health.³ Oral hygienists should also be able to recognise side effects that may occur from certain medications and know the contraindications for prescribing medications.^{4,5} This is particularly important when looking at oral-linked side effects, or side effects that may complicate oral treatment. In South Africa, even though oral hygienists do not prescribe drugs to patients,⁶ it is important that they have an in-depth understanding of the pharmacology needed for safe and effective dental treatment and oral healthcare.⁷

Despite pharmacology having a persuasive and profound impact on virtually every aspect of modern life, few clinical graduates have a fundamental understanding of the discipline.⁸ A lack of understanding of pharmacology could prove to be problematic in the long term in graduates' world-of-work. Pharmacology is presented to Bachelor of Oral Hygiene (BOH) students as a first-year, second-semester module at a single higher institution in Pretoria. The module focuses on pharmacotherapy directed towards oral conditions over 18 learning opportunities, with an allocation of 80h between teaching, learning and assessments to achieve competencies. Classes were presented twice a week, with assessments comprising class tests after the topic was presented, two larger assessments at defined periods of the module, and a final examination incorporating all work.

The BOH students and pharmacology module investigated here present with several challenges that have similarly been described for other biosciences and professions in literature: poor foundational biological knowledge⁹; early placement of the module in the tutelage of students; academic difficulties in learning

pharmacology¹⁰; and the transition from face-to-face to online-based teaching and learning during the Coronavirus Disease 2019 (COVID-19) pandemic.¹¹ Furthermore, there exists a possibility for misalignment of the pharmacology module to the scope of practice of oral hygienists.

Knowledge and perceptions of pharmacology have been well documented in pharmacy, nursing, and medical students; however, there is a paucity in literature for BOH students and graduates. It is important to assess the level of BOH students' and recent BOH graduates' knowledge in pharmacology, as it reflects one's understanding and competency in oral healthcare. In addition, by evaluating their perceptions towards pharmacology, it could improve student satisfaction with the course and identify priority areas for such improvements. This paper therefore provides an overview of BOH students' and graduates' knowledge and perceptions of pharmacology at a single higher institution in Pretoria.

2 | STUDY POPULATION AND METHODOLOGY

A cross-sectional study design was conducted using a questionnaire distributed between November 2021 and January 2022. The study population used a convenience sampling technique and included BOH I ($n=14$ students), BOH II ($n=7$ students), BOH III ($n=6$ students) and qualified oral hygienists who graduated in 2020 ($n=6$ graduates). Only students who were currently enrolled or completed a BOH degree (2020) were included. Participants who did not provide consent, failed to complete the questionnaires, or graduated before 2020 from the university were excluded from the study.

2.1 | Questionnaire construction

The questionnaire was designed based on relevant literature gathered before the study began.^{12,13} The questionnaires were created

using the Qualtrics® online platform. The questionnaires had an introductory page featuring the informed consent, which introduced the researchers, provided a brief description of the study, explained the purpose, procedures and rights of participants, and asked participants consent to participate in the study. The questionnaire was in the English language and consisted of three sections: section A contained questions relating to participants' perceptions of pharmacology; section B contained questions relating to participants' self-rated knowledge; and section C contained single-best answer questions on the topics presented in the pharmacology module to assess actual pharmacology knowledge. Participants' perceptions were measured quantitatively using a Likert-scale consisting of five options and ranging from 1 to 5, where 1=Strongly agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly disagree. The questionnaire contained 11 questions that aimed to quantitatively assess BOH students' and recent graduates' perceptions of pharmacology.

Participants' self-rating knowledge was assessed on a 10-point scale, with one being poor knowledge and 10 being excellent knowledge. The questionnaire contained 15 questions to assess the self-rating knowledge of BOH students and recent graduates relating to themes in pharmacology. Participants' actual pharmacology knowledge was assessed using single-best answer questions, including multiple choice and true/false questions. The questionnaire contained 14 questions to assess the actual pharmacology knowledge of BOH students and recent graduates. Mean percentages for each learning opportunity were calculated and a mean percentage of less than 50% (failure grade) was considered to be poor (knowledge deficits).

Actual knowledge was thus defined as their ability to answer questions correctly. The participants' total self-rated pharmacology knowledge was compared to their total actual knowledge scores. The values represent the means of the percentage of self-rating pharmacology knowledge and actual pharmacology knowledge.

