Original Article

Simulation-based Clinical Education Versus Early Clinical Exposure for Developing Clinical Skills in Respiratory Care Students

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Abstract

Background: Early clinical exposure (ECE) has been shown to improve clinical skills, but several factors limit its implementation.

Objective: To compare the use of simulation-based education (SCE) and ECE in improving respiratory care students' clinical skills in laboratory settings.

Methodology: This experimental prospective study was conducted among respiratory care students at Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia. Students from one batch were allocated to the ECE group, and students from another batch were allocated to the SCE group to concurrently undergo clinical training. On completion of the course, students completed the Clinical Learning Environment Inventory (CLEI), and their clinical practice course grades were evaluated.

Results: A total of 72 students from the two batches completed the CLEI and clinical performance evaluation; 32 (45%) were female. The mean age was similar across both groups. Between the groups, there was no statistical difference in the mean clinical grade (95% CI) (ECE: 167.29 [164.74–169.84], SCE: 166.88 [164.12–169.65]; $P = 0.837$) and the CLEI score (ECE: 128.25 ± 3.9, SCE: 123.08 ± 4.2; $P = 0.381$). Multivariable linear regression analyses revealed no significant difference in the clinical performance grades ($\beta = -0.09$; 95% CI: −0.78–0.59; $P = 0.788$).

Conclusion: The study found no significant difference in the performance between ECE and SCE in laboratory settings, indicating that SCE is a viable alternative to ECE in RC clinical training. Studies with larger cohorts are required to corroborate this finding.

Keywords: Clinical education, clinical skills, early clinical exposure, medical education, respiratory care, simulation-based education

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INTRODUCTION

Clinical education (CE) is essential for all healthcare professionals, including respiratory care (RC) students.[1,2] With a concentration in cardiovascular and pulmonary disorders, an RC degree prepares students with

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specialized skill sets to address unique patient issues and disorders, and thus work as a trained medical professional. For skill optimization, in countries such as the United States, United Kingdom, and Canada, clinical practice courses are initiated from the beginning of the RC coursework.

In Saudi Arabia, clinical practice courses (i.e., clinical training) start from the third year for 4 semesters. However, in the RC program at Imam Abdulrahman Bin Faisal University (IAU), Dammam, clinical practice starts from the second semester of the second year (level 3) for 1 day/week for 14 weeks over 5 semesters in different governmental and private hospitals under the supervision of faculty from the RC Department. However, due to shortage of clinical instructors and clinical sites, early clinical exposure (ECE) imposed high pressure on the department administrators. Given that clinical environments can be complicated, challenging, and consistently developing, planning for a clinical education practicum requires considerable effort and resources. Concurrently, the availability of resources and skilled clinical instructors is critical in shaping the clinical education experiences of the students.[3]

While generally considered beneficial, ECE can also lead to negative clinical education experiences if not optimally managed, as it can result in students feeling lost and not adequately interacting with their learning environment because of hesitancy or lack of confidence.[4] Alternatively, simulation-based clinical education (SCE) has been shown to be a useful pedagogical tool that not only helps develop clinical and decision-making skills but is also effective in the psychomotor domain.[5,6] In health sciences, simulations are used to facilitate a deeper understanding of concepts and to enhance problem-solving and decision-making abilities.[7,8] In medical education, simulations have been used to advance diagnostic competencies and motor and technical skills of prospective doctors, nurses, and emergency teams.[9-11]

Accordingly, as part of Clinical Practice Course I modification plan, the RC department administrators at IAU introduced SCE in laboratory settings as an alternative to ECE for one of the batches. However, to the best of the authors' knowledge, studies have neither addressed the use of SCE in RC nor investigated the status of clinical education or the solutions for challenges encountered in RC. Therefore, the aim of this study was to evaluate the effect of replacing ECE with SCE in laboratory settings on the clinical skills of RC undergraduate students.

METHODOLOGY

Study design and participants

This was an experimental prospective study conducted at the RC Department, College of Applied Medical Sciences, IAU, Dammam, Saudi Arabia, between February and July 2018. The Institutional Review Board approved the study, and informed consent was obtained before enrollment. In addition, all participants received laboratory competency checklist to ensure they met the safety requirements prior to patient care.

Study samples were taken from two different undergraduate RC student batches. In Group A, students followed the traditional clinical practice course conduction plan, in which the clinical skills required by Clinical Practice Course I were taught through ECE at a hospital for one day/week for 14 weeks. This was followed by Clinical Practice Course II at affiliate hospitals.

