

Cumulative Evaluation Data: Simulation Based Learning Courses for Pediatric R1 Residents

Sawsan Alyousef^{1,2}, Najd Alnojaidi³, Shahd Alnojaidi⁴, Shahd Alyousef³, Taif Alnojaidi⁵, Daad Alyousef⁶ and Muhamad Salman Bashir²

¹Specialized Children Hospital, Center for Research, Education & Simulation Enhanced Training (CRESENT)

²King Fahad Medical City

³Al-Maarefa Medical University

⁴Dar AlUloom University

⁵Al Imam University

⁶Alriyadh Dental College, Riyadh Saudi Arabia

Corresponding author

Sawsan AlYousef, MD, CAPB, FCCP, Senior Pediatric Intensive Care & Pulmonary Consultant, Assistant Professor at King Saud University for Health Specialties, Chairman, Department of Postgraduate Simulation, Center for Research, Education & Simulation Enhanced Training (CRESENT), King Fahad Medical City, P.O. Box 4911, Riyadh 11412, Saudi Arabia. E-mail: salyousef@kfmc.med.sa

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Abstract

Objectives: To utilize cumulative evaluation data of the Intensive pediatric simulation-based learning course on knowledge and practical skills for pediatric R1 residents at Saudi Commission for Health Speciality (SCFHS) in order to measure its efficacy and areas for improvement.

Methods: This evaluation design is a retrospective cohort study that compares pre- post- and retention test 6 months later (knowledge and skills) of an intensive pediatric R1 simulation course. The five-day bundle courses has been conducted once per month at CRESENT and is comprised of airway management with crew resource management, central line insertion under ultrasound guidance, thoracocentesis and chest tube insertion, chest X-ray interpretation and lung ultrasound, lumbar puncture and bone marrow aspiration and biopsy and cardiac simulation course. Our evaluation data includes all pediatric R1 residents who attended the course between September 2017 and May 2018.

Results: A total number of 43 trainees, 23 residents (43.5%) are males and 20 (46.5%) are females. 18 (41.9%) are KfMC residents and 25 (58.1%) non-KFMC residents (Table 1). Overall, there is statistically significant improvement between the pretest and post-test knowledge and practical skills scores for all the courses. Airway management simulation course, central line catheter insertion under ultrasound guidance course and lumbar puncture course a comparative analysis for knowledge and practical skills assessment of pre-test and post-test mean scores showed significant statistical improvement with P-value <0.001. Similarly, a comparative analysis for knowledge assessment of pre-test and post-test mean scores for all the five courses including pediatric cardiac simulation course and pediatric chest X-ray interpretation course showed significant statistical improvement with P-value <0.001. Retention test were limited to 4 candidates did retention practical skills test and showed 100% improvement in their scores while 9 candidates did retention knowledge test for airway management course, central line insertion under ultrasound guidance course and lumbar puncture course which showed 50% less than post test but more than pretest score, 30% had equivocal as post test and 20% more than post test score. Majority enjoyed training in simulation environment

Discussion: This study shows the importance and effectiveness of the pediatric simulation courses for pediatric R1 residents under SCFHS training programs. The striking results are the improvement in all assessed categories of knowledge and practical skills for all the courses, although the retention candidates were few but striking result of significant retaining the practice skills and even retaining the knowledge as non scored similar or below pre test score. Which makes a strong argument to mandate such courses to all pediatric residents.

Further research is needed to study skills' retention more widely and more importantly its impact on patients' care. Although resource-intensive, the use of cumulative evaluation data helped to focus quality improvement in our courses.

Introduction

Medical education has passed through different stages, initially it relied on traditional model where the learners observe experienced physicians perform a skill on a patient then they perform the skill by themselves [1]. Studies have demonstrated ineffectiveness in knowledge retention by using such methods [2, 3]. Then it progressed to integrated PBL. Because of increasing number of medical trainees and focusing of health care on preventive medicine have led to decreased resident clinical exposure [4]. For these reasons new approaches to medical education are needed to improve learning opportunities. Although Simulation was introduced in the aviation industry during NASA workshop in 1979 to improve air safety and reduce human error [5]. then David Gaba, American anaesthetist, trained as a pilot recognized similarities of the operating theatre and cockpit and developed anaesthesia crises simulation resources management since then there has been a significant growth of medical simulation over the last two decades. There is increasing evidence that simulation training improves health care education, practice, and patient safety [6]. Medical simulations aim to imitate real patients, anatomic regions, clinical tasks, virtual reality devices and low/high fidelity manikins or to mirror real-life situations in which medical services are rendered. Benefits of medical simulation includes safe environment, mistake forgiving, trainee focused vs. patient focused, controlled, structured, proactive clinical exposure, reproducible, standardized, debriefing, deliberate and repetitive practice. Medical simulation can assess professional competence as patient care, medical knowledge, practice-based learning & improvement, communication skills, professionalism and systems-based practice. High-fidelity mannequins are interactive and life-like and can illustrate physiological conditions [7, 8]. In 'Why Children Die', the inquiry at Maternal and Child Health in the UK, showed that 26% of child deaths were avoidable [9]. Other studies showed up to 30% of paediatric inpatients are harmed by health care error [10].

