BRITISH JOURNAL OF HOSPITAL MEDICINE

ARTICLE

Effectiveness of a BOPPPS Teaching Model in Standardized Training for Nephrology Resident Physicians: A Retrospective Cohort Study

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Abstract

Aims/Background Based on Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment and Summary (BOPPPS), the teaching model has gained increasing attention in the field of medical education. This study aimed to evaluate the effectiveness of the BOPPPS teaching model in standardized training for nephrology residents, particularly in educating on hyperkalemia in chronic kidney disease (CKD).

Methods This retrospective cohort study included students undergoing standardized training in the nephrology department at the Shanghai Traditional Chinese Medicine-Integrated Hospital Affiliated to Shanghai University of Traditional Chinese Medicine from 2021 to 2024. The observation group (n = 55) received instructions using the BOPPPS teaching model, while the control group (n = 64) was educated using the traditional teaching methods. The study evaluated learning outcomes and teaching satisfaction through theoretical and practical assessments, as well as self-assessment by the students.

Results The observation group demonstrated significantly higher scores in theoretical exams and practical assessments compared to the control group ($p < 0.05$). Additionally, the observation group reported higher self-assessment scores ($p < 0.05$) and greater teaching satisfaction ($p < 0.05$) than the control group.

Conclusion The BOPPPS teaching model is an effective approach to enhancing theoretical knowledge, practical skills, and teaching satisfaction in standardized training for nephrology residents. Compared to traditional teaching methods, the BOPPPS model improves learning outcomes, thereby strengthening the quality of medical education.

Key words: BOPPPS teaching model; nephrology residents; learning outcomes; teaching satisfaction

Submitted: 16 July 2024 Revised: 4 September 2024 Accepted: 13 September 2024

How to cite this article:
Li Y, Ren F, Qiu J, Li D, Wang J, Lin S. Effectiveness of a BOPPPS Teaching Model in Standardized Training for Nephrology Resident Physicians: A Retrospective Cohort Study. Br J Hosp Med. 2024. https://doi.org/10.12968/hmed.2024.0437

Introduction

Chronic kidney disease (CKD) is a growing global public health concern with a prevalence of 8%–16%, affecting approximately 132 million individuals in China (GBD Chronic Kidney Disease Collaboration, 2020; Ke et al, 2022; Li et al, 2022). Hyperkalemia is a common complication of CKD, associated with high incidence and recurrence rates, and remains a major cause of mortality among end-stage renal disease patients (Cowan et al, 2017; Sampani et al, 2023; Watanabe, 2020). Its

prevalence among CKD patients is significantly higher than the general population, presenting a concomitant rate increasing trend with CKD prevalence. Since hyperkalemia management necessitates excellent diagnostic and therapeutic abilities of physicians, it is widely accepted that offering systematic and effective training for resident physicians is extremely crucial.

Traditional medical education predominantly involves didactic teaching methods, which often results in low student engagement and inadequate practical skills, insufficiently meeting modern medical education demands (Challa et al, 2021). In recent years, the BOPPPS teaching model (Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, Summary) has garnered attention in the realm of medical education. Li et al (2023a) demonstrated that the BOPPPS teaching model significantly enhances students' engagement and clinical thinking during the course of "Clinical Basic Testing Techniques", with over 95% of the participating students feeling satisfied with the teaching model. Similarly, Shen (2024b) utilized the BOPPPS model in training community pharmacists and revealed that the subjects who were educated through seminars designed based on the BOPPPS model achieved higher overall scores and demonstrated more superior performance compared to those exposed to the traditional lectures. Initially developed for training teacher so as to enhance teaching effectiveness and skills (Pattison and Russell, 2006), the BOPPPS teaching model is centered around optimizing the teaching process through a structured framework. The model divides the teaching process into six modules: Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, and Summary, emphasizing interactivity and a student-centered approach (Zheng, 2023). Moreover, the effectiveness of this model has been demonstrated not only in pharmaceutical fields but also in nursing and dental courses, where it significantly improves students' knowledge acquisition and application abilities (Li et al, 2023b; Lin et al, 2023). These findings underscore the potential and practical efficacy of applying the BOPPPS teaching model in medical education. However, its systematic application in standardized training for nephrology residents has yet to be comprehensively studied.

