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The Effectiveness of Interprofessional Simulation Experiences Used in Health Science Education

Randy D. Case, PhD, RRT, RRT-NPS

Abstract

Introduction: Implementing interprofessional simulation experiences (ISE) into the curriculum of health science students often increases one's exposure to real-life scenarios while allowing educators the opportunity to utilize experiential learning strategies. Additionally, these experiences allow students the opportunity to develop teamwork, leadership, and communication skills. The purpose of this study was to measure the potential gain in these three skills by assessing student perceptions and learning outcomes through the use of ISE. **Methods:** Following IRB approval, students from the respiratory therapy, nursing, and radiology programs were divided into two equal groups, the control group (CG) and the experimental group (EG). Through the use of a validated instrument from TeamSTEPPS®, the CG completed pre- and post-surveys but was not exposed to the ISE. The EG completed pre-surveys, participated in the ISE, and completed post-surveys to measure the students' understanding of leadership, teamwork, and communication skills while determining if any significant differences were found after the exposure to the ISE. The ISE for this research study consisted of a simulated labor and delivery scenario, which included pre-term twins requiring neonatal resuscitation. **Results:** Pre-survey data obtained through independent samples t-test revealed similar existing knowledge of all three skills: EG (M=4.65) and CG (M=4.69), ($t[102]=0.31$, $P > .05$) $P = 0.76$, two-tailed. Post-survey data revealed that students participating in the ISE had a better understanding of leadership, teamwork, and communication than those students that did not participate: EG (M=4.87) and CG (M=4.65), ($t[102]=2.14$, $P < .05$) $P = .034$, two-tailed. **Conclusions:** Results of the study revealed that the development and implementation of ISE within the curriculum of health science students may lead to a more comprehensive understanding of leadership, teamwork, and communication skills. Due to the limited research on the use of ISE, future studies are needed to validate the necessity of these activities.

Key Words: Interprofessional, simulation, experiential learning, collaboration, teamwork, leadership, communication, health sciences, respiratory therapy.

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Introduction

Throughout the past several decades, simulation training and exercises have significantly grown in popularity as a form of health care education. One of the primary influences on the growth of simulation education has been the continued development and advancements in simulation technology and abilities. Rubio, Maestre, del Moral, and Raemer[1] suggest that high-fidelity simulation manikins and advanced computer technologies have allowed students the opportunity to participate in simulation experiences that mimic and replicate real-life scenarios that would typically only be available in the hospital setting. In addition, Becker and Schell[2] explain how the application of interprofessional components to simulation exercises has allowed health science students the ability to work collaboratively with other disciplines and understand the importance of coordinated patient care. As described by Dillon, Noble, and Kaplan,[3] interprofessional simulation scenarios have also permitted students from numerous fields of study the opportunity to interact and connect with other health care students in a controlled and coordinated learning environment. This provides experimental learning opportunities where students can develop leadership, teamwork, and communication skills.

Background

Simulation education and training can be defined as a series of virtual scenarios utilized to teach learners specific skills and performance strategies. These types of learning techniques are often recognized as a useful and beneficial strategy for delivering real-life scenario-based training and instruction to health care students.[4] This format of education is not typically available when using conventional lecture-based education or textbooks. Studies suggest the importance of implementing simulation training and education into the curriculum of health science students in an effort to increase their exposure and experience with real-life situations.[1] In addition, providing simulation training in the health care curriculum allows educators the opportunity to implement diverse techniques to advance students' health care-related knowledge and skills. Although simulation training has been used in numerous professions since the early 1910s, recent advancements in technology have allowed the growth and development of simulation training to expand exponentially.[5] The use of advanced technologies in simulation training has progressed rapidly and often provides students with unlimited opportunities to learn in a safe environment, increasing the need for simulation education.

Health care educators and systems, such as TeamSTEPPS,®[5] have recognized the need for increased collaborative training involving the use of interprofessional teams.[1] In an effort to increase quality of care, health care leaders have acknowledged that health care professionals must be provided with the essential training to develop teamwork, leadership, and communication skills. Unfortunately, many health science students gain limited exposure to team-training and interprofessional experiences during their formal education.[6] In response to the increased need for interprofessional simulation training, numerous colleges have implemented interprofessional simulation activities for health care students.

