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A review of clinical reasoning in nursing education: based on high-fidelity simulation teaching method

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Abstract: **Objective:** Clinical reasoning is an essential feature of health care practice; it is also a crucial ability for providing patient care of high quality. It has been identified that graduate nurses may lack the clinical reasoning skills to deliver safe and effective patient care. It is therefore of paramount importance to enhance nursing students' clinical reasoning ability. High-fidelity simulation (HFS) is proved to be an effective teaching and learning method, which may also have some advantages over other teaching methods.
Methods: The authors retrospectively reviewed the related literature, illustrated the application of high-fidelity simulation teaching method in nursing education, putting the focus on the use of it in teaching with clinical reasoning.
Results: The application of high-fidelity simulation to nursing education can simulate the clinical situation, thus to create a safe, continuous and efficient learning environment for students, and it can effectively improve students' clinical reasoning ability.
Conclusions: high-fidelity simulation is effective for clinical reasoning teaching in nursing education. The extension of its application in China should be of great value. The relevant further study is suggested focusing on how to overcome its own limitations and have it better applied in nursing education in China.

Keywords: *clinical reasoning • high-fidelity simulation • nursing education • teaching method*

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1. Introduction

Clinical reasoning, which has been studied abroad for more than 30 years, is an essential feature of health care practice; it is also a crucial ability for providing patient care of high quality. Levett-Jones et al[1] defined clinical reasoning as "a logical process by which nurses (and other clinicians) collect cues, process the information, come to an understanding of a patient problem or situation, plan and implement interventions, evaluate outcomes, and reflect on and learn from the process". It is agreed that clinical reasoning in nursing practice is of critical importance.[2] However, it has been identified that graduate nurses may lack the clinical reasoning skills to deliver safe and effective patient care.[3] Given

the situation, it is of paramount importance to enhance nursing students' clinical reasoning ability.

High-fidelity simulation (HFS) uses a human patient simulator to mimic real signs and symptoms and allows the change of physiological parameters in response to interventions.[4] The available evidence supports the notion that medium and/or HFS using manikins is an effective teaching and learning method where best practice guidelines are adhered to. Simulation may also have some advantages over other teaching methods, depending on the context and subject method. Simulation enables nurses to develop, synthesize, and apply their knowledge in a replica of real experience.[5]

While there has been some literature that explicates the concept of clinical reasoning and also the development of models that demonstrate the clinical reasoning process,[6,7] there is a paucity published about fostering

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nursing students' clinical reasoning ability by using HFS. This article mainly reviews the research progress of the clinical reasoning based on HFS in nursing education in recent years to provide suggestions for developing nursing education and strategies for nursing quality improvement.

2. HFS teaching method in nursing education

2.1. HFS teaching method in nursing education abroad

Simulations have long been used to promote learning in the health care professions and provide a safe, acceptable environment for practicing skills.[8] The use of all forms of simulation will be an essential element of the nursing education, and the use of high-fidelity patient simulators will be the most effective form of simulation in the near future.[9] As a new teaching mode, the HFS has been explored extensively by the nursing educators abroad.

2.1.1. HFS teaching method for undergraduate nurses

The explorations of HFS in higher education abroad provide insights for the curriculum construction in nursing education.

Burns et al[10] tested 114 first-year nursing students to see the efficacy of using HFS to facilitate the understanding of problem-solving skills among them. Pre- and posttests were used to evaluate their knowledge and attitude changes. Eighty-two percent of students showed a significant gain in knowledge. All students showed a significantly positive difference for multiple attitudinal items, including critical thinking skills, overall nursing knowledge, confidence, and communication. Facilitating acquisition of problem-solving through the use of HFS is effective and welcomed by all participants in this study cohort. To explore the reasons behind, it could be found that the HFS provides an interactive live application of the nursing process and therefore demonstrates the effectiveness of theoretical knowledge in practice.[11] Simulation participants use a problem-solving process to care and to work as part of a team. Such active learning opportunities not only foster the development of critical thinking skills[12] but also offer students instant feedback on clinical decisions as well as overall nursing knowledge, confidence, and communication, which helps students make the link between treatment decisions and patient outcomes.[13] It is reported that students who learned problem-solving through HFS gain a greater sense of being involved in diverse ways of

learning than students who used the traditional study method, and they valued this educational practice more than those students using other methods.[14] Similarly, taking part in group discussions, as in the simulation debriefing, leads to critical thinking because students reflect on their own decisions, synthesize information, and reconstruct concepts.[15]