Medical simulation training can be tailored according to the trainee level for example, for junior trainees, simulation can be used in taking histories and examination while for more experienced trainees, can be introduced into rare and common critical, non critical, medical or surgical scenarios beside leadership, prioritization, communication and breaking bad news also can be trained on invasive and non invasive procedures [11]. Simulation is increasingly used as part of a blended learning approach to enhance skills retention and prevent skill decay.

Objectives

To utilize cumulative evaluation data of the Intensive pediatric simulation-based learning course on knowledge and practical skills of pediatric R1 residents at Saudi Commission for Health Speciality (SCFHS) in order to measure its efficacy and areas for improvement.

Methods

We chose to use evaluation data over nine month's period since our participant

Numbers are quite small and we wanted to ensure weight of data and accommodate several iterations of the course. Although the course is standardized there may be variations based on participant engagement. This evaluation design is a retrospective cohort study that compares pre- post- and retention test 6 months later (knowledge and skills) of an intensive pediatric R1 simulation course.

Course description

Intensive pediatric R1 simulation course is five-day bundle of courses that has been conducted once per month at CRESENT, maximum of twelve participants per course learn with an instructor to resident ratio of 1:6. First day is airway management course, Second Day is Central line insertion under Ultrasound guidance followed by thoracocentesis and chest tube insertion under ultrasound guidance course, Day 3 is for chest X-ray interpretation and arterial blood gas interpretation and basics of lung ultrasound, Day 4 is for lumbar puncture plus bone marrow aspiration and biopsy course, Day 5 for cardiac simulation course. During the introduction for each day of the course, the course director introduces the instructors and simulation technicians. The course director and instructors are all pediatric intensivists with experience in simulation-based education including targeted training on using simulation to support learning. The faculty has participated in faculty development courses at CRESENT, namely the FD-Sim course, and IMS course from the Center of Medical Simulation (CMS). The residents tour the simulation center and are familiarized with the simulation rooms, debriefing rooms, simulators and all the equipment. The course director introduces the basic assumption and safety container [12]. The simulation rooms resemble PICU rooms and equipped with SimJunior® or SimBaby®, crash cart with a defibrillator and airway tools for infants and children for Pediatric airway course, blue phantoms for central line course, child and infant lumbar puncture (LP) manikin for LP course, thoracocentesis training manikin and Trauma man®, bone marrow Aspiration and biopsy blue phantoms and Harvey manikin. The course schedule includes: Day 1 two interactive lectures on airway management and crew resource management, 20 min each, a demonstration session on fundamentals of intubation for 45 min, two skills stations, four case scenarios, with concept of can ventilate-can intubate, can ventilate can't intubate. Each scenario is followed by video debriefing. All activities are done in group fashion. When the scenario necessitates, moulage is performed on SimJunior® or SimBaby®, Day 2 interactive lectures on basics of ultrasound knobology, hands on training of scanning main central vessels on volunteers, followed by training on insertion of internal jugular, subclavian and femoral vein catheter under ultrasound guidance using blue phantoms 60 minutes for each skill, hands on session of thoracocentesis, chest tube insertion under ultrasound guidance using thoracocentesis training manikin and Trauma man®, Day 3 interactive lectures on basics and advances of chest X-ray interpretation and arterial blood gases interpretation, lung ultrasound training on volunteers for 60 minutes followed by two respiratory failure scenarios with video debriefment. Day 4 interactive lectures on indication and contraindication of lumbar puncture for 30 minutes, video demonstration and hands on lumbar puncture insertion using child and infant lumbar puncture phantoms 60 minutes each, followed by hands on training on bone marrow aspiration and biopsy for 60 minutes Day 5 interactive lectures on basics and advanced ECG interpretation 30 minutes each, identification of normal and abnormal heart sounds using Harvey manikin followed by two cardiac scenarios and video debriefment. Our evaluation data includes all pediatric R1 residents who attended the course between September 2017 and May 2018.