Problem Statement

As the use of interprofessional simulation exercises in health care education has progressively developed, some have doubted the necessity of such complex and sophisticated instructional techniques and strategies, while others maintain the general demand for simulation training experiences to meet the requirements of advanced medical technologies and services.[3] Through the use of post-scenario debriefings and learner success assessments, research has recognized the advantages of interprofessional simulation exercises for health care students.[7] However, researchers have also discovered potential consequences and negative outcomes associated with these forms of experiential learning methods.[3] Therefore, it is essential to verify the effectiveness of interprofessional simulation experiences (ISE) used in health care education.

Purpose of the Study

This study examined the leadership, teamwork, and communication skills of health care education students at Midwestern State University, including students from the school's nursing, radiology, and respiratory therapy programs. Several key characteristics and traits were examined within each specific skill set in the attempt to acquire student perceptions of these skills. The purpose of this study was to measure the potential gain in leadership, teamwork, and communication skills through the implementation of ISE by assessing student perceptions. Several components of each skill were examined to determine the potential growth and development of these skills after the completion of an ISE. The aim of the research study was to determine the need for further development and use of ISE in health care education. If colleges and universities continue integrating interprofessional simulation activities into their curriculum, research must determine its purpose and value.

Research Questions

The following research questions were examined in the study:

1. Are there any differences in leadership, teamwork, and communication skills according to pre- and post-survey results between groups of health care students who are exposed to interprofessional simulation exercises and those who are not?
2. Can the implementation of interprofessional simulation exercises in health care education enhance the leadership, teamwork, and communication skills of students participating in these activities in comparison to students not participating in these activities?

Methods

This research study aimed to discover the effectiveness and impact of ISE on health care education students' leadership, teamwork, and communication skills. A quantitative survey approach was selected for this study due to its flexibility and use within the social sciences and educational research fields. The experimental research design and method implemented in this study was Quasi Nonequivalent Comparison-Group Design. The experimental treatment condition consisted of an interprofessional simulation scenario and activity in which health care education students interacted and worked collaboratively during a mock cardiac/respiratory arrest emergency of newborn infant twins. The pre-experience survey and post-experience survey results from the participating students were analyzed to determine any significant differences between the two surveys resulting from the ISE. Additionally, the results from the experimental group and control group were then analyzed to discover any significant differences noted between the two groups and the potential effects of the ISE.

Sampling Procedures

In order to begin this study, it was necessary to obtain the permission of Midwestern State University's Institutional Research Board (IRB) for the Protection of Human Subjects. The participants of this research study were health care education students from Midwestern State University (MSU Texas) in Wichita Falls, Texas. Students participating were from varying professional programs, including nursing, radiological sciences, and respiratory therapy.

Through random selection, half of the 104 participating students were selected to be part of the experimental group while the remaining half of students were categorized as the control group. Among both the experimental and control groups, all students from each discipline had previously been exposed to the same course materials for their respective disciplines. Each discipline, however, had varying degrees of exposure to neonatal resuscitative measures. All students participating in the experimental group were notified and informed of the experimental research prior to the simulation experience by their instructors. Students were provided with a letter of consent explaining that consent was implied through their voluntary participation. Students were also informed that survey information would be confidential and that no identifying information would be reported in the research findings.

Survey Instrument

The surveys provided to the students were part of the validated "Team Strategies & Tools to Enhance Performance & Patient Safety" TeamSTEPPS® 2.0 Teamwork Attitudes Questionnaire from the Agency for Healthcare Research and Quality[5] (see Appendix A). The surveys included six questions from each of the three primary sections: leadership, teamwork, and communication. For each question, participants were asked to select from a 5-point Likert scale (1=strongly disagree; 5=strongly agree). The questions were aimed to detect students' understanding, awareness, support, and perception of leadership, teamwork, and communication. The pre-experience and post-experience surveys were identical and all participants from the experimental and control groups were given the same surveys. In addition, the survey results were collected separately from each discipline and were not combined, in the event data could be collected and evaluated later, based on differences between disciplines.

Description of the Experience

The ISE was a scenario-based simulation involving teams of five or six students participating in the resuscitation of newborn twins. The teams consisted of two nursing students, two respiratory therapy students, and one or two radiologic science students. Prior to the simulation, all students within the experimental group were gathered and preempted with a presentation that gave a brief explanation of the scenario and the expected actions of the students. Although no specific details in regard to the treatment and care of the patient were given, the students were directed to participate and take corrective measures just as they would in a real-life situation.