In Group B, students followed the modified clinical practice course conduction plan (approved by the RC Department Board Members, College of Applied Medical Sciences, IAU, on May 18, 2016), in which the clinical skills required by Clinical Practice Course I were taught through SCE in the university's laboratory for the same duration as Group A. This was followed by Clinical Practice Course II at affiliated hospitals [Figure 1].

Simulation-based clinical education

The laboratory session was designed in a way that enabled students to learn and perform various respiratory care practices. On a weekly basis, a specific competency skill was taught by two respiratory care instructors using laboratory equipment and simulators listed in Table 1.

Practices involved an initial assessment of simulated patient cases that required therapy and management. This is to ensure students' attainment of entry-to-practice competencies, namely, patient assessment, respiratory therapeutic procedures, and medical gas therapy application. On completion of Clinical Practice Course I for both Groups A and B students are required to learn the following skills:

1. Perform adult basic assessment and therapeutic management.
2. Differentiate between normal and abnormal patient assessment data.
3. Demonstrate effective communication skills (verbal and written) with patients, families, members of the health-care team, colleagues, and clinical instructors.

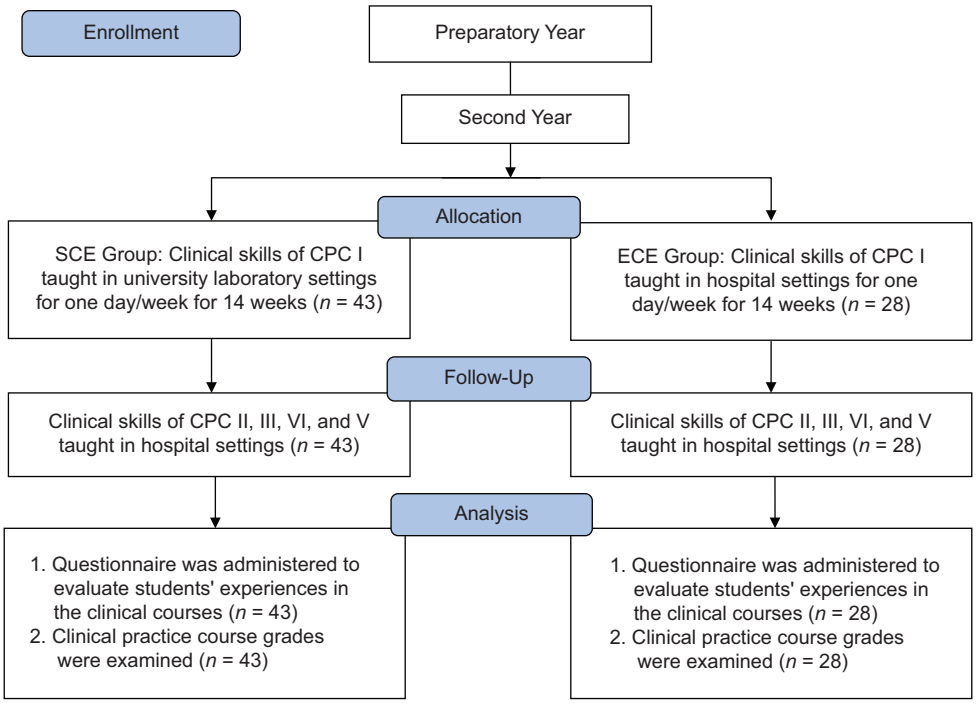

Figure 1: Study flow diagram

Table 1: Laboratory equipment and simulators used for the simulation-based clinical education at the respiratory care department

Simulator	Description
HAL® S1030 - Dynamic Airway and Lung Compliance Simulator	HAL® S1030 is a full-body computer-controlled patient simulator designed for training respiratory care students and professionals on the treatment and management of respiratory diseases using a real mechanical ventilator.
SimMan (Laerdal)	SimMan is an advanced patient simulator that can display neurological symptoms as well as physiological symptoms
Arterial Arm Stick Kit (Laerdal)	Lifelike adult male arm with infusible arteries designed for training the proper arterial puncture procedure for blood gas analysis
Arterial puncture simulator (life/form®)	Realistic arm model ideal for practicing and demonstrating drawing arterial blood samples for monitoring blood gases
Arterial puncture wrist (Kyoto Kagaku)	Radial artery puncture for blood collection and artery catheterization
MPL multi sounds manikin trainer speaker pediatric heart breath	Breath sound and heart sound training simulator
GD/J5S General Doctor Electronic Airway Intubation Model (General Doctor)	Endotracheal intubation trainer simulator
Laerdal Airway Management Trainer (Laerdal)	Realistic practice for developing proficiency in airway management skills
Resusci Baby (Laerdal)	Training manikin for the simulation of realistic and correct anatomical and physiological conditions during cardiopulmonary resuscitation of children and babies
Blood pressure trainer simulator (Medical Plastic Laboratory)	Blood pressure training simulator
Life/form® Auscultation Trainer and Smartscope™ and Amplifier/Speaker System	Breath sound and heart sound training simulator
Laerdal NG Tube and Trach Care Trainer Torso Manikin Patient Simulator	Tracheostomy and NG tube in patient care