This study aimed to evaluate the effectiveness of the BOPPPS teaching model in standardized training for nephrology residents, particularly in educating on hyperkalemia in CKD. Our hypothesis posits that the BOPPPS teaching model enhances students' theoretical knowledge, practical skills, and teaching satisfaction. The significance of this research lies in its potential to address the shortcomings of traditional teaching methods, enhance the clinical responsiveness and comprehensive qualities of resident physicians, thereby improving the quality of medical services.

Methods

Study Population

This retrospective cohort study included students undergoing standardized training at the nephrology department of the Shanghai Traditional Chinese Medicine-Integrated Hospital Affiliated to Shanghai University of Traditional Chinese Medicine

from January 2021 to June 2024. Each month, there are 2–4 resident trainees participating in the nephrology training program. For this study, the control group (n = 64) consisted of trainees who were educated with the traditional teaching methods from January 2021 to December 2022, whereas the observation group (n = 55) consisted of trainees who were mentored and educated under the BOPPPS teaching model from January 2023 to June 2024.

The subjects included in the present study were resident trainees who: (1) were aged ≥18 years; (2) were undergoing standardized training at the Shanghai Integrated Traditional Chinese and Western Medicine Hospital; and (3) had completed the basic clinical and medical theoretical courses at the undergraduate level.

Individuals with the following characteristics were excluded: (1) failure to meet inclusion criteria; (2) withdrawal from the study midway; and (3) having incomplete data.

Training Protocols

Traditional Teaching Methods in the Control Group (Approximately 40–45 Minutes)

Study materials were distributed to the resident trainees for pre-class preparation before the session begins. Subsequently, the nephrology mentor gave a "mini-lecture" in a traditional multimedia slide format on the following topics: (1) Review of clinical theoretical knowledge of hyperkalemia. (2) Analysis of case data related to CKD hyperkalemia patients, and discussion on diagnosis and treatment. (3) Summary by the mentor. The main objective of the lecture was to present actual case data and discuss about diagnostic and treatment plans. The content delivery of this method primarily relies on lectures, lacking simulation of practical operations and clinical scenarios. After the lecture session, relevant reference materials were shared with the trainees for their independent study.

BOPPPS Teaching Model Methods in the Observation Group (Approximately 50–60 Minutes)

Under the BOPPPS teaching model, the session started with a scenario simulation (e.g., serum potassium level of 6.2 mmol/L) aimed to immediately capture the attention of the resident trainees by create a sense of clinical urgency. This approach integrates theoretical knowledge with clinical practice through scenario simulation, enhancing trainees' clinical decision-making and practical skills. In the simulated scenarios, trainees were given the space to discuss specific cases and apply what they have learned in diagnosing and treating a medical condition. Compared to the traditional lectures, this method places more emphasis on the mentor-trainee interactions and practical application, significantly improving trainees' engagement and ability to apply their skills.

In the learning objective section, the focus of CKD hyperkalemia was clearly defined. Emphasis was placed on specific objectives and key challenges of this clinical learning course to ensure trainees understood what needed to be mastered and accomplished. Under this teaching model, basic theories were adapted into practical applications to educate on clinical skills—a teaching method for trainees

to accurately master the skills in diagnosing medical condition and proposing appropriate treatment plans.

During the pre-assessment stage, assessment of the trainees' familiarity with practical content was conducted so that course arrangements could be adjusted accordingly. Additional explanations surrounding the topics were provided, and the trainees were free to share their thoughts on the theoretical modules. On the basis of the questions shared with trainees before assessment, key learning outcomes were underlined and further clarified during subsequent practice sessions.

In contrast to traditional teaching methods, interactive learning methods empower trainees as active learners rather than passive ones. Through interactive learning, the trainees could engage in interacting with patients, families, and nurses, which gave them a platform to develop clinical interview skills and a channel to deepen their understanding of diseases.

Post-assessment was conducted to not only identify learning gaps in the trainees, but also to pinpoint the aspects in the contents and teaching methods that require continuous improvements and refinements by the mentors based on the assessment results. This iterative improvement process aims to consistently achieve optimal teaching outcomes. Fig. 1 shows the elements and processes of BOPPPS teaching model in details.