2.2 | Validation

Given the small sample size, content and face validity were conducted by the research team alongside qualified oral hygienists. A pilot test of the questionnaires was distributed to staff members who were not involved in the study. These researchers were asked to review the questionnaire and evaluate whether the questions were clear and unambiguous. Following collection of the pilot data, the responses were documented to help restructure the questionnaires accordingly. Cronbach's alpha was used as a measure of reliability for the perception, self-rating of pharmacology and knowledge items. The Cronbach's alpha value for each item was determined across the BOH groups. For perceptions and self-rated knowledge questionnaires, with the same response options (e.g., strongly agree to strongly disagree), non-standardised Cronbach's alpha values were used. For questionnaires that

presented with a variable number of responses (single-best answer questions), the standardised Cronbach's alpha values were used. The non-standardised Cronbach's alpha values for the perception questionnaire and the self-rating knowledge questionnaire were 0.362 and 0.879, respectively. The standardised Cronbach's alpha value for the actual knowledge of pharmacology questionnaire was 0.662. The wide variation between Cronbach's alpha values could be attributed to a low number of questions, a small sample size, as well as poor inter-relatedness between items. In addition, there was heterogeneity in participants' responses between the various BOH groups. It is likely that the year of study influenced the way in which participants responded, as students may have interpreted and answered questions differently due to changes in clinical experience because of changes made to educational programmes during the COVID-19 pandemic, resulting in a decrease in clinical exposure. Additional factors such as participant demographics and background, as well as pre- and post-COVID teaching and learning may have influenced these values.

2.3 | Distribution of questionnaire

In accordance with the Protection of Personal Information Act (POPIA),¹⁴ care was taken to ensure participant data were collected appropriately. An invitation to participate in the study was distributed to the full complement of students via their learning management system. Participants were asked to provide their email address should they be interested in participating in the study. A link to an electronic questionnaire was then distributed via email. Weekly reminders were sent to the students to encourage their participation in the study.

2.4 | Statistical analysis

Data obtained during the study were exported and quantitatively analysed using the Statistical Package for the Social Sciences (SPSS) (version 28.0.1.0). Frequencies and percentages were calculated for all variables. Analysis of variance (ANOVA) tests were conducted to compare the means and Pearson's chi-square tests were conducted to compare categorical variables between various BOH groups. Statistical significance was set at $p \leq 0.05$.

2.5 | Ethical consent

Permission to conduct this study was obtained from the School of Dentistry at a single higher institution in Pretoria (Protocol no: 2021/18). Ethical approval was obtained from the Faculty of Health Sciences' Research Ethics Committee (REC 350/2021). Participation in this study was voluntary and responses were anonymous.

3 | RESULTS

3.1 | Response rate

Questionnaires were sent to BOH I, BOH II, BOH III students and recent BOH graduates; therefore, an estimated 48 potential participants were expected to take part in this study. Thirty-three students from all the year groups participated in the study. An average response rate of 64.52% (50.00%–77.78% across the different years) was recorded. The response rates by year are shown in [Table 1](#).

3.2 | Perceptions of pharmacology

Respondents' perceptions of pharmacology in BOH are summarised in [Table 2](#) as a mean and standard deviation. Overall, mean values of between 1 and 2 demonstrated participants' agreement with various statements of pharmacology. The majority of participants agreed that pharmacology was an important subject. Participants perceived pharmacology positively and understood its relevance in the BOH curriculum ([Figures S1–S4](#) in [Appendix S1](#)). Participants also found pharmacology lectures interesting and stimulating and opined that the module helped them develop their logical-reasoning skills. Furthermore, participants agreed that the pharmacology module should be taught with clinical examples. Most participants believed that the assessments in pharmacology were fair, and that the assessment information provided was sufficient. Participants did, however, perceive pharmacology as content-heavy. Compared to the other groups, BOH I and BOH II students raised concerns about insufficient time for studying ($p=0.03$) ([Figures S1](#) and [S2](#) in [Appendix S1](#)), whereas BOH III students and graduates opined that assessments were more aligned to gaining factual knowledge than the development of problem-solving skills ($p=0.03$) ([Figures S3](#) and [S4](#) in [Appendix S1](#)).

