The Impact of Case-Based Education on the Development of Nursing Students' Clinical Reasoning Skills in Managing Critical Illnesses: A Pilot Randomized Controlled Trial

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Abstract

Background: Nursing students require the development of clinical reasoning (CR) skills to deliver safe and effective care.

Aim: This study aimed to determine the effect of case-based education on the development of CR skills among nursing students in managing critical illnesses.

Methods: The study was conducted from January 20 to June 30, 2021, utilizing a pilot randomized controlled trial design. Twenty-two volunteer students were assigned to either the experimental or control groups through simple randomization. Data were collected using a Student Information Form, the Clinical Reasoning Case Form (CRCF), the Student Satisfaction with Education Questionnaire, and a Form for Views on Education. The data were analyzed using frequency values, Fisher's exact test, paired/independent samples t-test, Cohen's d coefficient for effect size, intention-to-treat (ITT) analysis, and covariance analysis.

Results: The intervention and control groups were similar in terms of descriptive characteristics (P>0.05), and no significant difference was found between the groups in the pretest scores of the CRCF (P=0.351). In the intervention group, the posttest CR scores significantly increased following the education (P=0.015) with a large effect size [d=0.88 (-1.72-0.02)]. ITT analysis was conducted as one student from the control group did not complete the posttest. The results of the per-protocol and ITT analyses were similar. According to covariance analysis, the pretest scores did not affect posttest scores (P=0.155, η2=0.109). This study was registered on ClinicalTrials.gov with the number NCT05504824.

Conclusion: Case-based education was found to be effective in enhancing the CR skills of nursing students in critical illnesses.

Keywords: Case-based education, clinical reasoning, critical illness, nursing

Introduction

Critical illnesses develop acutely, require urgent intervention, exhibit life-threatening changes in vital signs, and lead to one or more organ/system failures.[1] They are associated with a high mortality rate since they affect one or more systems in the body.[2] Clinical symptoms in patients often do not appear clearly. Humans are complex, and health and sickness statuses are influenced by both internal and external factors. Nurses must consider these factors, identify early warning signs, utilize evidence-based knowledge, and then prioritize nursing actions.[3,4]

The recognition of early warning signs indicating a worsening of the disease process in critically ill patients is crucial in preventing the development of potential undesirable outcomes. Clinical reasoning, first developed by Groves et al,[5] and utilized at the Mayne School of Medicine, University of Queensland, Australia, is conceptualized by Tanner[6] as the process through which nurses make clinical judgments by choosing among alternatives, weighing evidence, using intuition, and recognizing patterns. There are five appropriate steps in improving the clinical reasoning skills of students and/or clinical nurses.[7] These steps include the process by which nurses or other health professionals collect clues, process information, identify a patient problem or condition, plan and implement interventions, and evaluate and reflect on outcomes.[7]

Case-based learning is a cognitive instructional/educational approach that promotes the clinical reasoning approach and provides nursing students with the capability to evaluate it.[3]

It is far more essential to teach students how to think about clinical cases than to teach medical knowledge. Inexperienced students often cannot synthesize the clinical features presented in the cases into meaningful clusters, leading to poorly organized clinical reasoning styles. They typically reason by testing one symptom at a time. In contrast, experienced nurses make diagnoses by clustering key clinical features, comparing and organizing them, and reasoning in order of priority.[8]

Teaching strategies to develop clinical reasoning skills in the classroom environment include collaborative learning activities, focused thinking, concept mapping, case studies, and role-playing.[3] Most nursing students learn clinical reasoning skills more effectively during clinical rotations, which vary in the quality of supervision. However, the disruption of the clinical practice process due to the Coronavirus Disease 2019 (COVID-19) pandemic has negatively impacted students' abilities to observe clinical cases, recognize their problems, form hypotheses, solve problems, and learn from these processes. Competency in professional practice requires not only psychomotor and sensory skills but also complex thinking skills. Effective clinical reasoning skills are also key in preventing malpractice of unknown origin.[7] In this context, there is a need to develop clinical reasoning skills in nursing education to improve patient outcomes and nursing interventions for critical illnesses. While there are studies addressing the concept of clinical reasoning in the education of medical faculty students in Türkiye,[9-11] no studies addressing this issue have been found in nursing research. Therefore, this study was conducted to determine the effect of case-based education on the development of nursing students' clinical reasoning skills in critical illnesses. The results obtained from this study are anticipated to contribute to the evaluation of the effect of case-based education on the development of clinical reasoning skills in nursing students and will guide future case-based teaching/intervention studies.

Research Hypotheses

H_{0-a}: Case-based education given to nursing students has no effect on the development of clinical reasoning skills.

H_{0-b}: Case-based education given to nursing students has no effect on student satisfaction.