Data Collection

Data for this study were retrospectively collected from hospital teaching records and clinical case records. After data entry, two independent researchers cross-checked the accuracy of data entered.

Basic Information Collection

Basic information about the resident trainees, such as age, gender, and educational background, were gathered.

Evaluation of Teaching Effects

Theoretical Exam Scores

The trainees were assessed using a series of tests about hyperkalemia designed by the department, which comprise objective and subjective question categories (each category accounting for 50% of the total score). Objective questions were multiple-choice with standardized answers (total of 50 points). Subjective questions covered the following: (1) diagnostic criteria for CKD hyperkalemia (10 points); (2) reasons why CKD patients are prone to hyperkalemia (20 points); and (3) summary of therapeutic medications for CKD patients with hyperkalemia (20 points). The content validity of the questionnaire was 0.931, and the Cronbach's α coefficient was 0.834.

Practical Assessment Scores

Practical management of hyperkalemia patients by resident trainees in the nephrology ward was assessed in five aspects: (1) Observing resident trainees' interviewing skills and accuracy in assessing patient hyperkalemia severity (20 points); (2) Evaluating resident trainees' communication skills with on-duty nurses, as well as

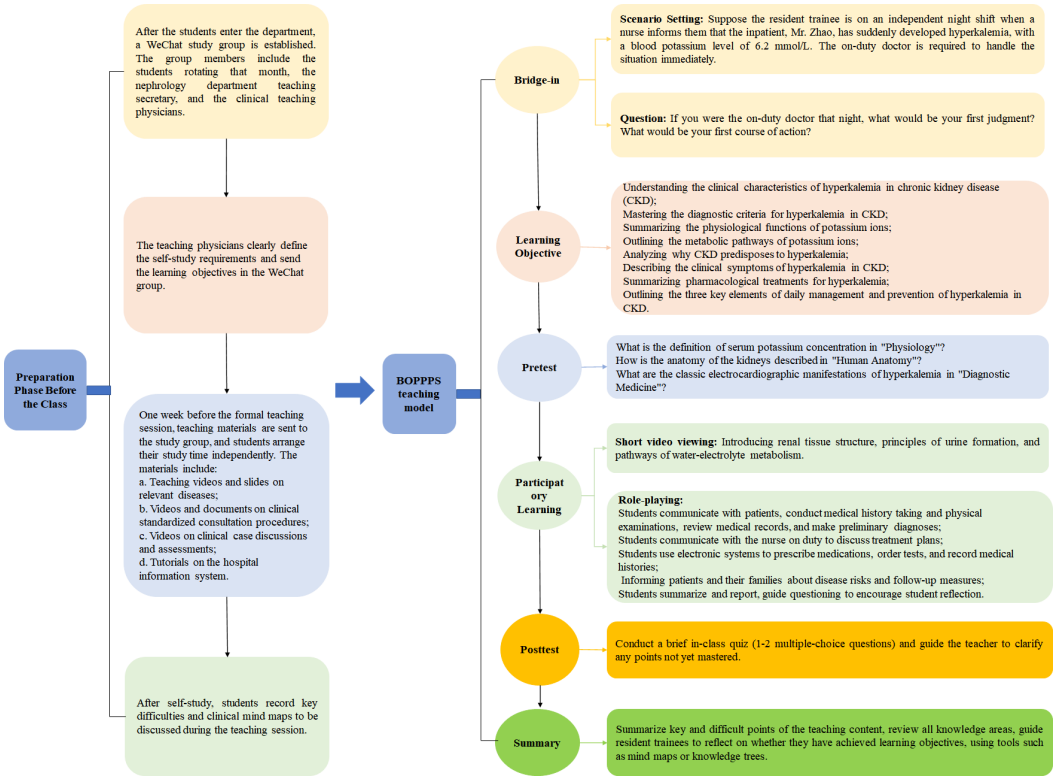

Fig. 1. BOPPPS teaching model. Note: The BOPPPS teaching model includes the following components: Bridge-in (engaging students at the start of the course through questions, discussions, or activities), Objective (clearly defining learning goals so that students understand the expected outcomes), Pre-assessment (evaluating students' prior knowledge and skills before the course begins), Participatory learning (teaching through interaction and engagement), Post-assessment (assessing learning outcomes at the end of the course), and Summary (summarizing and reflecting on the teaching content). CKD, chronic kidney disease.