Evaluation instruments

Evaluation of participants is done at the beginning and at the end of each day. Residents complete a pretest of 20 multiple choices questions with equal weight and a maximum score of 100% for airway management course, central line insertion under ultrasound guidance course, chest X-ray interpretation course, lumbar puncture

course and cardiac simulation course All the tests were developed by one the authors (SA) to reflect the learning objectives and was face validated with a group of experts in the field. In the practical skills test which was done for 3 courses only airway management course, central line insertion under ultrasound guidance course and lumbar puncture course, for the airway management day, the resident is given a scenario of a patient with respiratory failure and to manage. A 31-point checklist with equal weight adapted from ACCP is used to assess the resident's performance. The checklist is divided into 4 parts: equipment setup, patient positioning, pharmacology and intubation steps, similarly for central line insertion course and Lumbar puncture course. A 20-point checklist for each course with equal weight is used to assess the resident's performance. Retention test 6 months later done using same knowledge and clinical skill test for the airway management course, central line catheter insertion under ultrasound guidance and lumbar puncture course.

Study population

The study includes all pediatric R1 residents under Saudi Commission for Health Specialties (SCFHS) training program who attended the Intensive Pediatric R1 simulation course between September 2017 and May 2018 at CRESENT, KFMC.

Statistical analysis

All Categorical variables gender and level were presented as numbers and percentages. Whereas continuous age, pre and post evaluation of test scores were expressed as Mean \pm S.D. Paired sample t-test was applied to determine the mean significant difference among pre and post-test scores simulation courses. P- Value less than 0.05 was considered as statistically significant. All data was entered and analyzed through statistical package SPSS version 22. The study is approved by KFMC IRB Committee.

Finding

A total number of 43 trainees, 23 residents (43.5%) are males and 20 (46.5%) are females. 18 (41.9%) are KFMC residents and 25 (58.1%) non-KFMC residents Table (1). Overall, there is statistically significant improvement between the pretest and post-test knowledge and practical skills scores for all the courses. Airway management simulation course, central line catheter insertion under ultrasound guidance course and lumbar puncture course a comparative analysis for knowledge and practical skills assessment of pre-test and post-test mean scores showed significant statistical improvement with P-value <0.001 as presented in (Table 2,3,4)

Similarly, a comparative analysis for knowledge assessment of pre-test and post-test mean scores for all the five course including pediatric cardiac simulation course and pediatric chest X-ray interpretation course showed significant statistical improvement with P-value <0.001 as presented in (Table 5,6)

Table 1: Demographic data and training center

Characteristics	Description	n(n%)
Gender	Male	23 (43.5%)
	Female	20 (46.5%)
Hospital	KFMC	18 (41.9%)
	Non – KFMC	25 (58.1%)

Table 2: Comparative analysis of Mean Score of Pediatric Airway Simulation Course

Airway Simulation Course	N	Minimum	Maximum	Mean \pm S.D	P – value
Pre Knowledge	43	1	8	3.55 \pm 1.99	* < 0.001
Post Knowledge	43	4	9	6.74 \pm 1.25	
Pre-Clinical	43	1	6	2.53 \pm 1.48	* < 0.001
Post Clinical	43	5	29	16.790 \pm 9.02	

Table 3: Comparative analysis of Mean Score of Pediatric CVC Simulation Course

CVC Simulation Course	N	Minimum	Maximum	Mean \pm S.D	P – value
Pre Knowledge	43	0.0	8	4.09 \pm 1.62	* < 0.001
Post Knowledge	43	4	10	7.00 \pm 1.34	
Pre-Clinical	43	0	0	0.00 \pm 0.00	* < 0.001
Post Clinical	43	5	10	7.33 \pm 1.18	

Table 4: Comparative analysis of Mean Score of Pediatric Lumbar Puncture Simulation Course

Lumbar Puncture Simulation Course	N	Minimum	Maximum	Mean \pm S.D	P – value
Pre Knowledge	43	2	8	4.80 \pm 1.38	* < 0.001
Post Knowledge	43	5	9	7.57 \pm 0.98	
Pre-Clinical	43	2	7	4.87 \pm 1.31	* < 0.001
Post Clinical	43	6	9	7.96 \pm 0.83	