Materials and Methods

Research Design

This pilot randomized controlled trial with a pretest-posttest design was conducted between January 20 and June 30, 2021. The purpose of this pilot study was to evaluate the effectiveness of the concept of clinical reasoning, recently introduced in Türkiye, among a limited number of volunteer nursing students. The research was documented using the Consolidated Standards of Reporting Trials (CONSORT) 2010 checklist (Appendix A) and registered on ClinicalTrials.gov (NCT05504824). It took place in the Department of Nursing, Faculty of Nursing, Ankara University, a four-year educational institution. The study's population consisted of third-year spring semester students who had already completed courses in "Medical Nursing" and "Surgical Nursing," along with the basic medical sciences courses.

Sample of Study

The study population comprised third-year students (n=124) enrolled in the elective courses "Intensive Care Nursing" or "Oncology Nursing,"

which focus on nursing care for critical illnesses, during the spring semester of the 2020-2021 academic year at Ankara University, Faculty of Nursing. The inclusion criteria included completion of the "Medical Nursing" and "Surgical Nursing" courses, volunteering to participate in the study, and attendance at the "Case-Based Education" sessions. The exclusion criterion was dropping out of the educational intervention. The study included both intervention and control groups.

Randomization and Blinding

The purpose and scope of the study were explained to students enrolled in the elective courses "Intensive Care Nursing" or "Oncology Nursing." Consent was obtained from 22 volunteer students who met the inclusion criteria. These students were assigned to either the intervention or control groups through simple randomization. Following the administration of the pretest to all volunteers, students were assigned a number from 1 to 22 based on their nicknames in the student information form. Participants were then randomly assigned to groups using Excel software. The researcher became aware of the participants in the intervention and control groups during the education phase. Statistical blinding was maintained, as data entry and analysis were conducted by two independent researchers who were unaware of the group allocations of the students, identified only by their nicknames.

Dependent and Independent Variables

The dependent variables were the students' average scores on the Clinical Reasoning Case Form (CRCF) and the Student Satisfaction with Education scales. The independent variable in this study was the educational intervention.

Data Collection Tools

Student Information Form

This form contained nine questions covering students' nicknames, age, gender, duration of clinical experience, academic performance level, and perspectives on the nursing process.[3,6,7]

Clinical Reasoning Case Form

This research aimed to develop the first three steps of the clinical reasoning process.

(1) *Collecting Clues*: The process involves recalling or remembering information, such as the patient's medical history, complaints, physiological or pathophysiological knowledge, pharmacology, epidemiology, evidence-based practices, and ethical considerations.[7]

(2) *Processing the Information*: This step involves interpreting, distinguishing, inferring, monitoring, and predicting information. Information and symptoms are analyzed and interpreted by comparing them to normal or abnormal findings. Irrelevant information is distinguished from relevant information, and the collected clues are refined by identifying the most important information. Clues are integrated to uncover new insights and to understand their interrelations. Through the interpretation of both concrete and abstract clues, logical inferences are drawn, and hypotheses are formulated. Alternative outcomes are explored. The patient's current and previous conditions are monitored, and outcomes are predicted by consulting with one of the health professionals involved in case management.[7]

(3) *Identifying the Problem*: Inferences are synthesized to make a definitive diagnosis of the patient's issue.[7]

For the objectives of these three steps in students' clinical reasoning process, 10 clinical cases were prepared on the CRCF. These cases encompassed critical illnesses[1] and early warning signs indicative of deterioration in critical conditions, which are crucial for determining priority nursing diagnoses.[12] The cases covered a range of diagnoses, including dementia, cerebrovascular diseases, disseminated intravascular coagulation syndrome, pulmonary edema, diabetes mellitus, and septic shock. Early warning signs in the cases included systolic blood pressure of 80-100 mmHg, a Glasgow coma scale score of less than 9 to 11, hypoventilation, urine output of less than 200 ml in 8 hours, inadequate peripheral circulation, changes in mental status, reported pain, a pulse rate of 40-49/min, sudden chest pain, a blood glucose level of 8-52 mg/dL, excess fluid loss from drains, a PO_2 value of 50-60 mmHg, and forced expiration.[12] Each of the 10 cases featured 1-4 early warning signs, with four of these being utilized in case-based education sessions.

Student Satisfaction with Education Questionnaire

A questionnaire was developed by the researchers to assess students' satisfaction with the provided education.[3,7,8] It consisted of 15 statements, with the 10th item being negatively worded. Responses to each item on the questionnaire were scored on a scale from 1 to 6, where 1 indicates 'strongly disagree' and 6 'strongly agree.' According to this questionnaire, students' satisfaction levels with the education were interpreted based on the average score of each statement. A score approaching six indicated a high level of satisfaction.

Form for Views on the Education

The effectiveness of the education model was evaluated using a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). This analysis was based on data collected from students in the intervention group through an online questionnaire, post-education. The questionnaire, which did not require nicknames or personal information, consisted of four questions related to the strengths, weaknesses, perceived threats, and opportunities of the education model.