proficiency in handling cases and interpreting laboratory examination results (20 points); (3) Assessing resident trainees' grasp of using modern electronic systems for prescribing medications, requesting tests, recording medical histories of patients (especially those involving critical values), and taking note of specific treatment conditions (20 points); (4) Evaluating resident trainees' ability to inform patients and families about disease risks and subsequent treatment measures (20 points); (5) Assessing resident trainees' case presentation and summarization of medical histories to mentoring physicians (20 points). The content validity of the questionnaire was 0.927, and the Cronbach's α coefficient was 0.849.

The evaluations were conducted by two supervising instructors from the nephrology department, who were aware of the teaching modules these resident trainees had been subjected to but were not informed that the results would subsequently be used for academic comparison. This partial blinding procedure was implemented to minimize potential bias.

Self-Assessment of Learning Effects

A self-designed questionnaire was used to assess the trainees across three dimensions: analytical ability, clinical thinking ability, and self-learning ability, with

a total of nine items rated on a Likert four-level scoring scale, ranging from 1 (very poor) to 4 (very good). The Cronbach's α coefficient was 0.823.

Evaluation of Teaching Satisfaction

A self-designed teaching satisfaction evaluation questionnaire was utilized to assess the trainees across four dimensions: teacher-student interaction, teaching methods and resource utilization, practicality and applicability of course content, and professional competence and teaching experience of teaching staff, with 10 items rated on a Likert five-level scoring scale, ranging from 1 (very dissatisfied) to 5 (very satisfied). The teaching satisfaction was quantified using the formula below:

$$\text{Satisfaction rate (\%)} = \left(\text{Number of very satisfied} + \text{satisfied cases}\right) / \text{Total cases} \times 100$$

The Cronbach's α coefficient was 0.857.

Statistical Analyses

Statistical analyses were conducted using SPSS 22.0 software (IBM Corp., Armonk, NY, USA). Normally distributed data are expressed as mean $\pm$ standard deviation, and were analyzed using independent sample *t*-tests for intergroup comparisons. Count data and ordinal data are presented as frequency and were analyzed using Chi-square tests. All statistical analyses employed two-tailed tests, with $p < 0.05$ considered statistically significant.

Results

General Characteristics of Students

There were no significant statistical differences ($p > 0.05$) between the control group and the observation group in terms of age, gender, educational background, grade point average (GPA), years of clinical experience, and specialization. Specific details are shown in Table 1.

Theoretical Exam and Practical Assessment Scores of the Students

The trainees in the observation group subjected to the BOPPPS teaching methods achieved significantly better performance in both theoretical exam and practical assessment scores compared to those in the control group ($p < 0.05$). Specifically, the observation group achieved an average score of 82.1 in the theoretical exam, which was higher than the control group's average of 75.4. For the practical assessment, the observation group scored an average of 85.7, surpassing the control group's average of 78.9. These results indicate that the BOPPPS teaching model effectively enhances students' mastery of theoretical knowledge and practical skills. Detailed outcomes are presented in Table 2.

Self-Assessment of Learning Outcomes

In terms of analytical ability, clinical reasoning, and self-learning capabilities, the observation group scored significantly higher than the control group, with statis-

Table 1. Comparison of general characteristics between the control and observation groups.

Characteristic	Control group (n = 64)	Observation group (n = 55)	t/χ^2	p
Age (years)	26.3 ± 3.1	26.0 ± 2.9	0.542	0.589
Gender			0.002	0.965
Male	34 (53.13%)	29 (52.73%)		
Female	30 (46.88%)	26 (47.27%)		
Education background			0.231	0.631
Bachelor's degree	40 (62.50%)	32 (58.18%)		
Master's degree	24 (37.50%)	23 (41.82%)		
Undergraduate GPA	3.45 ± 0.32	3.50 ± 0.28	0.900	0.370
Clinical experience (years)	1.21 ± 0.41	1.31 ± 0.30	1.468	0.145
Specialty area			0.008	0.996
Internal medicine	40 (62.50%)	34 (61.82%)		
Surgery	15 (23.44%)	13 (23.64%)		
Other	9 (14.06%)	8 (14.55%)		

Abbreviation: GPA, grade point average.