At the beginning of the simulation, two teams of students from the experimental group were called to respond to

a mock labor and delivery scenario. Upon arriving in the simulation laboratory, the two teams determined that the scenario consisted of the delivery of 32-week gestational twins. Both infants were non-responsive and required resuscitative measures including warming, drying, stimulation, ventilation, chest compressions, medication administration, intubation, x-ray evaluation, and further stabilization procedures. As the teams were not directed on specific role assignments, one student in each group was required to take the lead position for the health care team. All other students were directed by the team leader on their specific roles, which included airway management, medication administration, monitor assessment, chest compressor, information recorder, and x-ray technologist. In an effort to be a student-led scenario, faculty members remained observers and did not actively participate in the resuscitation simulation. Upon completion of the simulation experience, students reconvened in a classroom setting to complete the post-experience surveys and take part in a debriefing period to openly discuss the events. During the debriefing, students were able to ask questions and make comments. Faculty members asked the students what they felt went well and what they felt could have gone better during the simulation. In addition, students from the varying disciplines were asked if they learned more about the roles and responsibilities of the other disciplines during the experience. After the debriefing period, the ISE was concluded.

Data Collection

During the study, the control group strictly took part in the pre- and post-surveys. This particular group was not exposed to the ISE. The experimental group was asked to complete the pre-experience survey, take part in the ISE, and complete the post-experience survey.

The primary data obtained from the experimental group's pre-experience surveys and post-experience surveys were used to assess the potential growth in the students' understanding and perceptions of leadership, teamwork, and communication skills after participating in the ISE. The post-experience survey results from the experimental group and the control group were also compared to determine the differences in understanding and perception of leadership, teamwork, and communication skills based on those that participated in the simulation activity and those that did not participate.

Statistical Testing Methodst

For this study, a series of inferential statistical analyses in the form of independent samples t-tests were performed utilizing pre-experience survey responses of the experimental group and the control group to determine any potential differences between the two groups. According to Lowry,[8] the purpose of independent samples t-tests, such as those used in this study, are to detect potential statistical differences between the means of two separate groups. In addition, a series of paired samples t-tests were performed in each group using the pre- and post-experience data to determine potential growth and improved understanding of the research questions. The purpose of paired samples t-tests, such as those used in this study, are to determine if statistical evidence is present when evaluating the mean differences between before-and-after observations on the same subjects.[8]

Results

According to the results of the pre-survey statistical analysis, students from both the experimental group and the control group had a similar existing knowledge of health care leadership, teamwork, and communication prior to the implementation of the ISE. In contrast, the results within the post-experience surveys found significant differences between the two groups. According to the post-experience survey results, students participating in the ISE exhibited better understanding and perception of leadership, teamwork, and communication skills than those that did not participate in the simulation activity.

The pre-survey results from the analysis of the data displayed no statistical significance between the means of the pre-survey of the experimental group and the control group regarding the students' prior knowledge of leadership, teamwork, and communication skills. The students in both groups had a similar degree of leadership, teamwork, and communication knowledge based on the survey results prior to the implementation of the ISE. In contrast, the post-survey results from the analysis of the data displayed a statistical significance between the means of the post-survey of the experimental group and the control group regarding the students' leadership, teamwork, and communication skills after the implementation of the ISE.

- Leadership: post-survey of experimental group (M = 4.87) and the post-survey of the control group (M = 4.65), (t [102] = 2.14, P < .05) P = .034, two-tailed.
- Teamwork: post-survey of experimental group (M = 4.83) and the post-survey of the control group (M = 4.52), (t [102] = 3.08, P < .01) P = .003, two-tailed.
- Communication: post-survey of experimental group (M = 4.98) and the post-survey of the

control group (M = 4.83), (t [102] = 2.73, P < .01) P = .007, two-tailed.

According to the results of the post-survey questions, the students participating in the ISE had a greater degree of leadership, teamwork, and communication skills and knowledge than those students that did not participate after the implementation of the ISE.

The paired samples t-test was utilized to compare data collected from pre and post surveys to determine any significant differences in leadership, teamwork, and communication skills between students participating in the ISE and students who did not participate in the simulation activities. When comparing the data from the group participating in the ISE, a significant difference between the means of the pre- and post-surveys for leadership, teamwork, and communication skills was noted (Figure 1).

- Leadership: pre-survey (M = 4.65) and the post-survey (M = 4.87), (t [51] = 3.70, P < .001) P < .001, two-tailed.
- Teamwork: pre survey (M = 4.48) and the post-survey (M = 4.83), (t [51] = 5.19, P < .001) P < .001, two-tailed.
- Communication: pre survey (M = 4.88) and the post-survey (M = 4.98), (t [51] = 2.33, P < .05) P = .02, two-tailed.

According to the data results, the students who participated in the ISE gained leadership, teamwork, and communication skills and knowledge during the activity. However, when comparing the data from the group not participating in the ISE, the results found no significant difference between the means of the pre- and post-surveys for leadership, teamwork, and communication skills.