Preliminary Stage of the Research

Development of Clinical Reasoning Cases

Fictional case examples were utilized for CR cases. The development process of CR cases involved drafting the cases (1), obtaining expert opinion to ensure scope validity (2), identifying priority nursing diagnoses with input from the reference nurse group—comprising experienced experts in the field, and analyzing data to support or refute these diagnoses (3).[5,9]

1. **Drafting the Cases:** The cases were developed by researchers with professional clinical experience in the field of critical illness, ensuring realism. Each case detailed individual characteristics, disease risk factors, patient complaints, symptoms, laboratory findings, treatment, and critical/early warning signs to help identify nursing diagnoses.

   Case writing specifically focused on "early warning" signs that indicate a deterioration in critical illness, aiming to enhance students' ability to identify priority nursing problems through clinical reasoning. The criteria for early warning signs were based on those established by Jaques et al.[12] A total of 10 cases were written by the researchers. Six of these cases were used in the CRCF to assess students' clinical reasoning skills, while the remaining four were utilized during the education phase. Each clinical case was designed without a single correct answer, presenting varying levels of difficulty.

2. **Expert Opinion/Scope Validity:** Five faculty members, experts in the field of medical nursing with clinical experience, were consulted from February 15 to 28, 2021, to confirm the clinical accuracy, realism, and comprehensibility of the CR cases. These experts were asked to evaluate the CR cases based on specific criteria: Whether the cases were reflective of real-life clinical situations, whether they were complex or difficult enough to engage students in problem-solving, and whether they aligned with the educational competencies of third-year nursing students.

   Following the expert consultation, a content validity analysis of the cases was conducted by the researchers using the Davis technique. The cases were evaluated as "appropriate," "needs slight revision," "needs serious revision," or "inappropriate". With this technique, the content validity index (CVI) for each item was calculated by dividing the number of experts who rated the items as "appropriate" or "needs slight revision" by the total number of experts. A content validity index value of ≥ 0.80 was considered acceptable.[13] The content validity index for the expert opinions, evaluated using the Davis technique, was determined to be 1. Necessary revisions were made to the cases based on the recommendations.[13]

3. **Analysis of the Cases:** The case analysis was performed in three stages to establish the reference standards for evaluating student responses in the pretest and posttest applications of the CRCF.[9,10]

   a. *Determination of the Reference Nurse Group*: A group of "reference nurses" was formed from nurses with significant experience in their professional field. These nurses were selected from those who volunteered to participate in the study, possessed at least an undergraduate degree, were employed as clinical nurses in university or public hospitals, and had a minimum of two years of experience (n=15). In the study, five nurses evaluated each of two cases, resulting in a total of 15 nurses for six cases.

   b. *Sending the Cases to the Reference Nurse Group via Email*: CR cases were distributed to the reference nurse group by email. During this phase, reference nurses were instructed to identify two priority nursing diagnoses in the cases and the clinical findings that led to these diagnoses. For each clinical finding, nurses were asked to assess how it supported or did not support the nursing diagnosis [(+): supports, (-): does not support] and to rate its relevance or importance on a scale from 1 to 3. This analysis by the reference nurses took place between March 1 and 28, 2021.

   c. *Analysis of Case Reviews from the Reference Group*: The researchers analyzed the case evaluations provided by the reference nurse group. Nursing diagnoses identified most frequently as the top two by more than half of the group (three nurses and above) were recognized as "the most frequently determined nursing diagnosis." Diagnoses determined by less than half of the reference group, alongside each relevant clinical finding and its degree of importance, were assessed using the "CR Case Evaluation Guide" (Figure 1).[9,10] Based on this guide, the pretest and posttest scores of students from the CR cases were calculated in relation to the reference nurse responses.

I	For each diagnosis	Scoring
	'The most frequently identified nursing diagnosis/problem' (if written)	2 points
	Each 'Clinical finding of correct weight (CW) and direction' (if written)	3 points
	Each CW+/-1	2 points
	Each CW+/-2	1 point
	Each incorrect finding	-1 point
II	For each diagnosis determined by two or fewer reference nurses	Scoring
	For nursing diagnosis/problem	1 point
	For each finding, provided that its direction is correct (+/-)	1 point
	For each incorrect finding	-1 point
III	For each diagnosis that was not determined by reference nurses	0 points
IV	Total score	

Figure 1. Case Assessment Guidelines for CR.

The pretest and posttest CRCF results of the students were anonymized using aliases. At the conclusion of the research process, the pretest and posttest scores of students were independently reviewed by two researchers who were unaware of the students' group allocations. A consensus was reached by revising scores that were inconsistent. Consequently, the total score obtained by each student from the cases was finalized.