3.3 | Self-rating knowledge of pharmacology

Participants' self-rated knowledge in pharmacology is summarised in [Table 3](#) as the mean and standard deviation of their perceived knowledge. Overall, between BOH groups, BOH III students and BOH graduates, displayed a statistically significant greater self-rating knowledge for antiviral agents ($p=0.05$), antifungals ($p=0.01$) and common agents used to treat oral conditions ($p=0.01$). Although not statistically significant between groups, participants perceived their self-rating

knowledge as fair (a score that is acceptable or adequate but may have some room for improvement) to good (a higher level of performance, or satisfaction) in general principles and routes of administration ($p=0.24$); local anaesthetics ($p=0.08$) and antimicrobials ($p=0.32$).

3.4 | Knowledge of pharmacology

Section C of the questionnaire assessed the actual pharmacology knowledge ([Appendix S2](#)). This section contained multiple choice questions with four distractor options, as well as true or false questions. The values in [Table 4](#) represent the number of participants who selected the correct response and the corresponding percentage. Knowledge deficits were evident with some pharmacological concepts (pharmacokinetics, pain, drugs altering dental treatment I: central nervous system drugs, drugs altering dental treatment II: respiratory and endocrine drugs, drugs altering dental treatment III: cardiovascular drugs, drug–drug interactions, and common agents used to treat oral conditions) across the various BOH groups with a mean score below 50%.

3.5 | Perceived knowledge versus actual knowledge

A comparison of the total sum of self-rating (Section B) and actual pharmacology knowledge (Section C) in BOH students and recent graduates is represented in [Table 5](#). Overall, participants rated their pharmacology knowledge between 57.24% and 69.44%, with no statistical significance observed between the perceived and actual knowledge in each BOH group. Their actual knowledge, however, was between 45.24% and 66.84%. Although not statistically significant, the total self-rated knowledge for BOH III students (67.78%) and graduates (69.44%) was higher than their actual knowledge of 45.24% and 59.52%, respectively.

4 | DISCUSSION

This study evaluated BOH students' and recent graduates' knowledge and perceptions of pharmacology at a single higher institution to identify possible gaps and weaknesses. To the best of our knowledge, this study is the first to assess these aspects among BOH students and graduates at a university. This study attempted to assess

Year	Number of participants (n)	Response rate	
		Number (n)	Percentage (%)
BOH I	18	14	77.78
BOH II	11	7	63.64
BOH III	9	6	66.67
BOH graduates	12	6	50.00

TABLE 1 Response rate by participants in the study.

TABLE 2 Participants' perceptions of pharmacology.

Statement	BOH I, n = 14	BOH II, n = 7	BOH III, n = 6	BOH graduates, n = 6	p-values
I believe pharmacology is an important subject in oral hygiene	1.86 ± 0.54	2.00 ± 1.00	1.83 ± 0.75	1.83 ± 0.75	0.97
I believe that pharmacology will prepare me for my duties as an oral hygienist	1.93 ± 0.62	2.00 ± 1.16	1.83 ± 0.41	2.33 ± 0.52	0.63
I find pharmacology lectures interesting and stimulating.	2.57 ± 0.85	2.00 ± 1.00	1.83 ± 0.41	1.67 ± 0.82	0.10
I would like pharmacology to be taught with clinical examples	1.86 ± 0.54	1.57 ± 0.79	1.67 ± 1.03	1.83 ± 0.98	0.86
Pharmacology has helped me to develop my logical-reasoning skills	2.36 ± 0.84	2.43 ± 1.13	2.33 ± 1.03	2.17 ± 1.17	0.97
The assessments in pharmacology were fair	2.00 ± 0.68	2.14 ± 0.38	1.50 ± 0.55	1.83 ± 0.75	0.29
The assessment concentrates on the ability to acquire facts rather than on the development of problem-solving skills	2.50 ± 0.76	2.71 ± 0.49	1.83 ± 0.41	1.83 ± 0.75	0.03*
The assessment information provided by the Department of Pharmacology was sufficient	2.07 ± 0.92	1.86 ± 0.38	1.67 ± 0.82	2.00 ± 0.89	0.77
I found the basic concepts in pharmacology challenging	2.86 ± 0.86	2.57 ± 1.13	3.17 ± 0.98	3.00 ± 1.27	0.75
Pharmacology is content-heavy	1.57 ± 0.51	2.43 ± 1.13	2.67 ± 1.37	2.33 ± 1.37	0.10
Generally, there is not enough time available to study for pharmacology	2.36 ± 0.93	2.86 ± 1.07	3.17 ± 1.17	3.83 ± 0.75	0.03*