4. Interpret patient data using information technology and data management systems.

Questionnaire structure

The Clinical Learning Environment Inventory (CLEI), a validated questionnaire, was used in this study.[12] CLEI is composed of 42 items divided into six domains: personalization, student involvement, satisfaction, task orientation, innovation, and individualization. The scoring is based on a five-point Likert-type scale (1 = Strongly Disagree; 5 = Strongly Agree). The Cronbach's alpha coefficients ranged from 0.73 to 0.84.[12]

The questionnaire was administered to Groups A and B in person after completion of Course I to examine their experiences in the clinical courses. The clinical practice course grades were also retrieved during the study period to determine differences between the groups. These grades

consist of two main components: performance evaluation, assignment, and reflection of the practical part (65%), and the theoretical exam (35%). Demographic characteristics of each participant was also recorded.

Data analysis

SPSS versions 23 and 24 (IBM Corp., Armonk, NY, USA) was used for data analysis. Comparisons in clinical skills grades between the two groups were made using *t*-test. Normality was assessed before the analysis. Outcome measures of clinical skills were analyzed in a multiple linear regression model. $P < 0.05$ was considered significant.

RESULTS

Seventy-one RC students were included in the study and completed the CLEI questionnaire: 28 and 43 students were in the ECE and SCE group, respectively (39% vs 61%, respectively). Table 2 shows the general demographic characteristics of the study participants. About 55% of the participants were male. The mean age of both groups was similar (ECE: 21.0 ± 0.81 years; SCE: 20.9 ± 0.83 years).

Students in the ECE group had higher mean CLEI, satisfaction, personalization, student involvement, task orientation, and innovation scores than those in the SCE group; however, none of these were statistically significant [Table 3]. Similarly, there were no significant difference between both groups across all clinical practice grades [Table 4]. In the multiple linear regression, where clinical skills were the dependent variable and the CLEI scale was the independent variable, no significant difference was noted in the clinical grade in relation to clinical exposure [Table 5].

Table 2: General characteristics of the study participants (*n*=71)

Variable	ECE (*n*=28)	SCE (*n*=43)	*P*
Age (mean±SD)	20.9±0.83	21.0±0.81	0.214
Gender, *n* (%)			
Female	14 (50.0)	18 (41.8)	0.074
Male	14 (50.0)	25 (58.1)	0.068

SD – Standard deviation; ECE – Early clinical exposure; SCE – Simulation-based clinical education

Table 3: Mean scores of total and subscales of Clinical Learning Environment Inventory actual form (*n*=71)

CLEI Scale	Mean±SD		*P*
	ECE (*n*=28)	SCE (*n*=43)	
CLEI total scale	128.25±3.9	123.08±4.2	0.381
Satisfaction	26.93±4.82	23.93±4.12	0.293
Personalization	23.27±4.02	20.27±4.31	0.256
Student involvement	22.67±3.04	21.60±3.12	0.314
Task orientation	21.73±3.52	19.75±2.98	0.327
Innovation	18.68±2.89	17.11±2.56	0.436
Individualization	18.01±3.50	19.05±3.45	0.253

CLEI – Clinical Learning Environment Inventory; SD – Standard deviation; ECE – Early clinical exposure; SCE – Simulation-based clinical education

DISCUSSION

The study compared the clinical skills of RC students who have undergone simulation-based curriculum and traditional early clinical exposure curriculum and found no significant difference between both groups across all measured parameters. This finding is suggestive of SCE being a viable alternative to ECE in hospital wards for RC students, which can be of considerable benefit for training in resource-constrained settings.