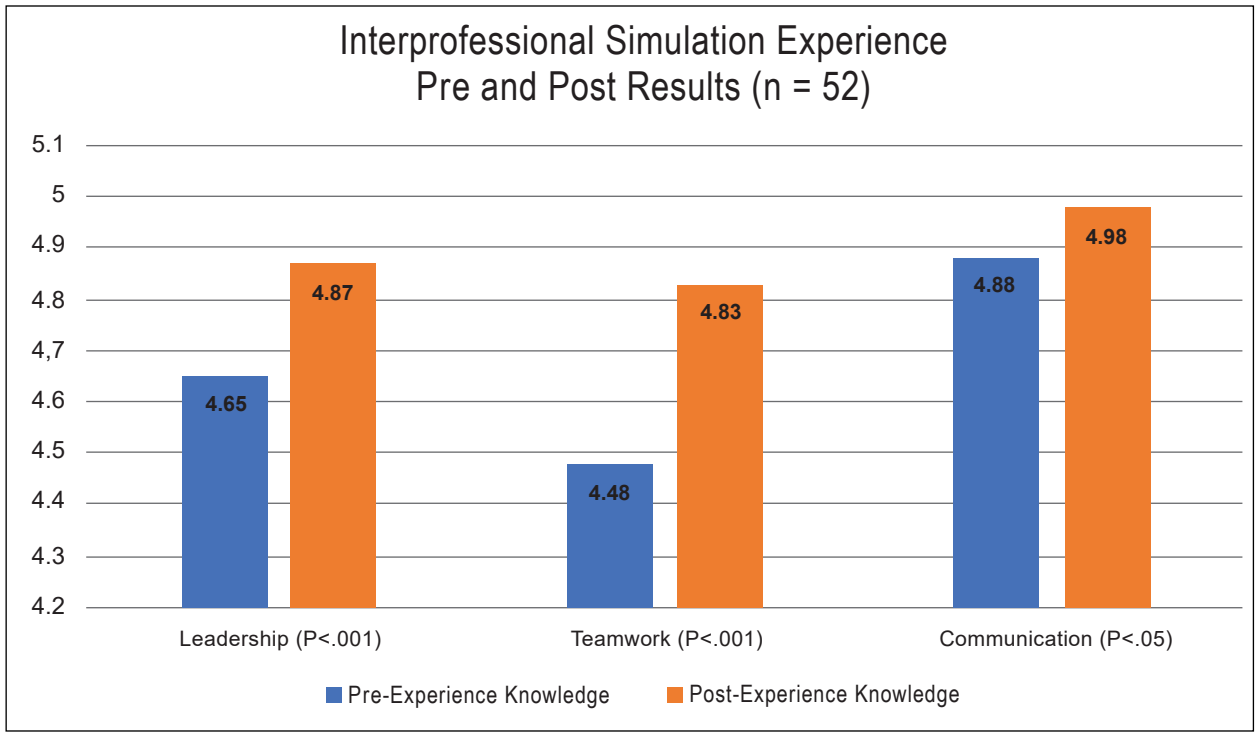
- Leadership: pre-survey (M = 4.69) and the post-survey (M = 4.65), (t [51] = 1.43, P > .05) P = .16, two-tailed.
- Teamwork: pre survey (M = 4.48) and the post-survey (M = 4.52), (t [51] = 1.43, P > .05) P = .16, two-tailed.
- Communication: pre survey (M = 4.87) and the post-survey (M = 4.83), (t [51] = 1.43, P > .05) P = .16, two-tailed.

The students who did not participate in the ISE indicated no gain in leadership, teamwork, or communication skills.

Discussion

The statistical results from the independent samples t-test performed in the study indicated that participants in both the experimental group and the control group had comparable existing knowledge and understanding of leadership, teamwork, and communication skills. Based

Figure 1: Leadership, teamwork, and communication Paired Samples *t*-test mean values of pre- and post-surveys for students participating in the interprofessional simulation exercise.



on the data analyzed with the paired samples *t*-test, the mean value of post-experience surveys increased from the pre-experience surveys for students that participated in the simulation exercise. However, students that did not participate in the simulation activity showed no gain in leadership, teamwork, or communication skills. Therefore, the implementation of the interprofessional simulation exercise provided participating students with increased knowledge and understanding of the three skillsets being studied.