Note: An asterisk (*) $p \leq 0.05$ indicates statistical significance between BOH groups.

all BOH groups; however, not all students chose to participate in the study. The response rate for this study was >50% for each cohort, however, the sample pool was relatively small as the BOH programme has a low intake of students per year. This is in-line with a previous study, which reported a decline in response rates to email surveys since the late 1980s.¹⁵ Many follow-up emails have been sent to increase the response rates in the current study; however, without the implementation of follow-up emails and reinforcements, response rates may only approximate 25% to 30%.¹⁵ The response rate obtained in the current study could have been due to the workload of the students or their lack of interest in the topic as well as the survey being conducted over the recess period.

4.1 | Pharmacology in a clinical setting

Graduates in the clinical spectrum require actual practice to acquire the necessary skills to provide safe and effective dental treatment.¹⁶ Pharmacology is addressed as a foundational science in the BOH degree, wherein pharmacological concepts are discussed in-depth in theory. Participants agreed that the pharmacology module should be taught with clinical examples. A challenge in the BOH curriculum is the delivery of pharmacology content, where it is taught as a separate module during the early stages of the degree. However, pharmacology does feature as part of their clinical training in the later years of their degree and students are expected to apply this knowledge during the clinical phases of the course.

BOH III students and recent graduates had a statistically significant higher self-rating knowledge in antivirals, antifungals, and common agents used to treat oral conditions in comparison to BOH I and BOH II students. This may be because of more clinical exposure and the relevance of the topics to their scope of practice through clinical rotations

as well as assessments being focused on in-patient treatment in the later years of the BOH degree. A study by Foster et al.¹⁷ highlighted that emphasis should be placed on teaching pharmacology in a clinical setting, as it may improve retention and application of pharmacological knowledge. The authors recommend that opportunities be created for students to practice authentic learning, as well as integrating and applying pharmacological knowledge and skills in a clinical environment.

4.2 | Early placement of the module in the BOH degree

Prior to the pandemic, lectures were spread over a full semester. Due to the pandemic-associated changes to the BOH schedule in 2020 and 2021, basic sciences' schedules were accommodated to finish classes earlier in the semester, thus affording students more time for practical and clinical integration thereafter (due to the need for social distancing and reduced on-site numbers). In addition, from the perspective of the authors, it is possible that BOH students and graduates' actual knowledge is impacted by their poor biological knowledge, which is potentially why they struggle with pharmacology. It is important to note that all BOH students would have similar deficiencies early on given the basic education structure and entry requirements. The students in later years may have shifted away from 'factual' knowledge and more towards the application of theory. The pharmacology course covers a wide range of learning opportunities however, not every learning opportunity features heavily in the clinical environment. In the context of oral hygiene, concepts such as local anaesthetics, pain, emergency medicine and common agents used to treat oral conditions are more aligned and representative of the clinical environment. As such, students tend to focus more on those concepts or learning opportunities that are more related to their scope of practice. Many theoretical

TABLE 3 Participants' self-rated pharmacology knowledge.