Table 2. Comparison of theoretical and practical examination scores between the control and observation groups.

Measure	Control group (n = 64)	Observation group (n = 55)	t	p
Theoretical exam score	75.4 ± 6.8	82.1 ± 7.2	5.215	<0.001
Practical assessment score	78.9 ± 7.5	85.7 ± 6.9	5.116	<0.001

tical significance ($p < 0.05$). Specific results are shown in Table 3. The distribution of respondents rating each item on the self-assessment of learning outcomes questionnaire as "excellent" is depicted in Fig. 2.

Fig. 2. Distribution of number of participants rating each item as "excellent" on the self-assessment questionnaire on learning outcomes.

Table 3. Comparison of self-assessment scores on learning outcomes between the control and observation groups.

Dimension	Control group (n = 64)	Observation group (n = 55)	*t*	*p*
Analytical ability	9.69 ± 2.17	10.52 ± 2.01	2.176	0.032
Clinical thinking ability	9.47 ± 2.10	10.47 ± 2.07	2.616	0.010
Self-learning ability	9.17 ± 2.33	10.09 ± 2.40	2.115	0.037
Total score	47.48 ± 10.13	52.09 ± 10.46	2.437	0.016

Table 4. Comparison of teaching satisfaction scores between the control and observation groups.

Dimension	Control group (n = 64)	Observation group (n = 55)	*t*	*p*
Interaction between teachers and students	10.66 ± 2.98	11.84 ± 2.65	2.264	0.025
Teaching methods and resource utilization	6.61 ± 2.16	7.75 ± 1.90	3.020	0.003
Practicality and applicability of course content	10.13 ± 3.07	11.84 ± 2.64	3.232	0.002
Professional level and teaching experience of instructors	6.89 ± 2.06	7.89 ± 1.75	2.826	0.006
Total score	34.28 ± 10.13	39.31 ± 8.90	2.853	0.005

Teaching Satisfaction

Satisfaction ratings in four dimensions—interactions between teachers and students, teaching methods and resource utilization, practicality and applicability of course content, and expertise and teaching experience of instructors—were significantly higher in the observation group compared to the control group ($p < 0.05$). Detailed results are outlined in Table 4. The distribution of satisfied respondents for each item on the teaching satisfaction questionnaire is illustrated in Fig. 3.

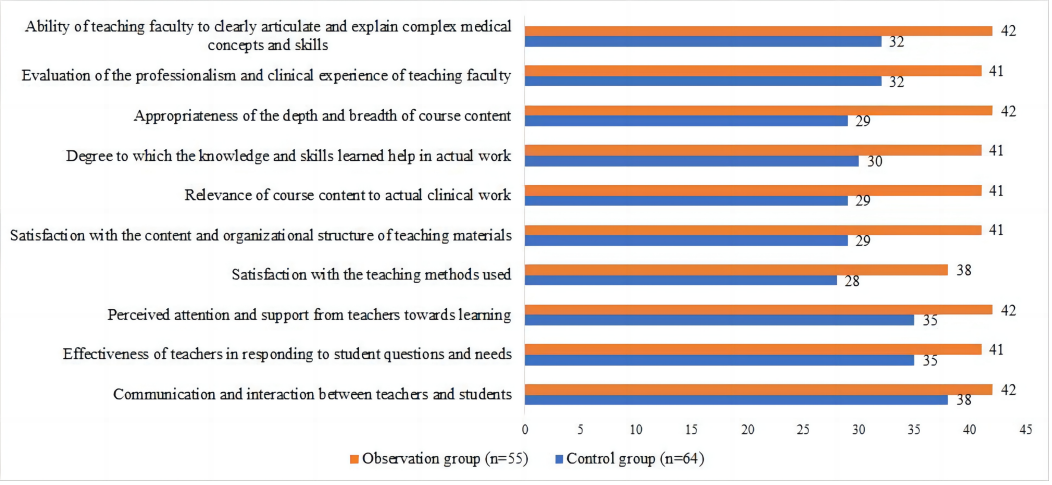

Fig. 3. Distribution of number of participants satisfied with each item on the teaching satisfaction questionnaire.