In Norway, Thidemann and Soderhamn[16] divided students in the second year of a 3-year bachelor nursing program into small simulation groups with different roles: nurse, physician, family member, and observer. After the project, the students evaluated the simulation to be a valuable teaching–learning method. Moreover, three simulation outcomes were measured: knowledge of learning, student satisfaction, and self-confidence in learning. Overall, the students rated the student satisfaction and self-confidence in learning as high. Knowledge about the specific patient focus increased after the simulation activity. Wotton et al.[17] also proved that the third-year students perceived HFS as enjoyable, with an appropriate degree of challenge yet possessing congruency with concepts studied in the course.

Smith and Barry[18] examined an HFS home care experience to determine effects on student satisfaction, self-confidence, and learning outcomes. Senior baccalaureate students took part in the experience. Results indicated that students were very satisfied with the experience and felt that it increased their confidence in providing care in the home.

Luctkar-Flude et al.[19] investigated learners' satisfaction, self-efficacy, and performance behavior among high-fidelity human simulators (HFS), standardized patients (SPs), and community volunteers (CVs); 44 undergraduate nursing students were randomly assigned to perform focused respiratory assessments on HFS, SP, or CV. The results showed that HFS may provide a low-stress opportunity for novice learners to practice skills, but learners were significantly less satisfied with this modality.

It can be seen from the abovementioned literature that, in the nursing education for undergraduate students abroad, no matter in which grade the students are, or whether it is used to simulate a clinical situation or a home environment, the HFS is proved to be effective in student satisfaction, self-confidence, and learning outcomes; it is also proved to be effective to stimulate students' learning interest and provide a safe learning environment.

2.1.2. HFS teaching method in postgraduate nursing education and continuing education

The HFS was actively practiced and explored in the postgraduate nursing education as well as continuing education. Lucas identified[20] opportunities for

employers to use HFS-based learning programs that promote continued competency and confidence in practicing nurses.

Gordon and Buckley[21] had 50 medical–surgical graduate students participated in high-fidelity immersive simulations to examine the effect of simulation on their perceived ability and confidence in responding to patient clinical emergencies. The graduate students had been tested before and after simulation to rate their perceived ability and confidence. Compared with the beginning of the simulation, the graduates' confidence and perceived technical and nontechnical skills during patient clinical emergencies were enhanced.

Cannon-Diehl et al.[22] explored the usefulness of HFS as a valuable tool for continuing education and reported the results of a needs assessment conducted among 22 practicing nurse anesthetists. After the use of HFS, 81% participants identified that they envisioned simulation as a valuable tool to assess competency.

Thirty-three nurses were divided into two groups to compare the effectiveness of HFS with traditional static mannequins as a teaching strategy for pediatric staff nurse education. Results indicated that knowledge retention was maintained, skill performance was improved, and teamwork performance scores were increased in the experimental group, which indicated that the use of HFS was an effective teaching modality when educating pediatric staff nurses in the identification and intervention of the deteriorating pediatric patient.[23]

There are several advantages and many positive outcomes in using simulations for continuing nursing education. Although nurses are expected to acquire new clinical knowledge through experience and independent study, health care institutions have struggled with providing quality patient care and supporting nurses' learning through experience at the same time. HFS-based learning addresses this need by providing no-risk experiential learning that expands skills without jeopardizing patient safety.

However, a systematic review by Yuan et al.[24] indicated a mixed contribution of HFS to confidence and competency with a lack of high-quality random control trials and large sample sizes. There are also some limitations in the evaluation of simulation as an education intervention. The instruments in which the researchers selected have been typically used for traditional clinical assessments but not specifically designed for HFS. It is necessary to call for the development of evaluation tools designed specifically for an HFS.

In addition, it is a challenge for nurse educators to implement teaching strategies that promote learners' confidence and clinical competency. The use of HFS requires strategic planning. It should be a concern about whether learning is occurring under the right conditions.