This study's results correlate with the general findings of other researchers. As described by Horton-Deutsch and Sherwood,[9] health care students participating in interprofessional activities and simulation exercises tend to acquire confidence, and self-assurance through the development of leadership skills and capabilities. Lisko and O'Dell[10] emphasized the importance of experiential learning opportunities, such as simulation activities, due to their ability to allow faculty to reinforce course objectives while simultaneously evaluating students' teamwork capabilities. In addition, Angelini[11] found that health care students subjected to teamwork-based interprofessional activities during their educational preparation are generally more understanding of teamwork concepts when entering the health care environment. Rice et al[12] found that the use of interprofessional training activities provides health care students with critical communication skills to which most students are never exposed. In a study by Vernon et al,[13] communication was rated by surveyed respiratory therapy faculty as the most important learning component within interprofessional learning activities. Similarly, Galloway[14] expressed the importance of interprofessional simulation training for health science students because these types of exercises typically engage students in scenarios that require enhanced communication skills, which are essential to the success of health care professionals.

Limitations of the Study

This study has several limitations. One limitation was the generalization of the research findings. The data collected in this research study was obtained within one university. This limits the findings to the instructional methods and strategies utilized on one campus versus a variety of student populations and locations.

Secondly, the size of the student sample was somewhat small, which could have potentially limited the use of the data. Although a total of 104 students were active participants within the study, a larger number of students could have provided a more precise mean value as well as a greater representation of health science students. In addition, a larger sample size could have limited the influence of outliers or extreme observations.

Another potential limitation pertains to the background of the health science students participating in the research study. It is important to note that the data obtained were the collected opinions of three specific health care disciplines and may not be applicable to all health care education and instructional services. Due to this potential limitation, the findings in this study should be focused on the health care professions surveyed, which included nursing, radiology, and respiratory therapy.

The final limitation also pertains to the health care students participating in the research study. As different fields of practice within the health care professions, the three disciplines that participated in the study had varying levels of previous simulation training and experience. Not having equal training and simulation experiences prior to the event, some students' perception and attitudes toward interprofessional simulation activities could have been altered. This potential barrier to simulation exercises has been demonstrated in previous studies including that of Leclair et al[15] where those participating in interprofessional simulation exercises expressed having differing levels of clinical experience which resulted in some disengagement with the activity.

Implications for Future Research

Developing a strong educational foundation for health science students while incorporating leadership, teamwork, and communication skills is essential to the success of future health care professionals.[3] However, research studies based on using interprofessional simulation activities in the curriculum to enhance these specific skill sets are limited. Future studies pertaining to the use of interprofessional simulation activities to enhance leadership, teamwork, and communication skills should be conducted in an effort to validate the necessity of these activities. Future studies should encompass larger numbers of students, as well as student populations from a variety of university locations. In addition, future studies should be conducted to provide repetition of research throughout several semesters for the students participating. This progressive style of study could provide evidence of enhanced growth and development over an extended period of time. Future studies could also place an emphasis on specific health care disciplines. This type of study could provide evidence to determine if interprofessional simulation activities are more beneficial to certain professions. Additionally, future studies could incorporate other health care professions outside of nursing, radiology, and respiratory care.

Another implication for future studies pertaining to interprofessional simulation activities for health care education involves decreasing medical errors through

simulation activities. As described by Galloway,[14] providing health science students with opportunities to interact with one another through simulation education allows students to practice health care-related skills in a controlled environment which tolerates possible errors and oversights. Future research could be conducted to determine if students that were exposed to interprofessional simulation exercises during their health science education had fewer medical errors in comparison to those that did not have exposure to these types of learning activities.

Lastly, future research pertaining to the effectiveness of interprofessional simulations could incorporate the comparison of simulation exercises with differing teaching methodologies. Data obtained from individuals learning new concepts through simulation could be analyzed and compared to data obtained from students learning the same concepts through a different strategy. This type of study could potentially verify the effectiveness of simulation training in comparison to other teaching approaches.

Conclusion

As colleges and universities across the United States strive to incorporate the most effective teaching strategies in their curriculum, numerous health care programs have determined the potential need in implementing interprofessional simulation activities to enhance students' skills involving leadership, teamwork, and communication.[16] According to the data discovered in the research study, students participating in an interprofessional simulation activity experienced significant gains in leadership, teamwork, and communication skills when compared to students that did not participate in the simulation activity. Therefore, it can be concluded that implementing interprofessional simulation activities into the curriculum for health science students can be beneficial and valuable. Future studies should replicate this study to provide further evidence of the effectiveness of interprofessional simulation exercises for health science students.