Implementation of the Study

Students in both the intervention and control groups completed the student information form and the CRCF pretest between May 18 and 20, 2021, before starting the educational intervention. Due to the COVID-19 pandemic, students were instructed to fill out the online data form independently, without consulting resources or interacting with other students. The schedule for the education intervention was arranged according to the convenience of the students in the intervention group, which took place from June 8 to 11, 2021. Meanwhile, students in the control group continued with their standard education process. Following the completion of the education sessions, the CRCF was administered as a posttest to both groups on June 28, 2021. Students in the intervention group were also asked to complete the Student Satisfaction with Education Questionnaire and the Form for Views on the Education online (Figure 2). All students were informed that the scores from clinical reasoning problems would not affect their official end-of-term assessments. Both the education intervention and the post-education assessments were conducted outside the
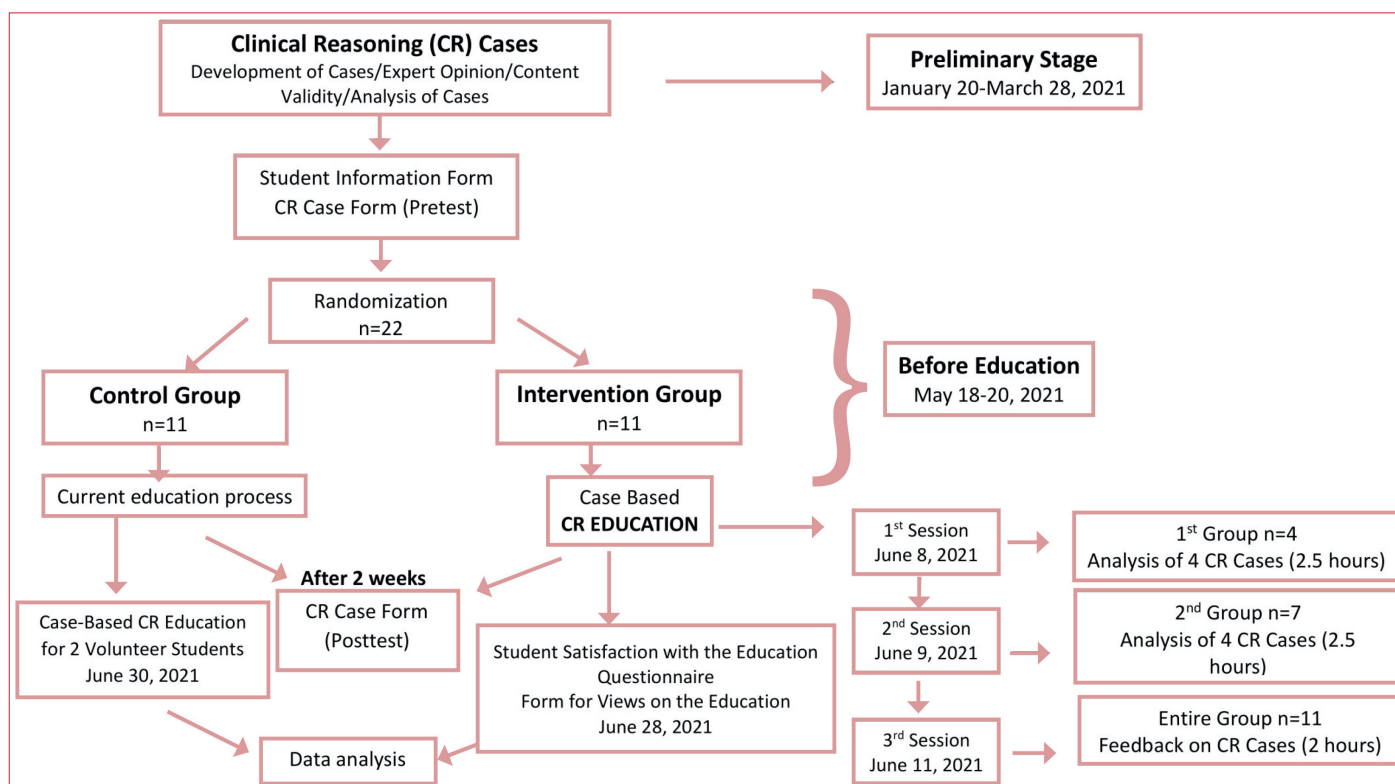

Figure 2. Flow chart of the study.

regular school schedule. Students who completed the research process received a scientific book as a reward.

The Education Phase

This phase encompassed the explanation of the CR process, analysis of CR cases, drafting of new cases by students suitable for the CR process, and the analysis thereof. One of the cases used in the education intervention is provided in Appendix B.

The education program was delivered via a web platform (Zoom), adapting to changes necessitated by the COVID-19 pandemic. To ensure students were prepared for the group discussions, the CR cases intended for case-based education were sent to the students via email before the group session. In case-based education, after reading the case, students were asked several questions to elucidate their decision-making and reasoning processes: 1) What is the priority nursing problem you have identified? 2) What are the clinical justifications for this problem? 3) At what level do clinical findings support or not support the problem? 4) What additional information would you need to learn to analyze the causes of the problem you have identified? 5) What laboratory findings would you need to know to identify and manage the priority problem you have identified, and why? 6) Is the medication's dosage and timing of administration adequate and appropriate for addressing the problem you have identified? and 7) Are the interventions applied to the patient adequate and appropriate for solving the identified problem? Additionally, the researchers sought to boost students' motivation by highlighting the aspects they interpreted and analyzed effectively. The educational program was completed over three sessions.