Nurse educators should acquire the knowledge and skills needed to use this education strategy, develop realistic case scenarios, and design and validate standardized and reliable testing methods. Although the effectiveness of HFS was reported in reviewed studies, it was not always measured in a clinical setting. The student may perceive an increase in confidence because of being in a controlled, supervised setting where he or she can do no harm. Perhaps, the increase in confidence and competence is not realized until the student experiences a real situation like the one in the simulation. Further research needs to be conducted to examine the transferability of the simulation experience into real clinical situations.

2.2. HFS in nursing education in China

The HFS is still in its infancy in China. The existing researches mostly focus on its application and effect in higher vocational college and undergraduate nursing education.

Pu et al.[25] compared the effect of application between clinical recess trainee and HFS teaching method. They divided 194 higher vocational nursing students into experiment group and control group: the experiment group accepted HFS teaching method while the control group accepted traditional teaching method. After four classes, the students in the experiment group had higher score in learning and communication ability as well as self-confidence. Tian[26] used HFS model in the course of internal medicine nursing for higher vocational students. Based on the characteristics of internal medicine nursing and the teaching materials and teaching outline, the representative cases and simulation scenarios were prepared and the students were told about the scenarios and related questions that they would need to simulate and prepare. After completing the corresponding nursing tasks according to the assigned characters in the simulation scenarios, the students reflected and summarized the implementation of the simulated operation under the teacher's organization. The result proved that, using HFS for classroom teaching inspires students' interest in learning, their learning efficiency and the ability of logical thinking and comprehensive application of knowledge were also improved. Wen[27] provided evidence-based nursing study materials for nursing students in higher vocational colleges and tried to carry out evidence-based nursing practice with HFS. The results showed that the practical training program based on the HFS was an effective carrier for the introduction of evidence-based nursing, and action-oriented teaching was an effective way to obtain the evidence ability.

In the study of undergraduate nursing students, Liu and Chen[28] used methods of phenomenological study

of qualitative research to conduct in-depth interviews among four focus groups: 28 nursing undergraduate students. The result showed that HFS training was beneficial to integrate theory with practice, cultivate students' comprehensive ability, and increase clinical practical opportunities.

Gu[29] selected 23 undergraduate nursing students to participate in HFS education, then used questionnaire to investigate their attitudes toward HFS and the confidence and satisfaction. The results showed that the students held a relatively positive attitudes toward HFS, their learning satisfaction and self-confidence were high, and their knowledge level was significantly improved.

Li et al.[30] used concept map and HFS in the nursing plan and implementation to 62 nursing undergraduate students. This specialty course helped students understand theoretical knowledge, enhance teaching outcomes of simulation teaching, and promote teaching.

In recent years, HFS has also been proved to be effective in in-service training for clinical nurses.

In 2015, Du et al.[31] investigated 39 newly recruited nurses to evaluate the effects of HFS teaching method on the clinical decision-making ability and critical thinking ability of new nurses. They used HFS teaching method in pre-job training. After the training, the HFS teaching method was proved to be a useful tool in pre-job training to improve the clinical decision-making ability and critical thinking ability of new nurses.

Wang et al.[32] used the teaching method that integrated the lectures, practice, simulation, and feedback together, with the application of first-aid simulation robot and typical clinical cases, to cultivate the defibrillation for 384 clinical nurses. They gave pretest and posttest to the nurses, and the result showed that the HFS was beneficial for the clinical nurses to improve their confidence to cope with the emergency clinical situations such as defibrillation and first aid.

From the abovementioned literature, it can be seen that HFS is gradually being used in nursing education in China. The application mainly focuses on higher vocational and undergraduate nursing education. In recent years, it has been gradually applied to nurse training, and the research focuses on the effectiveness of HFS applications. From the result of the researches, the use of HFS in nursing education has positive effects on the study effect of higher vocational students and undergraduates: their critical thinking, learning satisfaction, and self-efficacy are all improved. Meanwhile, when nurses are trained with HFS, their critical thinking and decision-making ability are also improved. Compared with researches abroad, there are fewer applications in continuing education and career education, and the existing researches are mostly compared with traditional teaching methods, instead of other teaching methods such as problem-based learning (PBL) method or think aloud approach which has already been proved to be an effective tool in nursing education. In addition, domestic research mainly used self-designed questionnaire, which might lack reliability and validity.