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Appendix A
TeamSTEPPS® TEAMWORK ATTITUDE QUESTIONNAIRE

The purpose of this survey is to measure your impressions of various components of teamwork, leadership, and communication as it relates to patient care and safety through simulation training.

Instructions: Please respond to the questions below by placing a check mark (√) in the box that corresponds to your level of agreement from Strongly Disagree to Strongly Agree. Please select only one response for each question.

Team Structure	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1. It is important to ask patients and their families for feedback regarding patient care.					
2. Patients are a critical component of the care team.					
3. This facility's administration influences the success of direct care teams.					
4. A team's mission is of greater value than the goals of individual team members.					
5. Effective team members can anticipate the needs of other team members.					
6. High performing teams in health care share common characteristics with high performing teams in other industries.					
Leadership	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
7. It is important for leaders to share information with team members.					
8. Leaders should create informal opportunities for team members to share information.					
9. Effective leaders view honest mistakes as meaningful learning opportunities.					
10. It is a leader's responsibility to model appropriate team behavior.					
11. It is important for leaders to take time to discuss with their team members plans for each patient.					
12. Team leaders should ensure that team members help each other out when necessary.					

Communication	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
13. Teams that do not communicate effectively significantly increase their risk of committing errors.					
14. Poor communication is the most common cause of reported errors.					
15. Adverse events may be reduced by maintaining an information exchange with patients and their families.					
16. I prefer to work with team members who ask questions about information I provide.					
17. It is important to have a standardized method for sharing information when handing off patients.					
18. It is nearly impossible to train individuals how to be better communicators.					

Please provide any additional comments in the space below.

Thank you for your participation!

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Career Intentions of Degree Advancing Respiratory Therapists: A Mixed-Methods Study

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Abstract

Background: Many degree advancement respiratory therapist (RT) programs are working toward earning bachelor's degrees through degree advancement programs at colleges and universities. Previous research has suggested that more than a third of degree-enhancing RTs plan to use the degree to enter new careers. The loss of experienced RTs to other careers may affect skill and knowledge levels within respiratory care departments and lead to increased training and recruitment costs. This study sought to quantify the number of students considering career exit, identify and explore the dominant factors affecting the decision, identify popular career alternatives, and to uncover the relationship between age and work experience on career change. **Methods:** A 5-item survey was emailed to students (n=395) enrolled in a degree advancement program in North-Central Texas. The survey responses were first analyzed using descriptive statistics then the data were grouped according to age/experience and career intention. The data groupings were analyzed using the chi-square test. Factors affecting career intention were then analyzed thematically. **Results:** The survey return rate was 36%. Fifty-nine percent of the respondents indicated they were considering a career change. The most frequently identified career destination was physician assistant 33%, followed by clinical perfusionist 18%. Additional career choices were education (teacher, not RT - 14%), health care-related (not RT - 13%), other (13%), and nursing (10%). Respondent age and experience as an RT was not found to be significantly related to career intention. Participants in the 26-30-year-old age group represented the largest group contemplating career exit. Factors selected most often as influencers of career change decisions were opportunity, salary, respect, and work schedule. Analysis of qualitative data resulted in the identification of three superordinate themes: opportunity, autonomy, and demands (workplace). **Conclusions:** Degree advancing RTs are considering leveraging the BSRC degree to enter different careers, and such decisions are made more commonly by younger RTs. The application of retention models borrowed from nursing and the use of other tools may aid in the retention of young, early career RTs.

Key words: Mixed methods, thematic analysis, career intention, career change, two-factor theory, job satisfaction, respiratory therapist

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Introduction

The increased demands on respiratory care practice brought about by technological change, evidence-based clinical decision making, and the need to work collaboratively with other health care professionals has revealed the importance of enhanced levels of formal education for respiratory therapists.[1] The American Association for Respiratory Care (AARC) has long recognized the increased responsibilities inherent in modern practice. As a result of a series of task force conferences to determine the skills, competencies, and educational preparation necessary for future respiratory therapists, consensus reports stressing the baccalaureate degree as the minimum educational level for respiratory therapists have been developed.[2]

Although over 75% of respiratory therapists (RTs) possess associate degrees, many graduates have chosen to continue their educational development through degree enhancement programs offered by universities and colleges.[3] Information from the 2017 AARC Human Resource Study showed 56% of respiratory therapists have either earned or are working toward a bachelor's degree.[3] A baccalaureate degree confers advantages to graduates beyond those found with associate degrees. In addition to the increased breadth and depth of the curriculum, the bachelor's degree is considered the minimum professional degree by government agencies, third-party groups, and the military.[4,5] Baccalaureate degrees are generally a prerequisite for entry into graduate schools and the 2017 AARC Human Resource Survey showed the positions of director (76.5%), supervisor (51.3%), educator (78.9%), research coordinator/associate (74.4%), and industry representative/sales (63.6%) are held by individuals with bachelor's or higher academic degrees.[3]