First Session

After a brief introduction to the purpose and scope of CR, four CR case studies focused on a critically ill case were conducted. This session took place on June 8, 2021, from 2 p.m. to 4:30 p.m. with four students, lasting 2.5 hours with sessions of 30 minutes each.

Second Session

This session was held on June 9, 2021, from 1 p.m. to 3:30 p.m. and involved the other seven students in the intervention group. Four CR cases were analyzed over 2.5 hours. Following the analysis, as a continuation of the second session, students were tasked to create their own CR cases within two days on predetermined topics (cerebral vascular event, congestive heart failure, lung cancer and chronic obstructive pulmonary disease). Each student was instructed to submit two CR cases, based on their selected topic, along with possible answers, to the educator via email.

Third Session

This session conducted by the researcher/educator on June 11, 2021, from 2 p.m. to 4 p.m. focused on analyzing the CR cases written by students and providing feedback. The educator offered suggestions for addressing any missing or incorrect points in these cases and how they could be rectified, enabling students to strengthen their CR process and conduct self-evaluations.

Two weeks after the educational intervention was completed, students in both the control and intervention groups were administered the CRCF as a posttest on June 28, 2021. Following the posttests, case-based CR education was provided to two volunteer students in the control group from 2 p.m. to 4 p.m. on June 30, 2021.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 21 was utilized to analyze the data obtained from the study and to generate tables. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to present the participants' descriptive characteristics, their views on the nursing process, and their satisfaction with the education provided. The Fisher Exact test and the Mann-Whitney U test were applied to analyze the similarity of the descriptive characteristics between students in the intervention and control groups. The Kolmogorov-Smirnov test, conducted to assess the mean scores of students on the pretest and posttest application of the CRCF, revealed that the scores followed a normal distribution. The paired samples t-test was employed for the intra-group comparison of the pretest and posttest scores of both the intervention and control groups on the CRCF, while the independent samples t-test was utilized for the inter-group comparison of scores. Cohen's d formula was applied to calculate the effect size in the analyses performed to identify the differences between the mean scores of the two groups. According to this, $d \leq 0.20$ was interpreted as indicating a weak effect, $0.20 < d < 0.80$ as a medium effect, and $d \geq 0.80$ as a large effect.[14] An Intention to Treat (ITT) analysis was conducted to mitigate dropout bias in the study. Covariance analysis was used to assess the impact of the pretest on the posttest scores. For this analysis, it was verified that the variances of the variables were homogeneous and that the regression coefficients were evenly distributed. For the SWOT analysis of the intervention group regarding education, the written data collected from the students were organized under a common theme and presented. A p-value of <0.05 was considered statistically significant for all analyses.

Ethical Approval

The study received ethical approval from Ankara University Non-Interventional Research Ethics Committee (Approval Number: 56786 525-050.04.04/100858, Date: 12.05.2021; Issue: 06/53). Informed consent was obtained from the students, along with the necessary institutional permissions. Additionally, permission was secured from the author of the clinical reasoning (CR) assessment guide for its use in the study.

Results

The analysis of the distribution of students in the intervention and control groups based on their descriptive characteristics revealed similar mean ages and mean durations of clinical experience. It was found that 72.7% of the students in the intervention group achieved a good level of success, compared to 54.5% in the control group. Students in both groups reported the most difficulty in the diagnosis stage of the nursing process, with 45.5% of the intervention group and 18.2% of the control group indicating they often encountered problems when determining priority nursing problems in critically ill patients. It was determined that there was no significant difference between the intervention and control groups in terms of their descriptive characteristics across all variables, indicating similarity between the groups (P>0.05) (Table 1).

The study found no difference in the pretest scores of the groups according to the per-protocol analysis (P>0.05). Although there was no difference between the groups' post-test scores (P=0.236), it was determined that the intervention's effect size was 0.54 [Confidence Interval (CI)=-0.36-1.38], which was not statistically significant as the 95% CI included 1. A paired samples t-test for intra-group comparison revealed no significant difference in the pretest and posttest scores of the control group

Table 1. Comparison of Students in Intervention and Control Groups by their Descriptive Characteristics