3. The application of HFS to improve clinical reasoning in nursing education abroad

3.1. The teaching methods of clinical reasoning in nursing education

Effective clinical reasoning skills are found to be positively correlated with patient outcomes. To enhance students' ability of thinking and nursing practice, the training of students in clinical reasoning is considered to be necessary and nursing education scholars have made some explorations in the development of teaching methods of clinical reasoning. Those methods and approaches include the following: questioning, team-based learning (TBL), web-based unfolding cases, and self-explanation.

Lim[33] suggested that clinical teachers using focused questions to help students think about what they are doing. Using think effective questioning and responding to questions are specific teaching methods to enhance student learning. Asking those questions during pre-conference, during the course of the clinical day, or on post-conference is one way to promote clinical reasoning.

Ryan et al.[34] proved that an online "clinical reasoning guide" was effective for assisting integration of PBL method in the clinical setting and promoting further development of students' clinical reasoning abilities in 2004. However, Okubo et al.[35], researchers from Japan, made another point that students who underwent PBL still had difficulty in acquiring clinical reasoning skills. In their research, students found that TBL was effective, particularly in the areas of problem-solving by both individuals and teams and feedback from specialists. In conclusion, TBL for clinical reasoning is useful in improving clinical reasoning ability in students with PBL experiences with limited clinical exposure.

Johnson and Flagler[36] used web-based unfolding cases as a strategy to foster the development of clinical reasoning skills and evaluate students' performance in cognitive arena. The student's comparison of the desired and submitted responses provides information to enhance the development of clinical reasoning skills.

Chamberland and Mamede[37] studied the use of self-explanation as a strategy to foster clinical reasoning.

Self-explanation is a positive learning technique, which is an effective method for students to explain information about learning materials to themselves. Studies available have demonstrated that students' diagnostic performance improved when they used self-explanation while solving clinical problems of a less familiar clinical topic.

3.2. The application of HFS to improve clinical reasoning in nursing education abroad

In 1969, when Denson and Abrahamson used Sim One to supplement the training of anesthetists, which is the first available documented evidence of the use of human patient simulation manikins in clinical education.[38] Since then, various human patient simulation manikins have been developed and are broadly classified into three categories based on the level of fidelity: low, medium, or high.[39] It has been an important part of nursing education to develop HFS that prepares nursing students to improve clinical reasoning ability.

Benner suggested that moving education from an emphasis on critical thinking to an emphasis on clinical reasoning could be achieved by integrating the use of high-fidelity patient simulation in a pediatric curriculum.[40] Lapkin et al.'s[41] systematic review found evidence suggesting that the use of simulation mannequins significantly improved three outcomes integral to clinical reasoning: knowledge acquisition, critical thinking, and the ability to identify deteriorating patients.

As nurses should make decisions under conditions of uncertainty and risk, they will need to perform complex problem-solving within a dynamic and changing environment for which there is no one clear solution.[17,42] A safe environment can be provided by HFS. To compare undergraduate nursing students' perceptions of learning in HFS and clinical placement during a critical care course, Brien et al.[43] had 314 students completed questionnaires and 23 focus groups were held. They found that both HFS and clinical placement contributed to student learning in similar and different ways. HFS is a good complement to clinical placement. A serious game to improve nurses' clinical reasoning and detection skills in home care and community settings has been developed by Petit et al.[44] Serious gaming is understood in this article to include the following: HFS, learning, and game. The first phase of this project includes the development of a scenario, the game engine, and the graphic design, and the serious games have been proved to become an important tool offering a safe, consistent, and efficient learning experience for health care professionals.