Question	BOH I, n=14	BOH II, n=7	BOH III, n=6	BOH graduates, n=6	p-values
General principles and routes of administration	7.93±2.13	6.14±2.19	7.17±1.84	6.17±2.64	0.24
Pharmacokinetics	6.71±2.16	5.57±2.07	4.67±2.16	6.17±1.33	0.22
Pharmacodynamics	5.71±2.09	5.57±2.30	4.83±1.90	5.67±1.40	0.83
Pain	6.29±1.54	5.43±2.94	8.17±1.33	7.67±2.34	0.07
Local anaesthetics	7.36±1.55	7.71±0.95	8.50±1.52	9.00±0.89	0.08
Anxiolytics	6.64±1.60	5.71±2.92	6.00±1.27	6.83±1.72	0.65
Antiviral agents	5.64±2.02	4.86±1.77	7.50±1.64	6.83±1.33	0.05*
HIV	6.29±2.56	5.14±2.12	7.67±1.75	7.50±1.38	0.14
Antifungals	5.57±1.45	6.00±1.63	8.00±1.41	7.17±1.33	0.01**
Antimicrobials	6.21±1.48	6.14±1.95	7.50±1.05	6.33±1.21	0.32
Drugs altering dental treatment: (i) Central nervous system drugs	5.71±1.59	5.71±2.43	6.00±1.67	6.83±2.48	0.69
Drugs altering dental treatment: (ii) Respiratory and endocrine drugs	5.79±1.19	5.57±2.37	6.33±1.37	6.50±2.43	0.73
Drugs altering dental treatment: (iii) Cardiovascular drugs	6.14±1.70	5.29±1.38	6.17±1.17	6.50±2.43	0.61
Emergency drugs	6.71±1.73	5.14±1.46	5.83±1.84	6.50±2.26	0.29
Common agents used to treat oral conditions	6.64±1.60	5.86±1.07	7.33±1.21	8.50±0.84	0.01**

Note: An asterisk (*) $p \leq 0.05$; ** $p \leq 0.01$ indicates statistical significance between BOH groups.

concepts are thought of as practically irrelevant and as such, are not adequately understood by students to have any practical utility. In addition, in some cases, it is almost impossible to accurately describe and theoretically represent the complex and ever-evolving clinical environment. As a result, by the final year, students may have forgotten the concepts that are emphasised as knowledge and just remember the overarching structure or outcome. As per the entry requirements for students in the BOH degree at a single higher institution in Pretoria, students often start the course with a limited background in biology,¹⁸ which leads to challenges regarding teaching and learning in pharmacology. In addition, the module is presented quite early in the BOH degree, thus creating a potential problem with integrating basic sciences vertically and horizontally, and ultimately relating it to their clinical practice. As a result, students in the latter years may struggle to retain knowledge in pharmacology.

4.3 | The importance of pharmacology in the scope of practice of oral hygiene

Students' perceptions can be used to identify teaching strategies that students perceived to be the most effective means to facilitate the learning of pharmacological concepts. There is a paucity in literature regarding BOH students' perceptions of pharmacology; however, it has been described in other health professions and thus inferences can be made. Across the board, health practitioners typically find pharmacology content-heavy and generally decontextualised from their actual practice, which may lead to a theory-practice gap.¹⁹⁻²¹ The lack of theory-practice integration can be due to the teaching environment focusing more on theory rather than practice.^{16,22,23}

Changing the way in which theoretical learning is facilitated can foster greater integration of theoretical knowledge into clinical practice, for example, by encouraging the use of student-centred teaching strategies and authentic learning environments.^{16,24}

Pharmacology has been described as a demanding interdisciplinary topic in biosciences and health professions.²⁵ It was found that students' perceptions and attitudes towards the sciences have a special importance in health professions education.²⁶ The way students perceive learning can significantly impact their approach to learning, regardless of whether it stems from their motivation, the relevance of the subject matter, an evaluation perspective, or their own personal biases.¹⁹ If students perceive a module as difficult, the module will invariably be more difficult and ultimately leave students feeling overwhelmed.^{27,28} In pharmacology, some concepts may be easily understood while others impose a greater 'cognitive load'.^{29,30} As mentioned earlier, pharmacology's demanding and content-heavy nature aligns to achieving cognitive overload, which promotes amotivation. The volume and depth of facts that are presented quite often exceed the requirements of a student's specific scope of practice. In the current study, participants tended to self-rate their knowledge in pharmacology higher in themes that were more aligned to the scope of practice of oral hygienists, such as general principles and routes of administration, local anaesthetics and antimicrobials.^{31,32}

4.4 | Assessments in pharmacology

Overall, BOH students and recent graduates agreed that pharmacology assessments were fair and that the assessment information

TABLE 4 Participants' actual knowledge of pharmacology.