Descriptive Characteristics	Intervention Group		Control Group		Test
	n	%	n	%	
Gender					
Male	1	9.1	-	-	χ^2=1.048
Female	10	90.9	11	100	P= 1.000
High school					
Health vocational high school	1	9.1	-	-	χ^2=1.048
Anatolian/Science high school	10	90.9	11	100	P= 1.000
The level of school achievement					
Moderate	2	18.2	3	27.3	χ^2=0.819
Good	8	72.7	6	54.5	P= 0.664
Very good	1	9.1	2	18.2	
Difficulty in applying the nursing process					
Rarely	8	72.7	9	81.8	χ^2=0.259
Often	3	27.3	2	18.2	P= 1.000
Difficult stage in the nursing process					
Data collection	-	-	1	9.1	
Making a diagnosis	5	45.5	4	36.4	χ^2=1.778
Planning	2	18.2	1	9.1	P= 0.777
Application	3	27.3	3	27.3	
Assessment	1	9.1	2	18.2	
Difficulty in identifying the priority nursing problem in critically ill patients					
Never	1	9.1	2	18.2	χ^2=1.952
Rarely	5	45.5	7	63.6	P= 0.377
Often	5	45.5	2	18.2	
Mean age (year) $\bar{x} \pm$ S.D. (min-max)	21.18 $\pm$ 0.98 (20-23)		21.18 $\pm$ 0.87 (20-22)		U=59.000 P=0.917
Mean clinical experience (term) $\bar{x} \pm$ S.D. (min-max)	2.5 $\pm$ 0.50 (2-3)		3.00 $\pm$ 0.83 (2-5)		U=41.000 P=0.217

χ^2: Fisher's exact test
U: Mann-Whitney U test

(P=0.964). Conversely, a significant difference was observed in the CRCF scores from pretest to posttest within the intervention group; posttest scores increased significantly following the educational intervention (P=0.015), yielding a large effect size of 0.88 (CI=-1.72-0.02) (Table 2). Based on these results, the H_{0-a} hypothesis was rejected.

In the study, an ITT analysis was conducted to address dropout bias, as a student in the control group did not complete the posttest. For this purpose, the "group mean score" was assigned to the missing data, revealing no significant difference between the pretest and posttest scores of the control group (P>0.05). Additionally, there was no significant difference between the posttest scores of the intervention and control groups (P>0.05). The findings from the ITT and per-protocol analyses were found to be similar.

In the covariance analysis performed to assess the effect of the pretest on posttest outcomes, it was determined that the interaction between the group and the pretest yielded F=2.202 and P=0.155, indicating that the regression trends across groups were equal. Furthermore, Levene's test for equality of error variances resulted in a p-value of 0.434, confirming that the variances across groups were homogeneous. The analysis also revealed that total pretest scores accounted for 10% of the variance in posttest scores, with no significant impact on the education intervention (P=0.155) (Table 3).

The average satisfaction score with the education intervention among students in the intervention group was high, recorded at 5.70 ± 0.33 on a scale of 4 to 6 (Table 4). This result led to the rejection of the H_{0-b} hypothesis. The perspectives of students in the intervention group

Table 2. Intra- and inter-group Comparisons of the Pretest and Posttest CRCF Scores of Intervention and Control Groups

Groups	Pretest Score		Posttest Score		Test*	Effect Size Cohen's d (%95 CI)
	n	$\bar{x} \pm$S.S.	n	$\bar{x} \pm$S.S.		
Intervention group	11	40.63 $\pm$ 16.77	11	62.18 $\pm$ 30.21	t=-2.916 **P=0.015^**	0.88 (-1.72-0.02)
Control group	11	47.63 $\pm$ 17.62	10	48.50 $\pm$ 19.13	t=-0.047 P=0.964	
Test**	t=-0.954 P=0.351		t=1.225 P=0.236			
Effect size Cohen's d (%95 CI)			0.54 (-0.36-1.38)			

*Paired samples t-test, ** Independent samples t test, CI=Confidence interval, ^ p<0.05

Table 3. Comparison of the pretest and posttest CRCF scores of intervention and control groups with one-factor analysis of covariance (ANCOVA)

Dependent Variable	Posttest CRCF Score					
Source	Sum of Squares	df	Mean Square	F	p	Eta Square (η2)
Corrected model	2334.610ª	2	1167.305	1.898	0.179	0.174
Intercept	2848.151	1	2848.151	4.631	0.045	0.205
Pretest CRCF score	1354.079	1	1354.079	2.202	0.155	0.109
Group	1543.737	1	1543.737	2.510	0.131	0.122
Error	11070.057	18	615.003			
Total	78479.000	21				

ª:R Square:0.174

regarding the education program were assessed using a SWOT analysis. This analysis categorized student feedback into three themes including student, instructor, and materials/technique. The findings indicated that students perceived the education program as enhancing their ability to identify priority nursing problems, critical thinking skills, and knowledge retention, while eliminating rote learning, fostering quick thinking, and reducing intervention time and workload. However, the online delivery of the program and the consequent absence of simulation techniques were identified as weaknesses. Additionally, students expressed concern that online education might increase the number of passive learners, particularly in accurate case analysis, if there is insufficient knowledge about the disease and its treatment (Figure 3).