HFS has also been proved to be effective in clinical reasoning courses. Researchers from Yonsei University, Korea, have performed a research in which 49 nursing students have been divided into two groups: the experimental group consisting of the students who took the "clinical reasoning" course which was led by HFS, while the control group was made up of students who did not. The result showed that there was a significant improvement in nursing core competencies in the experimental group, which means that the HFS is an effective instructional method to improve clinical reasoning ability in nursing education.[45] Researchers from Capella University explored Bachelor of Science in Nursing (BSN) students' insights on the development of clinical reasoning skills through HFS and interactive case studies; the students perceived the use of HFS to increase their clinical reasoning skills.[46]

HFS is also used in the study of clinical reasoning with other teaching methods. Think aloud, a strategy in which subjects are instructed to verbalize thoughts as they occur while completing an assigned task, was integrated into a study of clinical reasoning during high-fidelity patient simulation by baccalaureate nursing students, Burbach et al.[47] considered that Think-Aloud Strategies (TA) provides a rich source of data regarding clinical reasoning as experienced by the baccalaureate nursing student during high-fidelity patient simulation. Calleja et al.[48] divided 669 third-year nursing students into two groups: think aloud as a strategy within the simulation was used in group 1; group 2 was not given a specific strategy outside of nursing assessment frameworks. The researchers aimed to use the "think aloud" strategy within a simulation context to assist the students to uncover cognitive approaches that best assist them to make effective patient care decisions and improve their confidence, clinical reasoning, and active critical reflection on their practice. After the project, it can be proved that the exploration of alternative strategies to improve critical thinking skills and develop clinical reasoning and problem-solving for nursing students is imperative. Hur and Song[49] from Korea designed a simulation-based clinical reasoning education consisting of seven weekly, 120-minute HFSs. They had 47 students participated. All the participants completed the pretest and 7-week post-measurements of a clinical judgment, collaboration, and communication skills with 4-week post-measurement of collaboration, and 17 participants in the experimental group provided a measurement of perceived education practices and simulation design characteristics. The experimental group had been significantly improved for clinical judgment, collaboration, communication skill, and perceived education practices and simulation design characteristics. The results showed the impact of simulation design characteristics facilitating the effectiveness of simulation education, and they suggested a feasible and sound teaching method for student nurses.

To evaluate students' critical reasoning ability, some instruments have been developed and used to measure this ability. However, few have focused on clinical reasoning for the nursing profession. The Watson Glaser Critical Thinking Appraisal and the California Critical Thinking Skills Test are the most well-known instruments used to evaluate nurses' critical thinking. Criticism of these tools includes their general measure of critical thinking rather than clinical reasoning and they are not developed for nursing. The Lasater Clinical Judgment Rubric (LCJR) has been developed as a tool to evaluate nursing students' clinical reasoning during simulated patient care scenarios.[7] According to Jensen's[50] research, students may be able to use the LCJR to explore and assess their clinical reasoning development, reflecting on their actions and thoughts during simulated or actual patient care, so the LCJR can help identify those students who require additional remediation prior to graduation.

Kuiper et al.[51] described the Outcome Present State Test Model of clinical reasoning following high-fidelity patient simulation to teach students how to solve clinical problems. Though they considered it challenge faculty to create and manage patient simulation scenarios that coordinate with didactic content and clinical experiences to direct student learning for the best reinforcement of clinical reasoning outcomes, the use of HFS in the current educational environment has obvious short-term benefits. It can be taken as part of student evaluation and curriculum development.

Although there are still some reported issues when using HFS, it would be less useful than actual clinical placements to do nursing education, because of the lack of face-to-face contact. The abovementioned researches show that the HFS can help students develop clinical reasoning skills in a safe environment; it is also an effective way to teach clinical reasoning. The use of HFS significantly improves three outcomes integral to clinical reasoning: knowledge acquisition, critical thinking, and the ability to identify deteriorating patients. The results of these studies prove the effectiveness of the use of HFS to teach clinical reasoning skills to both nursing students and nurses.

4. Clinical reasoning in nursing education in China

In China, some nursing colleges such as School of Nursing in Hong Kong Polytechnic University, School of Nursing in Sichuan University have set up clinical reasoning courses for undergraduates, but until now, the research is mainly carried out in colleges and focused on the curriculum construction rather than on

clinical nurses' clinical reasoning abilities. Nevertheless, clinical practice is an important way to improve the clinical reasoning ability. Therefore the aims were to explore the cultivation process of clinical reasoning in the clinical environment as well as the clinical teacher's influence on the students' clinical reasoning abilities. The limited literature in clinical reasoning in nursing education in China mainly focuses on the teaching method of clinical reasoning.