ECE has been shown to produce higher competencies among students than those undergoing training after course completion.[13-15] These studies showed that ECE motivates the students to put academic findings into practice;[13] improves their confidence, motivation and interpersonal skills;[14,16] prepares them for the clinical environment;[15] and helps improve their attitude and allows more experiences.[17] ECE in correspondence with theoretical courses can also provide a framework to develop the quality and application of basic sciences.[18] ECE also has positive cognitive, psychomotor, and affective domains,[19] and it helps students link their theoretical knowledge to the medical environment.[20]

Several factors may limit the implementation of ECE. One of those factors is limited availability of resources, such as clinical instructors and sites. Another factor is limited learning opportunities: for skills acquired in environments of low-frequency, high stakes, an equal opportunity may not be possible for all students in rotations. This highlights the need for alternatives. In nursing education, simulation has been shown to be a feasible alternative to ECE, as it allows students to experience difficult situations and scope for making mistakes without resulting in harm to patients.[21] However, to the best of the authors' knowledge, limited research has been conducted to provide robust evidence of using SCE for educational purposes in RTs, with most publications being recommendations.[21-23] Therefore, the current study provides valuable insight for those involved in RT curriculum development. Our finding of SCE being a useful tool for RT educational purposes is in line with studies from other clinical domains such as medical, dental, and nursing education.[5,6,24,25]

The findings of this study should be interpreted with discretion given that the study had a small sample size in both groups and that the student population is representative of a single region of Saudi Arabia. Another limitation of

Table 4: Mean scores of students' clinical skills, as reflected by the clinical practice grades (*n*=71)

Clinical skills	Mean (95% CI)		*P*
	ECE (*n*=28)	SCE (*n*=43)	
Total clinical grade	167.29 (164.74-169.84)	166.88 (164.12-169.65)	0.837
Clinical practical-I	61.64 (60.85-62.42)	61.21 (60.41-62.0)	0.451
Clinical practical-II	61.18 (59.95-62.41)	61.69 (60.97-62.42)	0.436
Clinical theory-I	23.28 (22.19-24.37)	22.16 (20.78-23.53)	0.239
Clinical theory-II	21.1 (19.7-22.6)	21.8 (20.3-23.2)	0.548

CI: Confidence interval; ECE – Early clinical exposure; SCE – Simulation-based clinical education

Table 5: Multiple linear regression with clinical skills as a dependent variable, and the Clinical Learning Environment Inventory scale as an independent variable

Independent variables	β [95% CI]		*P*
	Unadjusted	Adjusted	
Clinical exposure	−0.40 (−4.33-3.52)	−1.10 (−4.47-2.26)	0.516
CLEI score	−0.43 (−1.21-0.35)	−0.09 (−0.78-0.59)	0.788

CI: Confidence interval, CLEI: Clinical Learning Environment Inventory

the current study was that a baseline evaluation was not obtained for both groups, which would have provided a more accurate comparison. Therefore, a study with a larger sample size would provide a more statistically powerful comparison and substantiate the findings of this study.

CONCLUSION

No significant difference was found between ECE and SCE in all measured clinical practice parameters. This indicates that SCE may be a viable alternative to ECE in RC clinical training. Further similar studies are needed to examine the different methods of clinical education across institutions in Saudi Arabia and determine the most effective strategy for teaching RC students.

Ethical considerations

This study was approved by the Institutional Review Board of IAU, Dammam (Ref. no.: IRB-2018-203-CAMS, dated: February 02, 2018). The study adhered to the Declaration of Helsinki, 2013, and all measurements were carried out following the relevant guidelines and regulations. Informed consent was obtained from all participants before enrollment.

Data availability statement

The datasets generated and/or analysed during the current study are not publicly available due to privacy and confidentiality agreements as well as other restrictions but are available from the corresponding author on reasonable request.