Question	BOH I, n = 14	BOH II, n = 7	BOH III, n = 6	BOH graduates, n = 6	p-values
Xoli is suffering from an itchy rash due to contact dermatitis. Which one of the following routes of administration is most suitable for treatment with a corticosteroid?	14 (100.00)	7 (100.00)	6 (100.00)	6 (100.00)	-
Topical					
A weak base in an alkaline environment is more likely to be: Unionised and more lipophilic	6 (42.85)	5 (71.42)	0 (0.00)	3 (50.00)	0.07
State whether the following statement is TRUE or FALSE. A partial agonist will activate a receptor system fully. False	14 (100.00)	5 (71.42)	5 (83.33)	3 (50.00)	0.05*
Peter is diagnosed with morphine overdose. Which one of the following drugs can be used to counteract the effects of morphine? Naltrexone	11 (78.57)	5 (71.42)	1 (16.66)	3 (50.00)	0.06
Which one of the following local anaesthetics has a long duration of action? Bupivacaine	10 (71.42)	4 (57.14)	4 (66.67)	6 (100.00)	0.36
Post-exposure prophylaxis should be continued for a period of: 28 days	10 (71.42)	4 (57.14)	3 (50.00)	4 (66.67)	0.80
Which one of the following is a common side effect of antifungal therapy? GIT disturbances	9 (64.28)	6 (85.71)	4 (66.67)	5 (83.33)	0.67
Prophylactic antimicrobial therapy is important in dentistry to: Prevent bacteraemia	10 (71.42)	7 (100.00)	6 (100.00)	6 (100.00)	0.10
State whether the following statement is TRUE or FALSE. An antipsychotic may cause a patient to faint due to orthostatic hypertension. False	4 (28.57)	3 (42.85)	2 (33.33)	0 (0.00)	0.36
Dudley has been booked into your clinic for an oral health assessment. The medical history states that they are taking a sulfonylurea. What condition would he be suffering from? Diabetes mellitus	8 (57.14)	3 (42.85)	2 (33.33)	6 (100.00)	0.09
Mr. Ndlovu has poorly controlled hypertension. He has been on a calcium channel blocker for 5 months. and you decide to add a thiazide diuretic. You know that these diuretics cause numerous electrolyte and metabolic abnormalities. including: Hypokalaemia	10 (71.42)	2 (28.57)	0 (0.00)	1 (16.67)	0.01**
Urinary alkalinisers increase the pH of the urine thus reducing the reabsorption of weak acids from the kidney tubules. Which pharmacokinetic parameter is altered in this interaction? Excretion	4 (28.57)	4 (57.14)	0 (0.00)	1 (16.67)	0.12
Which one of the following can be used to treat an anaphylactic shock? Adrenaline	12 (85.71)	5 (71.42)	4 (66.67)	5 (83.33)	0.75
Which condition may require systemic immunosuppressive treatment if it is resistant to other treatments? Recurrent aphthous stomatitis	9 (64.28)	3 (42.85)	1 (16.67)	1 (16.67)	0.11

Note: The correct answer to each question is indicated in bold and an asterisk (*) $p \leq 0.05$; ** $p \leq 0.01$; indicates statistical significance between BOH groups.

Abbreviation: n, number of participants.

provided was sufficient to prepare them for tests and examinations. Students were assessed summatively using class tests, two module tests and an examination. Class tests provided feedback

on students' performance in specific topics and were thus geared to have a formative assessment component. Participants opined that the module helped them develop their logical-reasoning skills.

TABLE 5 A comparison of the total sum of self-rating and actual pharmacology knowledge.

BOH I, n = 14		BOH II, n = 7		BOH III, n = 6		BOH graduates, n = 6	
Self-rating Pharmacology knowledge	Actual Pharmacology knowledge	Self-rating Pharmacology knowledge	Actual Pharmacology knowledge	Self-rating Pharmacology knowledge	Actual Pharmacology knowledge	Self-rating Pharmacology knowledge	Actual Pharmacology knowledge
63.57 ± 10.12	66.84 ± 20.32	57.24 ± 16.20	64.29 ± 22.21	67.78 ± 7.47	45.24 ± 14.75	69.44 ± 9.09	59.52 ± 7.38
p-value	0.23	0.47		0.20		0.44	

Note: The values represent the means of the percentage self-rating pharmacology knowledge and actual pharmacology knowledge ± standard deviation. An asterisk (*) indicates significance ($p \leq 0.05$).