Wang et al.[52] found that the PBL teaching method is an effective teaching method and conforms to the modern concept of teaching methods. In the nursing clinical reasoning and decision-making course, the PBL teaching method can help students expand their knowledge and improve their reasoning and decision-making ability. In addition, it has a higher requirement for both the teachers and students to use PBL teaching method. When implementing PBL teaching method, the teacher is more flexible by considering the specific situation of the students, so as to ensure the maximization of the effect of PBL teaching method.[52]

According to Li and Zhu's[53] research, "think aloud approach" simulated the real scene of nurses in the face of the patients and made students analyze and solve the possible problems in clinical practice in the classroom, which can facilitate the smooth adaptation of nursing students to the clinical practice. When the teacher was teaching the professional knowledge, the teacher can also teach their students some thinking strategies and demonstrate how to use these strategies in clinical practice. Through the analysis of the similar case offered by the teacher, the students can absorb and internalize the thinking strategies. When they face the similar situations, they can apply this reasoning method to care for their patients consciously.

Clinical research shows that the evidence-based nursing education truly helps to cultivate students' nursing concept on the basis of empirical evidence. The graduate nursing students improve their ability of doing nursing research, thus making students improve their professional knowledge and clinical reasoning ability.[54]

As the first nursing school that offers the course of nursing clinical reasoning in the mainland of China, the researchers from the School of Nursing, Sichuan University, found that this course has certain effects on improving the critical thinking ability of nursing undergraduates, mainly because clinical reasoning is relevant in decision-making and critical thinking ability.[55]

The first affiliated hospital of Zhengzhou University has established a dual-process model teaching group including five experienced teachers and 20 nursing postgraduates, receiving clinical reasoning training including analytic systematic training, intuition system training, comprehensive scenario simulation, and

clinical practice. After training, based on dual-process model, nursing postgraduates' clinical reasoning course is proved to be beneficial to improve nursing postgraduates' critical thinking ability and their satisfaction with the teaching.[56]

It can be concluded that, currently, only a few universities in China have conducted clinical reasoning teaching. Compared with the studies abroad, the researches mostly focus on the teaching methods of clinical reasoning in undergraduate nursing education. Currently, relevant postgraduate teaching, continuing education, and on-the-job education are rarely involved. There are few studies on the application of HFS to clinical reasoning in nursing education in Chinese colleges.

5. Conclusions

Studies have shown that the application of HFS to nursing education can simulate the clinical situation, thus to create a safe, continuous, and efficient learning environment for students, and it can effectively improve students' clinical reasoning ability. In particular, students' theoretical knowledge and nursing skills as well as test scores and the clinical competence can be improved. Meanwhile, the HFS is effective to enhance students' learning interest and initiative, the comprehensive application ability of knowledge, theory and practice, and teamwork spirit and reduce the pre-internship tension. HFS has also been used in the evaluation of clinical reasoning in nursing education.

Without doubt, HFS has its irreplaceable value in the field of clinical reasoning.

In China, although the HFS has become increasingly popular in nursing education, such as in higher vocational college and undergraduate nursing education, clinical nurse training, etc., according to its own characteristics, it also has some limitations in nursing clinical reasoning courses: first, the cost of the investment for HFS is expensive; second, higher requirements have been put forward for teachers; it requires teachers not only to have a solid theoretical foundation but also to have rich clinical experience and clear clinical thinking.[57] At the same time, the HFS also raises higher requirements for students; besides the theoretical knowledge and methods of practice, the students should have a strong clinical thinking and problem-solving ability. If HFS is applied to the clinical reasoning in nursing education, the curriculum framework and time will be adjusted. Therefore, how to integrate the HFS into the curriculum system in the most effective way is one of the difficulties in the promotion of clinical reasoning in nursing education.

However, in view of a large number of studies abroad, HFS is effective for clinical reasoning teaching in nursing education. The extension of its application in China should be of great value. The relevant further study is suggested focusing on how to overcome its own limitations and have it better applied in nursing education in China.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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