Discussion

Graduate nurses must develop critical thinking and clinical reasoning skills to deliver safe and effective care, alongside possessing adequate knowledge and clinical psychomotor skills. Reasoning involves thought processes, organization of ideas, and exploration of experiences to formulate conclusions.[15] Developing clinical reasoning skills is crucial for making informed decisions, enhancing patient safety, and improving the quality of care.[16] Recent nursing education curricula aim to bolster clinical reasoning competency through various strategies, including simulation-based, case and problem-based, and mobile device-based learning.[17-19] However, there are studies in the literature that indicate that the clinical reasoning abilities of nursing students are often limited.[20,21] For instance, research focusing on

the clinical reasoning, judgment, and safe drug therapy management practices of senior nursing students found that students struggled to apply theoretical knowledge in practice.[20] Another study reviewing the clinical reasoning practices of nurses in safe drug management revealed inadequate use of clinical reasoning in 10 out of the 11 studies reviewed.[21]

Nursing students' diagnostic reasoning skills are enhanced through intensive clinical education and laboratory practices.[22] Case-based learning, a student-centered method, facilitates learning by utilizing case studies[23] and is effective in increasing nursing students' abilities to analyze complex clinical data and evaluate health.[24,25] It also supports students' learning through interaction with one another and the acquisition of diverse ideas.[23]

Case-based education enables students to identify problems, prioritize, and plan appropriate interventions before encountering patients.[26] One study evaluated the impact of an educational intervention on virtual clinical simulation and problem-based learning using a mobile application. The study employed a case-based educational approach to assess the reasoning skills of second-year nursing students before and after the educational intervention. A statistically significant difference was found between the pre- and post-test scores of the students who participated in the intervention.[19] In our study, it was determined that the case-based CR education significantly increased the clinical reasoning scores of the students in the intervention group, and the education had a large effect size.

Table 4. Distribution of the Scores of the Intervention Group on the Student Satisfaction with the Education Questionnaire (N=11)

Items of the Questionnaire	x̄ ± S.D. (min-max)
1. I have a good understanding of the concepts/principles of clinical reasoning.	5.54 ± 0.68 (4-6)
2. The education model can be easily understood.	5.81 ± 0.40 (5-6)
3. The education model provides a multifaceted perspective.	6.00 ± 0.00 (6-6)
4. The education model reduces the possibility of making mistakes in making a priority nursing diagnosis.	5.81 ± 0.40 (5-6)
5. The quantity of material used in education was adequate.	4.80 ± 1.16 (3-6)
6. The difficulty level of the cases analyzed in the education was appropriate.	5.36 ± 0.67 (4-6)
7. The clinical reasoning case writing approach helped me improve my clinical reasoning skills.	5.81 ± 0.40 (5-6)
8. Cases prepared for clinical reasoning problems were useful for improving my clinical reasoning skills.	5.90 ± 0.30 (5-6)
9. Clinical reasoning problems helped improve my ability to identify priority nursing problems.	6.00 ± 0.00 (6-6)
10. Attending a course to develop clinical reasoning skills would be a waste of time in the nursing curriculum.	1.09 ± 0.30 (1-2)
11. This education model made me think about the justification for my decision.	5.45 ± 0.68 (4-6)
12. This education model can be easily applied to the cases that I will encounter in the clinic.	5.72 ± 0.46 (5-6)
13. This education model reduces the loss of time while I am determining the priority nursing diagnosis.	5.90 ± 0.30 (5-6)
14. I would like to learn system-specific diseases with this education model.	5.63 ± 2.67 (4-6)
15. Participation in this education model made me feel good.	5.90 ± 0.30 (5-6)

In a study on the effectiveness of case-based teaching, it was found that students not only understood the course content more deeply but also were able to transfer the acquired knowledge to practical settings. This teaching method enhanced their critical thinking skills and piqued their interest in problem-solving.[23] In our study, the students in the intervention group who received education reported high levels of satisfaction with the education provided. They identified the small number of students in the education program as a strength.

STRENGTHS
- The low number of people receiving the education
- Providing an interaction discussion environment
- Increasing the ability to identify the priority nursing problem
- Gaining knowledge and skills to recognize and analyze symptoms
- Increasing critical thinking skills
- Increasing the permanence of acquired knowledge
- Provision of the education program by educators who are competent in their professional field

WEAKNESSES
- Provision of education via online system
- Provision of education mainly theoretically, and lack of simulation technique
- Provision of education on a limited number of diseases
- The long duration of case discussions
- The short duration of education

OPPORTUNITIES
- Directing people to search for information and analyze the data obtained
- Making it possible to identify the priority problem with the right case analysis method
- Eliminating rote learning
- Making it possible to handle the patient multidimensionally with a holistic perspective
- Developing quick thinking skills
- Gaining the ability to respond quickly to the problem
- Reducing the workload with rapid response to the problem

THREATS
- The confusion caused by the presence of too many supportive/ unsupportive signs and symptoms related to the disease during the analysis
- The negative effect of students' lack of knowledge about the disease and its treatment on CR practice
- The likelihood that the implementation of education online can increase the number of students who will be passive.

Figure 3. SWOT analysis results of the intervention group regarding the education model (N=11).

They reported that the program steered them away from rote learning and encouraged them to seek information actively. It was also noted that the program increased their critical thinking skills, supported a holistic approach to patient care, and enhanced their awareness of symptoms and their ability to prioritize problems.