Discussion

The current study compared the application effects of traditional teaching methods and BOPPPS teaching model on the standardized training of nephrology resident trainees. Our findings revealed that the BOPPPS teaching model has significant advantages in enhancing students' theoretical knowledge, practical skills, and teaching satisfaction. Specifically, students in the observation group scored significantly higher in theoretical exams, practical assessments, and self-assessments compared to those in the control group. Additionally, the observation group reported higher satisfaction with the professional level and experience of the teaching staff. These findings indicate this model effectively addresses the shortcomings of the traditional methods and improves students' overall competence, potentially leaving a favorable impact on the quality of medical services.

Comparisons with previous studies further validate the efficacy of the BOPPPS teaching model in medical education. In a study on the application of BOPPPS teaching model to 265 undergraduate students having clinical obstetrics and gynecology internships, Xu et al (2023) found that the experimental group, who had been subjected to training under the BOPPPS model, showed enhanced learning interest and initiative, improved practical capabilities in clinical settings, and increased satisfaction compared to those educated by traditional teaching methods. Their results indicated that this model effectively motivated interns and enhanced their comprehensive skills, and the interns demonstrated favorable teaching outcomes in clinical settings. Additionally, Yang et al (2019) found that this model stimulated learning interest, enhanced critical thinking skills among dental students, inspired innovative teaching approaches among instructors, and improved overall teaching quality.

A meta-analysis of 13 randomized controlled trials (RCTs) highlighted significant improvements in theoretical scores, practical performance, self-learning abilities, and teaching satisfaction using the BOPPPS model in foundational nursing courses compared to traditional methods (Li et al, 2024). Furthermore, a systematic review encompassing 41 studies involving 5042 medical students in China underscored the effectiveness of this model in enhancing skill, knowledge, comprehensive ability scores, and teaching satisfaction, affirming its value in Chinese medical education (Ma et al, 2022). The efficacy of the BOPPPS model has also been validated in clinical training across biopharmaceutical engineering, anatomy, and pharmacy domains (Yao et al, 2024; Shen et al, 2024a; Sun et al, 2022).

The structured and interactive nature of the BOPPPS model significantly enhances students' theoretical knowledge, practical skills, and self-directed learning abilities. Compared to traditional methods, this approach better meets the demands of modern medical education, improving teaching quality and effectiveness. With an emphasis on student engagement and interaction, the BOPPPS model effectively stimulates learning interest and initiative, fostering not only enhanced learning outcomes but also cultivating lifelong learning skills crucial for medical education and professional development. By simulating real clinical environments and promoting case discussions, the BOPPPS model facilitates the application of theoretical knowledge to actual practice, thereby strengthening the trainees' clinical decision-

making and operational skills. The outstanding performance of the observation group in practical assessments further substantiates this point, underscoring its significance in cultivating high-quality clinical professionals. The higher satisfaction reported by students using the BOPPPS model in teaching satisfaction evaluations also suggests its capacity to improve both learning outcomes and satisfaction with the teaching process—a testament that lays a stepping stone for teaching methodology revamp in the educational institutions and warrants the need to improve teaching standards.

Consistent with prior research, this study demonstrates the favorable application effects and broad applicability of the BOPPPS teaching model across various medical disciplines, whether in foundational medical courses or clinical internships. The findings underscore its effectiveness in supporting medical education reform and advancement. Through its application in nephrology resident training, this study further validates the efficacy and advantages of this model, highlighting its significant importance and widespread clinical value in medical education. These findings offer beneficial insights for other medical educators who seek to advance the development and implementation of the BOPPPS model in medical education.