We know little concerning the effect of degree enhancement on employment prospects and career mobility in respiratory therapists, or whether degree enhancement provides an edge to applicants when compared to those who entered practice with a baccalaureate degree. Another area worthy of exploration are the plans of respiratory therapists currently enrolled in degree enhancement programs. AARC study data has revealed nearly 35% of respiratory therapists were pursuing higher education in order to change careers.[3]

Career exit in respiratory therapists is under-explored, but a clear link exists between job satisfaction and career change in health care workers. The concept of job satisfaction may be the outcome of a particular attitude; thus, job satisfaction can be viewed as the attitude one holds toward a job ranging from favorable to unfavorable.[7] Much of the work in the areas of job satisfaction and career intention of health workers is situated around the identification of internal (personal) and external (environmental) factors that influence job satisfaction.[8,9,10] Theories related to motivation and job fit are also used to guide research in areas relating to job satisfaction and career intention.[11,12]

Elevated levels of job dissatisfaction have been found to exist among respiratory therapists.[13,14,15] Data from previous studies indicated that job satisfaction in respiratory therapists is primarily related to workplace factors, such as quality of supervision, opportunity for advancement, support of co-workers, recognition by nurses and physicians, role clarity, management style and department size.[16,17,18] In a study focused on the professional role, responsibilities, and future plans of therapists, salary and professional opportunity were found to be the most important factors for career retention and over 30% of respondents indicated they were considering leaving the profession due to limited opportunities for professional growth and lack of confidence in the profession.

It is important to understand the career goals of degree-completing respiratory therapists. For educators, the data are valuable for program planning purposes. For department heads and administrators, the movement of personnel to other careers may be viewed as a loss to the profession as their skill sets are not easily replaced and personnel loss can result in increased training costs for departments. In addition, it is helpful to identify which careers appeal to therapists planning career exit and why respiratory care is no longer viewed as a viable option; such distinctions are necessary if the profession is to address areas of current practice viewed as undesirable. This mixed methods study, focused on degree enhancing therapists in an online program, was designed to answer the following questions: (a) what percentage of students are planning to exit the profession; (b) which careers are attractive to students; (c) what are the reasons for considering a career switch; and (d) what is the effect of student age and length of career on career change decisions. It is important to clarify these data, specifically, to identify which careers are appealing to therapists, and to understand the reasons why such careers are viewed as more desirable. The loss of one-third of the workforce to other professions as a result of degree enhancement is not the goal of increased educational levels for current practitioners.

Methods

Survey data were collected from a sample of students enrolled in an online respiratory therapy degree advancement program. Analysis of data was used to

identify career intention, preferred career pathways, the effect of age and length of career on career intention, and factors believed to influence career change decisions. The research was conducted at Midwestern State University (Wichita Falls, TX), and the authors received institutional review board approval for the study.

A survey was developed containing variables identified from reviews of respiratory literature and relevant studies from other health care disciplines. Variables included respondent age, experience level, career intention post-graduation, preferred career pathway, and factors believed to influence career change decisions (e.g., opportunity, salary, working conditions, etc.). The 5-item survey instrument (see Appendix A) was developed and evaluated by the authors, experienced researchers in mixed methods and survey design, for face and content validity. The survey was made available to a convenience sample of students (n=395) enrolled in an online degree-enhancement program. Students were recruited via university email and through email from course professors. Potential participants were directed via a link embedded in the recruitment document to a consent form and the survey. Data collection spanned a two-week period from March 17 to April 1, 2019 and students were contacted twice for follow-up via email.

Statistical analyses explored the relationship between the age of the respondent, experience level, and career intention with two-tailed tests and differences were considered significant when $P < .05$. The chi-square test was used to determine whether there was any relationship between age or experience level on career change decisions. Descriptive statistics were used to evaluate differences between students planning to continue respiratory care careers versus those who were not, intended career pathway, and factors affecting the career change decision. In addition to data collection in regard to change factors, respondents were requested to describe how the factors they selected influenced the decision-making process; descriptions provided by participants were analyzed thematically. An interpretational approach was used for the qualitative analysis of open-ended answers. Two researchers read all of the statements in the initial sample and carried out the analysis separately. The initial analysis generated almost identical sets of categories. Reviewers compared findings and discussed their analyses in order to develop the consensus statements.