Logical-reasoning skills are important for oral hygienists as it will influence the diagnosis and treatment of oral conditions and assist with the foundational development of certain competencies (such as the use of local anaesthetics).³³ In this study, students opined that pharmacology assessments were more aligned to gaining factual knowledge than to the development of problem-solving skills. The current findings are consistent with previous studies, indicating that traditional pharmacology education follows a lecture-based approach, with a great deal of emphasis being placed on the acquisition of factual knowledge of drugs. However, it fails to train students sufficiently in their practical application.^{34,35} As a result, basic pharmacological knowledge has remained quite poor in all BOH groups, especially in BOH III and graduates, as seen in the total actual pharmacology knowledge scores. Although some pharmacology lectures in the module were presented in an interactive manner, further bolstering of student-centred learning can be done to provide students with opportunities to actively engage with content material and the process of scientific inquiry in relation to their practice.³⁶

4.5 | Challenges in the oral hygiene curriculum

Overall, the findings indicated a lack of knowledge of pharmacological concepts; however, due to the relatively small sample size, further investigation is warranted. In alignment with a study by Foster et al.,¹⁷ results obtained from the current survey showed that the pharmacology curriculum was perceived to be content-heavy, potentially leaving students overwhelmed, which may have led to students spending most of their time memorising theory rather than understanding concepts. In addition, BOH I and BOH II students agreed that there was not enough time available to study for pharmacology. This could be attributed to pandemic-associated changes whereby pharmacology lectures were scheduled earlier in the semester to allow for enough time for clinical rotations thereafter. Although time was available for remedial intervention prior to class tests, the reduced contact time with students meant that there was a tight schedule for various learning opportunities. These findings were consistent with a previous study by King¹⁹ who stated that the deluge of information presented with limited time in the academic schedule, often resulted in nursing students turning to rote learning, which involves arbitrary, verbatim and non-substantive incorporation of new ideas into the cognitive

structure. As a result, BOH students and recent graduates lack sufficient knowledge and may therefore struggle to apply pharmacology in their practice. Furthermore, many of the difficulties associated with teaching and understanding of pharmacology emerge from the complexity of concepts,³⁷ which can hinder the learning process as pharmacology poses concepts that are diverse and exciting to students, however, may prove to be rather confusing at the same time.^{37,38} These are major challenges described by students in literature,^{8,12,38} as well as in the current cohort of BOH students and graduates. Despite the use of different interactive teaching methods in the pharmacology module, including discussion-based learning, game-based learning and a flipped classroom approach, many of the concepts are still presented predominantly using didactic modalities; hence, it is quite common to see learning difficulties surface. It is, however, important to consider the multiple factors that can contribute to barriers in pharmacology education, ranging from the student to the teacher. For example, students who are often amotivated fail to take ownership of their own learning. In addition, lecturers' teaching styles often differ based on their educational beliefs. Additional factors that pose a barrier to pharmacology education include a possible overloaded curriculum, and poor valuation or intrinsic motivation of the students. Furthermore, the COVID-19 pandemic hampered the theoretical and clinical foundation due to the suspension of on-site classes, adjustment of the curricula, limited time in the academic schedule, the availability of infrastructure to support online learning and limited clinical rotations, to name but a few.^{37,39}

4.6 | Online teaching and learning during COVID-19

During 2020 and 2021, the COVID-19 pandemic required students to be taught in the online space, while module tests and examinations were approved for on-site, invigilated testing. Prior to online teaching, the average grade for pharmacology was slightly better than the subsequent years (2020 and 2021). Although not statistically significant, BOH I and BOH II students who were exposed to online teaching and learning during the COVID-19 pandemic had a higher actual knowledge in comparison to their self-rated knowledge. Several studies have highlighted the benefits of online learning. According to Ratheeswari,⁴⁰ the use of information and communications technology

in the digital age enables students to learn and put their 21st-century abilities into practice. A previous study on online learning showed that it is an alternative pedagogy for the age of technological advancement and communication, requiring students to adapt.⁴¹ The inclusion of learning on online platforms has become more frequent, with aspects of online learning being integrated into most courses.⁴² Davies and Graff's⁴³ suggested that online learning can have a beneficial impact on students if conducted in a way that mimics traditional learning. In addition, Morris et al.⁴⁴ concluded that online learning does have a positive impact on tertiary students; however, this study did not take into account the difference in online course construction.