Table 5: Comparative analysis of Mean Score of Pediatric Cardiac Simulation Course

Cardiac Simulation Course	N	Minimum	Maximum	Mean \pm S.D	P – value
Pre Knowledge	43	2	8	5.31 \pm 1.78	* < 0.001
Post Knowledge	43	4	10	8.21 \pm 1.50	

Table 6: Comparative analysis of Mean Score of Pediatric Chest X-ray Simulation Course

Chest X-ray Simulation Course	N	Minimum	Maximum	Mean \pm S.D	P – value
Pre Knowledge	43	3	9	6.41 \pm 1.53	* < 0.001
Post Knowledge	43	3	10	7.19 \pm 1.36	

Only 4 candidates did retention practical skills test and showed 100% improvement in their scores while 9 candidates did retention knowledge test for airway management course, central line insertion under ultrasound guidance course and lumbar puncture course which showed 50% less than post test but more than pretest score, 30% had equivocal as post test and 20% more than post test score. All candidates filled in satisfactory evaluation with indicator of (5 = Strongly Agree, 4= Agree, 3= Neutral, 2= Disagree, 1= strongly disagree) and average score showed for all courses: the course acquired new knowledge 83.7% scored 5 while 1.15% scored 1. The course enhanced my skills, 87.2% scored 5 while 2.3% scored 1, The course linked the training to my daily practice, 84.8% scored 5 while 0.0% scored 1. The objectives of the simulation course were clearly defined, 82.55% scored 5 while 1.1% scored 1. The course objectives were met, 83.85% scored 5 while 0.0% scored 1. The simulation course content was organized and easy to follow,

81.3% scored 5, while 0.0% scored 1. I enjoyed learning in simulated environment, 87.2% scored 5 while 0.0% scored 1. The time given for demonstration/simulation in the course was enough, 82.7% scored 5 while 0.0% scored 1. I would rate this educational activity as satisfactory, 89.5% scored 5 while 0.0% scored 1. I would recommend this simulation/educational activity to the others, 89.5% scored 5 while 0.0% scored 1 (Table 7,8,9,10,11)

Table 7: Satisfactory Evaluation of Airways Course

	5	4	3	2	1
1. The course acquired new knowledge	33 (76.7%)	6 (14%)	2 (4.7%)	1 (2.3%)	1 (2.3%)
2. The course enhanced my skills	38 (88.4%)	5 (11.6%)	0.0%	0.0%	0.0%
3. The course linked the training to my daily practice	36 (83.7%)	6 (14%)	1 (2.3%)	0.0%	0.0%
4. The objectives of the simulation course were clearly defined.	33 (76.7%)	6 (14%)	3 (7.0%)	1 (2.3%)	0.0%
5. The course objectives were met	32 (74.7%)	9 (20.9%)	1 (2.3%)	1 (2.3%)	0.0%
6. The simulation course content was organized and easy to follow.	33 (76.7%)	6 (14%)	3 (7.0%)	1 (2.3%)	0.0%
7. I enjoyed learning in simulated environment	38 (88.4%)	3 (7.0%)	2 (4.7%)	0.0%	0.0%
8. The time given for demonstration / simulation in the course was enough	32 (74.7%)	6 (14%)	5 (11.6%)	0.0%	0.0%
9. I would rate this educational activity as satisfactory	36 (83.7%)	5 (11.6%)	2 (4.7%)	0.0%	0.0%
10. I would recommend this simulation / Educational activity to the others.	36 (83.7%)	3 (7.0%)	4 (9.3%)	0.0%	0.0%

Table 8: Satisfactory Evaluation of CVC Course

	5	4	3	2	1
1. The course acquired new knowledge	33 (76.7%)	6 (14%)	2 (4.7%)	1 (2.3%)	1 (2.3%)
2. The course enhanced my skills	38 (88.4%)	5 (11.6%)	0.0	0.0	0.0%
3. The course linked the training to my daily practice	36 (83.7%)	6 (14%)	1 (2.3%)	0.0	0.0%
4. The objectives of the simulation course were clearly defined.	33 (76.7%)	6 (14%)	3 (7.0%)	1 (2.3%)	0.0%
5. The course objectives were met	32 (74.7%)	9 (20.9%)	1 (2.3%)	1 (2.3%)	0.0%
6. The simulation course content was organized and easy to follow.	33 (76.7%)	6 (14%)	3 (7.0%)	1 (2.3%)	0.0%
7. I enjoyed learning in simulated environment	38 (88.4%)	3 (7.0%)	2 (4.7%)	0.0%	0.0%
8. The time given for demonstration / simulation in the course was enough	32 (74.7%)	6 (14%)	5 (11.6%)	0.0%	0.0%
9. I would rate this educational activity as satisfactory	36 (83.7%)	5 (11.6%)	2 (4.7%)	0.0%	0.0%
10. I would recommend this simulation / Educational activity to the others.	36 (83.7%)	3 (7.0%)	4 (9.3%)	0.0%	0.0%