Several factors should be considered when evaluating the effectiveness of clinical reasoning skills. These include student characteristics, such as the number of students, their readiness for education, school year, and clinical experience; the learning environment, which encompasses the classroom environment, teaching techniques used, allocated time for applying the curriculum, cooperation with clinics, the physical space, and the availability of adequate hardware or software; and the qualities of educators, including the student/educator ratio, their ability to encourage critical thinking, their awareness of clinical reasoning, and their professional and clinical experience.[27-30] In current study, factors affecting clinical reasoning skills identified by students in the SWOT analysis, such as the learning environment, educators' competency, and students' level of knowledge and skills in case discussions, were emphasized. Specifically, the weaknesses of the educational approach were highlighted, including issues such as delivering training online, the need for better support through simulation in case studies, broadening the range of diseases covered, extending the duration of case discussions, and the brevity of the training period. In this context, to enhance the training's effectiveness on students' clinical reasoning skills, it is recommended to conduct the training in-person, transition case studies to digital platforms supplemented with visual and video aids, and integrate case analyses into the curriculum following the exposition of diseases related to each system. Regarding the strengths of the training, students reported an enhancement in their ability to identify primary problems in cases, as well as in their critical thinking and symptom analysis skills. Indeed, in the studies conducted by Burucu and Arslan,[31] it was found that case-based education bolstered the critical thinking abilities of nursing students, leading them to adopt a more holistic approach to patient care.

Limitations

The study have several limitations. Firstly, its results may not be broadly applicable beyond the student population at the institution where the research was conducted. Secondly, the educational program was delivered online due to the pandemic. For future studies, it is recommended that the program be offered face-to-face, as this could increase the effectiveness of the education. Thirdly, since this was a pilot study, it was conducted with a limited number of students. Based on the findings from the pilot study, the sample size for future studies can be calculated using G*power analysis.

Conclusion

The study found that case-based education enhances the clinical reasoning skills of nursing students in managing critical illnesses, demonstrating a considerable impact. High levels of student satisfaction were also reported. Moreover, students identified realistic and key aspects in their SWOT analysis of the education model. The strength of the training lies in its emphasis on solving nursing problems and enhancing critical thinking skills, while its weakness is attributed to being conducted online without the support of visual or audio simulations. In this light, it is believed that the study's outcomes will inform the development of educational models for inclusion in nursing curricula. It is suggested that the efficacy of this teaching method be assessed in nursing students across various educational levels and cultural backgrounds.

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Appendix A

CONSORT 2010 Flow Diagram

Enrollment

Assessed for eligibility (n=124)

Excluded (n=102)
- Not meeting inclusion criteria (n=0)
- Declined to participate (n=102)

Randomized (n=22)

Allocation

Allocated to intervention (n=11)
- Received allocated intervention (n= 11)
- Did not receive allocated intervention (give reasons) (n=0)

Allocated to control (n=11)
- Received allocated intervention (n=11)
- Did not receive allocated intervention (give reasons) (n=0)

Follow-Up

Lost to follow-up (give reasons) (n=0)

Discontinued intervention (give reasons) (n=0)

Lost to follow-up (give reasons) (n= 1)

Discontinued intervention (give reasons) (n=0)

Analysis

Analysed (n=11)
- Excluded from analysis (give reasons) (n= 0)

Analysed (n= 10)
- Excluded from analysis (give reasons) (n=0)

Appendix B

A 67-year-old female patient was admitted to the neurology outpatient clinic with right facial paralysis and right hemiplegia. The finding of the patient's cerebrospinal fluid (CSF) analysis is 260 mmH$_2$O and blood pressure is 240/140 mmHg. The patient has projectile vomiting. When the level of her consciousness was evaluated, it was determined that the Glasgow Coma Scale score was 7. Despite antihypertensive treatment, her blood pressure cannot be lowered. The level of consciousness tends to decrease, and she has hypoventilation. A herniation in the foramen magnum was detected in the Computed Tomography taken thereupon. The evaluation of her history indicated that she had been diagnosed with hypertension for 12 years and Diabetes Mellitus for 20 years, had entered menopause at the age of 53, and had been using oral contraceptives for 5 years. Her BMI (Body Mass Index) is 21, and her HbA1c is 8.3%.

1. What is the priority nursing diagnosis for this patient? _____
2. List the characteristics of the case that you think support (+) or do not support (-) this diagnosis and score each one between 1 and 3.

Characteristics	(+) supports (-) does not support	Scoring **1:** somewhat supports / does not support **2:** supports moderately / does not support **3:** supports a lot / does not support

3. If the above nursing diagnosis is not correct, what would be your next priority nursing diagnosis? _____
4. List the characteristics of the case that you think support (+) or do not support (-) this diagnosis and score each one between 1 and 3.

Characteristics	(+) supports (-) does not support	Scoring **1:** somewhat supports / does not support **2:** supports moderately / does not support **3:** supports a lot / does not support