When compared to traditional face-to-face teaching and learning, research examining the effectiveness of remote teaching and learning on student learning outcomes often revealed no significant differences.⁴⁵ According to a report by the United States Department of Education, online learning can lead to better learning outcomes than in-person learning.⁴⁶ Additionally, a study by Pei and Wu⁴⁷ supported this notion, demonstrating that online learning was as successful as face-to-face learning with respect to undergraduate medical students. While online learning has advantages over face-to-face teaching, such as flexibility and student-centred learning,⁴⁸ this may not necessarily be suitable in all instances. During COVID-19, the transition to a new learning environment was hampered by many extraneous factors such as pedagogical, logistical, economical, technological, and psychosocial challenges.⁴⁹ For many educational institutions, moving to an online learning format may prove to be problematic when the impact of online learning on students' success is not fully understood.^{50,51} Without a proper understanding of how online learning impacts the student, efforts to incorporate online learning into the learning environment are rendered futile. Results showed that student performance was quite poor, which may indicate that they could not make use of their resources appropriately, showcasing a deeper learning problem. It is also important to note that not all students have access to internet facilities to help facilitate their learning; hence, the transition to an online-based teaching and learning platform could incidentally play a role in students experiencing difficulties understanding course material and ultimately affect student performance. Further research needs to be conducted in order to determine the appropriate use of blended and hybrid learning in the pharmacology module.

4.7 | Curricular realignment

Re-curricularising the pharmacology curriculum may lead to academic success by implementing different types of pedagogy more authentic assessment practices, and greater alignment of the curricula to the needs of BOH graduates. The pharmacology module is a first year, second-semester module which is placed very early in the BOH degree. The horizontal alignment of pharmacology with other basic sciences should be implemented to complement each other and therefore promote vertical alignment to oral hygienists'

scope of practice. In addition, it could help bridge the issues with time constraints and a decontextualised content-heavy curriculum. Understanding current perceptions of BOH students and recent graduates with respect to learning and the importance of pharmacology in both clinical practices may be helpful in improving the teaching of this discipline and could positively impact students' performance.

Based on informal communication from dental schools in South Africa, it was found that on average, 50 BOH students graduate across five dental schools (University of Pretoria, University of Witwatersrand, Sefako Makgatho Health Sciences University, University of Kwa-Zulu Natal, and University of the Western Cape). Since the study was conducted at a single higher institution, the extrapolation of data to other institutions in South Africa is not possible. The authors recommend that the module be re-curricularised and further aligned to the scope of practice of oral hygienists to improve student learning and satisfaction. The authors also recommend that Life Sciences (Biology) be a prerequisite for the BOH programme, and that pharmacology be vertically integrated in a clinical setting. We recommend that the study be repeated in a larger population to improve the representation of the South African population and to determine how the module is being taught at other training institutions to identify strengths and weaknesses and to standardise the teaching content and pedagogy for all BOH students in South Africa.

5 | CONCLUSION

The findings of this study have highlighted significant gaps in pharmacology education among students and recent graduates within the field of oral hygiene. Notably, self-rated knowledge deficiencies in specific pharmacological concepts were reported, and these deficiencies were substantiated through the measurement of actual knowledge between the various BOH groups. Further investigation into knowledge deficiencies is needed to guide curriculum review to further strengthen oral hygienists' pharmacological competencies and ensure alignment to their scope of practice.

6 | CLINICAL RELEVANCE

6.1 | Scientific rationale for study

Evaluating the level of knowledge and perceptions of BOH students and recent graduates regarding pharmacology could aid in improving the teaching of the discipline and impact the design and development of the pharmacology course.

6.2 | Principal findings

Self-rated knowledge deficiencies were noted by students and graduates for certain pharmacological concepts and supported by the

measurement of their actual knowledge. It is important to consider the various factors that could influence the results between various BOH groups.

6.3 | Practical implications

Further investigation into knowledge deficiencies is needed to guide curriculum review to further strengthen oral hygienists' pharmacological competencies and ensure alignment to their scope of practice.

AUTHOR CONTRIBUTIONS

All authors contributed to the study's conception and design. MB and CB led data collection. MB, WC, AB and CB contributed to data analysis and interpretation. MB and CB led manuscript development with critical review and input from WC, AB, MM and NS. All authors gave final approval for the manuscript and are accountable for ensuring accuracy of all aspects of the work.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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