Peer review

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Akaike M, Fukutomi M, Nagamune M, Fujimoto A, Tsuji A, Ishida K, *et al*. Simulation-based medical education in clinical skills laboratory. J Med Invest 2012;59:28-35.
2. DeWaay DJ, McEvoy MD, Alexander LA, Kern DH, Nietert PJ. Simulation curriculum can improve medical student assessment and management of acute coronary syndrome during a clinical practice exam. Am J Med Sci 2014;347:452-6.
3. Recker-Hughes C, Wetherbee E, Buccieri KM, Fitzpatrick Timmerberg J, Stolfi AM. Essential characteristics of quality clinical education experiences: Standards to facilitate student learning. J Phys Ther Educ 2014;28:48-55.
4. Kehoe A, Illing J. Early clinical exposure requires facilitated access to support learning. Med Educ 2017;51:989-91.
5. Kim J, Park JH, Shin S. Effectiveness of simulation-based nursing education depending on fidelity: A meta-analysis. BMC Med Educ 2016;16:152.
6. Issenberg SB, McGaghie WC, Hart IR, Mayer JW, Felner JM, Petrusa ER, *et al*. Simulation technology for health care professional skills training and assessment. JAMA 1999;282:861-6.
7. D'Angelo C, Rutstein D, Harris C, Bernard R, Borokhovski E, Haertel G. Simulations for STEM Learning: Systematic Review and Meta-Analysis. SRI International; 2014. Available form: https://www.sri.com/publication/simulations-for-stem-learning-systematic-review -and-meta-analysis- full-report/[Last accessed: September 10, 2021].
8. Wu Y, Anderson OR. Technology-enhanced STEM (science, technology, engineering, and mathematics) education. J Comput Educ 2015;2:245-9.
9. Cook DA. How much evidence does it take? A cumulative meta-analysis of outcomes of simulation-based education. Med Educ 2014;48:750-60.
10. Cook DA, Brydges R, Zendejas B, Hamstra SJ, Hatala R. Technology-enhanced simulation to assess health professionals: A systematic review of validity evidence, research methods, and reporting quality. Acad Med 2013;88:872-83.
11. Hegland PA, Aarlie H, Strømme H, Jamtvedt G. Simulation-based training for nurses: Systematic review and meta-analysis. Nurse Educ Today 2017;54:6-20.
12. Chan D. Development of an innovative tool to assess hospital learning environments. Nurse Educ Today 2001;21:624-31.
13. Afra B, Alizadeh M, Taghavi S, Jabbari Bayrami H, Yari J. The impact of early clinical exposure on the knowledge and attitude of basic sciences medical students at Tabriz University of medical sciences. Res Dev Med Educ 2015;4:55-60.
14. Sathishkumar S, Thomas N, Tharion E, Neelakantan N, Vyas R. Attitude of medical students towards early clinical exposure in learning endocrine physiology. BMC Med Educ 2007;7:30.
15. Shuid AN, Yaman MN, Abd Kadir RA, Hussain RI, Othman SN, Nawi AM, *et al*. Effect of early clinical skills teaching on 3rd year

medical students' learning: The student perspective. J Taibah Uni Med Sci 2015;10:26-32.
16. Ali K, Zahra D, McColl E, Salih V, Tredwin C. Impact of early clinical exposure on the learning experience of undergraduate dental students. Eur J Dent Educ 2018;22:e75-80.
17. Khabaz Mafinejad M, Mirzazadeh A, Peiman S, Khajavirad N, Mirabdolhagh Hazaveh M, Edalatifard M, *et al*. Medical students' attitudes towards early clinical exposure in Iran. Int J Med Educ 2016;7:195-9.
18. Ebrahimi S, Kojuri J, Ashkani-Esfahani S. Early clinical experience: A way for preparing students for clinical setting. Galen Med J 2012;1:42-7.
19. Govindarajan S, Vasanth G, Kumar PA, Priyadarshini C, Radhakrishnan SS, Kanagaraj V, *et al*. Impact of a comprehensive early clinical exposure program for preclinical year medical students. Health Prof Educ 2017;4:133-8.
20. Başak O, Yaphe J, Spiegel W, Wilm S, Carelli F, Metsemakers J. Early clinical exposure in medical curricula across Europe: An overview. Eur J Gen Pract 2009;15:4-10.
21. Canadian Association of Schools of Nursing Practice Domain for Baccalaurate Nursing Education: Guidelines for Clinical Placements and Simulation; 2015. Available from: http://www.casn.ca/wp-content/uploads/2015/11/Draft-clinical-sim-2015.pdf. [Last accessed on 2021 Dec 03].
22. Walsh CM, Reise KS, Correia R. Simulation use in paediatric student respiratory therapy training. Can J Respir Ther 2017;53:62-3.
23. West AJ, Parchoma G. The practice of simulation-based assessment in respiratory therapy education. Can J Respir Ther 2017;53:13-6.
24. Perry S, Bridges SM, Burrow MF. A review of the use of simulation in dental education. Simul Healthc 2015;10:31-7.
25. Chernikova O, Heitzmann N, Stadler M, Holzberger D, Seidel T, Fischer F. Simulation-based learning in higher education: A meta-analysis. Rev Educ Res 2020;90:499-541.