This study has some limitations and contextual constraints. Firstly, in this retrospective cohort study, the relatively small sample size limited the generalizability of its findings to only residents trained at the Shanghai Integrated Traditional Chinese and Western Medicine Hospital. However, according to Xu et al (2023), the calculated sample size required for each group was approximately 51. This indicates that our current study sample has adequate statistical power to yield reliable and valid research results. Secondly, the brief observation period in this study is not sufficient for assessing the long-term effects of applying BOPPPS teaching model on the overall development of residents' comprehensive abilities. The lack of long-term evaluation may limit a comprehensive understanding of the full scope of the BOPPPS teaching model's potential impact on career development. Thirdly, all assessment metrics were measured through self-designed questionnaires, lacking objective assessment tools. Despite these limitations, the study's conclusions remain reasonably reliable and meaningful. Notably, the results of this study demonstrate the significant advantages of the BOPPPS teaching model in enhancing teaching effectiveness, consistent with findings by Xu et al (2023) and Shen et al (2024a). The consistency of similar conclusions drawn by different research teams in different contexts enhances the credibility of the results. Despite being a retrospective cohort study, this study adhered to strict research design and data collection methods to ensure the systematic and scientific integrity of the data. Finally, the BOPPPS teaching model was found to be well-received in a different cohort in an unpublished validation study, demonstrating the effectiveness of this teaching model in enhancing student learning interest, initiative, and teaching satisfaction. This successful application in practice further validates the reliability of the research findings. Future research with an extended observation period can be carried out in a wider range of multi-center settings and measured using an array of objective assessment tools to further verify the long-term effects and applicability of the BOPPPS teaching model. Continuing to verify and receive feedback regarding the practical

experiences of using this teaching model will further improve and expand the application research of the BOPPPS teaching model in medical education, providing more reliable basis and guidance for educational practice.

Conclusion

The study demonstrates that the BOPPPS teaching model is more effective than traditional teaching methods in improving theoretical knowledge, practical skills, and teaching satisfaction of nephrology resident physicians. This teaching model holds huge potential in strengthening medical education and enhancing healthcare service quality by addressing limitations of traditional teaching methods. Further research and implementation of BOPPPS in medical education are warranted to validate its broader applicability and benefits.

Key Points

- Applying the BOPPPS teaching model in standardized nephrology training can significantly improve theoretical knowledge, practical skills, and teaching satisfaction of resident trainees, particularly on the topic of hyperkalemia in chronic kidney disease (CKD), as compared to the traditional methods.
- The BOPPPS model, which includes components such as Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, and Summary, can achieve superior outcomes in both theoretical exams and practical assessments among the resident trainees, highlighting its effectiveness in medical education.
- Compared to traditional teaching methods, the BOPPPS model enhances students' self-assessed analytical and clinical thinking abilities, raising their satisfactions towards teaching quality in various dimensions, thus addressing the common shortcomings encountered in the conventional training approaches.
- The BOPPPS teaching model not only fosters better learning outcomes and higher engagement among nephrology residents but also offers valuable insights for improving medical education practices, underscoring its potential for broader application in clinical training programs.

Availability of Data and Materials

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

Author Contributions

YL, SL and FR designed the study. All authors conducted the study. JQ and DL and JW collected and analyzed the data. YL and SL participated in drafting the manuscript, and all authors contributed to critical revision of the manuscript for

important intellectual content. All authors gave final approval of the version to be published. All authors participated fully in the work, took public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or completeness of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

This study has been approved by the Ethics Committee of Shanghai Traditional Chinese Medicine-Integrated Hospital Affiliated to Shanghai University of Traditional Chinese Medicine (Approval No: 2021-073-1). All participants provided informed consent before participating in the survey. The study was conducted in strict adherence to the Declaration of Helsinki and relevant ethical guidelines to ensure participant privacy and data confidentiality.

Acknowledgement

Not applicable.

Funding

(1) Research project within the budget of Shanghai Municipal Education Commission: Application research on CKD hyperkalemia in standardized training of nephrology residents based on BOPPPS teaching model (No.23JYZ813). (2) Shanghai University of Traditional Chinese Medicine Curriculum Construction project: Application of BOPPPS model combined with flipped classroom in residential training and teaching in nephrology Department (No.2023SHUTCMKCJS008).

Conflict of Interest

The authors declare no conflict of interest.

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