Table 9: Satisfactory Evaluation of X-ray Course

	5	4	3	2	1
1. The course acquired new knowledge	42 (97.7%)	0.0%	0.0%	1 (2.3%)	0.0%
2. The course enhanced my skills	41 (95.3%)	0.0%	0.0%	0.0%	2 (4.7%)
3. The course linked the training to my daily practice	41 (95.3%)	1 (2.3%)	1 (2.3%)	0.0%	0.0%
4. The objectives of the simulation course were clearly defined.	38 (88.4%)	4 (9.3%)	1 (2.3%)	0.0%	0.0%
5. The course objectives were met	38 (88.4%)	3 (7.0%)	2 (4.7%)	0.0%	0.0%
6. The simulation course content was organized and easy to follow.	38 (88.4%)	3 (7.0%)	2 (4.7%)	0.0%	0.0%
7. I enjoyed learning in simulated environment	38 (88.4%)	3 (7.0%)	2 (4.7%)	0.0%	0.0%
8. The time given for demonstration / simulation in the course was enough	37 (86%)	3 (7.0%)	3 (7.0%)	0.0%	0.0%
9. I would rate this educational activity as satisfactory	36 (83.7%)	4 (9.3%)	3 (7.0%)	0.0%	0.0%
10. I would recommend this simulation / Educational activity to the others.	40 (93%)	3 (7.0%)	0.0%	0.0%	0.0%

Table 10: Satisfactory Evaluation of LP Course

	5	4	3	2	1
1. The course acquired new knowledge	38 (88.4%)	3 (7.0%)	1 (2.3%)	0.0%	1 (2.3%)
2. The course enhanced my skills	37 (86%)	3 (7.0%)	0.0%	0.0%	2 (4.7%)
3. The course linked the training to my daily practice	39 (90.7%)	4 (9.3%)	0.0%	0.0%	0.0%
4. The objectives of the simulation course were clearly defined.	36 (83.7%)	1 (2.3%)	3 (7.0%)	2 (4.7%)	1 (2.3%)
5. The course objectives were met	40 (93%)	3 (7.0%)	0.0%	0.0%	0.0%
6. The simulation course content was organized and easy to follow.	37 (86%)	3 (7.0%)	3 (7.0%)	0.0%	0.0%
7. I enjoyed learning in simulated environment	39 (90.7%)	3 (7.0%)	1 (2.3%)	0.0%	0.0%
8. The time given for demonstration / simulation in the course was enough	40 (93%)	1 (2.3%)	2 (4.7%)	0.0%	0.0%
9. I would rate this educational activity as satisfactory	41 (95.3%)	1 (2.3%)	1 (2.3%)	0.0%	0.0%
10. I would recommend this simulation / Educational activity to the others.	41 (95.3%)	0.0%	2 (4.7%)	0.0%	0.0%

Table 11: Satisfactory Evaluation of Cardiac Course

	5	4	3	2	1
1. The course acquired new knowledge	39 (90.7%)	4 (9.3%)	0.0%	0.0%	1 (2.3%)
2. The course enhanced my skills	37 (86%)	4 (9.3%)	0.0%	0.0%	2 (4.7%)
3. The course linked the training to my daily practice	37 (86%)	5 (11.6%)	1 (2.3%)	0.0%	0.0%
4. The objectives of the simulation course were clearly defined.	38 (88.4%)	2 (4.7%)	3 (7.0%)	0.0%	0.0%
5. The course objectives were met	40 (93%)	2 (4.7%)	1 (2.3%)	0.0%	0.0%
6. The simulation course content was organized and easy to follow.	35 (81.4%)	6 (14%)	2 (4.7%)	0.0%	0.0%
7. I enjoyed learning in simulated environment	36 (83.7%)	4 (9.3%)	3 (7.0%)	0.0%	0.0%
8. The time given for demonstration / simulation in the course was enough	39 (90.7%)	4 (9.3%)	0.0%	0.0%	0.0%
9. I would rate this educational activity as satisfactory	40 (93%)	2 (4.7%)	1 (2.3%)	0.0%	0.0%
10. I would recommend this simulation / Educational activity to the others.	41 (95.3%)	2 (4.7%)	0.0%	0.0%	0.0%

Discussion

This study shows the importance and effectiveness of the pediatric simulation courses for pediatric R1 residents under SCFHS training programs. The striking results are the improvement in all assessed categories of knowledge and practical skills for all the courses, although the retention candidates were few but striking result of significant retaining the practical skills and even retaining the knowledge as non scored similar or below pre test score. which makes a strong argument to mandate such courses to all pediatric residents. Several studies have shown the efficacy of airway management training on improving intubation skills [13, 14]. another study showed the efficacy of pediatric airway simulation courses and how junior residents scored in knowledge and practical skills as high as senior residents at the end of the course However, reducing the hazards and risk on the patients still limited [15,16]. A key element in assessing the effectiveness of simulation-based educational activity is to document measurable improvement in knowledge, behavior and skills [17,18]. The detailed and comprehensive outcomes-based evaluation in this 5 days course provides sufficient data for us to maintain the course and improve others. On the other hand, by integrating the evaluation into the course schedule, it facilitates ease of data collection. It also has an orienting impact for all residents at the opening activity in the course. The practical skills assessment in particular is labor intensive; however, it is an imperative tool for accurate measurements of the course's impact. The Airway management course focuses on skills such as teamwork, crew resource management and communication

techniques. These skills together with proper preparation of the intubation equipment, having them organized in predetermined way and the use of cognitive aid have crucial effects on the success of safe intubation [13, 19, 20]. Similar results have been reported with training of all levels of pediatric residents on airway management [15]. The Central line insertion under ultrasound guidance focuses on orientation about ultrasound knobology, identification of central vessels, differentiation between veins and arteries then training on proper technique, sterilization and coordination with ultrasound during insertion of central line. The lumbar puncture course focuses on anatomy, landmark, sterilization and technique of the whole procedure. Chest X-ray interpretation focuses on basics and advances on reading chest X-ray, while pediatric simulation cardiology course focuses on identification and differentiation between normal and abnormal heart sounds , rhythm and murmurs and how to read ECG. Majority of candidates find such courses had enhanced their knowledge , skills and linked to their daily practice, beside the course content was organized and met the objectives and most striking is the candidates enjoyed learning in simulation environment. The intensive pediatric simulation course at CRESENT targets all R1 pediatric residents. There are clear differences in the pre-test scores among the five courses which give validity to the assessment tool used and strengthens the effectiveness of the course. Training on these vital courses should be conducted early during residency to get the maximum benefit and it reflects directly on patients' outcome and safety [16, 18, 21-23]. So a simulation-based education curriculum for a residency

program is best constructed in amodular fashion [24]. A pediatric airway management course, central line insertion under ultrasound guidance, lumbar puncture course, chest X-ray interpretation course and pediatric cardiac simulation course are one of these modules that best be administered early in the residency program.

Conclusion

The intensive pediatric simulation courses at CRESENT is effective in improving the knowledge and practical skills of pediatric residents. Although retention test was limited but results are promising so similar courses need to be integrated in the pediatric residency curriculum preferably at early stage of residency programs and to create more advance courses for senior pediatric residents. Further research is needed to study skills' retention widely and more importantly its impact on patients' care. Majority of the candidates found these courses are enjoyable, safe, not stressful and very useful training methods. Our outcomes-based evaluation strategy has provided targeted insight to the strengths and areas for development in the course which we have acted upon.

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Declaration section

Ethics Approval: The research was approved by IRB Committee at King Fahad Medical City (IRB 18-473)

Authors' Contributions

Study conception and design: S.Alyousef and N.Alnojaidi

Acquisition of data: N.Alnojaidi, T.Alnojaidi, S.Alnojaidi, SH.Alyousef and S.Alyousef

Analysis and interpretation of data: S.Alyousef, T.Alnojaidi, and M.Bashir

Drafting of manuscript: S.Alyousef, S.Alnojaidi, SH.Alyousef, D.Alyousef

Critical revision: S.Alyousef and N.Alnojaidi

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