Results

A total of 395 surveys were emailed to participants. The return rate of completed surveys was approximately 36% (143/395). Data were reviewed by two members of the research team. Of the 5 age groups surveyed, the largest group was the Over 40 group at 37.8% of participants (Table 1). Respiratory care experience levels were revealed to be less than 5 years in a majority of cases (42%). Table 1 shows the characteristics of the respondents.

Career Plans Post-Graduation

The survey instrument provided for two pathways for determining career intention. Participants could respond "No" to the question "Do you plan to use the BSRC degree to advance your career as a respiratory care practitioner?" and then select or list the career they were planning to enter (see Appendix A). This was the expected route for respondents planning to exit the respiratory care profession. Alternatively, participants could answer "Yes" to the question and still select or list a different career. The selection of an intended career path and influencing factors indicated to reviewers that the individual was an

Table 1. Participant Characteristics

	n (143)	Percentage
Age Group (Years)		
20-25	15	10.5
26-30	23	16.1
31-35	31	21.7
36-40	20	14
Over 40	54	37.8
Experience (years)		
1-5	60	42
6-10	26	18.2
11-15	19	12.6
16-20	15	10.5
Over 20	23	16.1

RT hoping to gain some professional benefit from the degree, but one who was still considering career exit; comments supplied by respondents helped confirm this viewpoint.

Data were independently reviewed by two members of the research team. Initial data review showed approximately 29% (42/143) of the sample answered "No" to the survey question concerning use of the BSRC degree for career advancement in the profession. Additional review revealed 30% (43/143) of respondents had answered "Yes" to the question concerning professional advancement and selected alternate career pathways and motivating factors for the decision. Based on the criteria discussed above, 59% (85/143) of the study group were considered to be planning an exit from respiratory care practice.

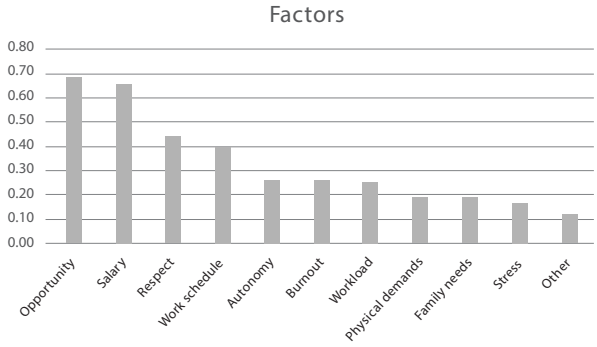
Intended Career Pathway

Health care-related professions were the preferred careers for therapists planning to exit practice. Physician's assistant represented the expected career pathway for 33% (28/85) of respondents; perfusionist 18% (15/85); education (teacher, not respiratory care) 14% (12/85); health care-related (not respiratory care) 13% (11/85); other (e.g., business, physician, attorney) 13% (11/85); and nursing (RN, NP, CRNA) 10% (8/85) completed the list.

Factors Exerting the Greatest Influence on Career Change Intent

Participants were asked to select the factors considered most influential on career change plans. Two dominant factors and two subfactors emerged from data analysis:

Figure 1: Figure 1. Factors influencing career change decisions



Opportunity 68% (57/85), salary 65% (55/85), respect 44% (37/85) and work schedule 39% (33/85) (Figure 1).

Effect of Student Age and Experience on Career Change Decisions

The results of chi-square analyses suggested no statistically significant difference in career plans based on the age of the participant or length of career. Participants with 1-5 years of experience were revealed to have the most interest in career exit compared to more experienced peers (68%; 41/60). Data pertaining to age were significant at a .10 level but not at .05. A greater percentage of participants in the 26-30-year-old age group (87% 20/23) were found to be considering career exit compared to participants in the other four age groups (Table 2).

Qualitative Data

Participants also provided additional information concerning how factors influenced the decision to consider career change. The survey included an open-

Table 2. Chi-Square Results Comparing Age and Experience Level to Career Intentions

Career Exit	Yes	No	*P*
Experience			**.31**
1-5 years	41	19	
6-10 years	15	11	
11-15 years	8	11	
16-20 years	8	7	
20+ years	13	10	
Age			**.053**
20-25	9	6	
26-30	20	3	
31-35	16	15	
36-40	12	8	
40+	28	26	
P<.05			

ended question: "Select the factors most important in determining your decision to seek a different career pathway, and briefly describe how the factor(s) influenced your choice." A total of 26 participants provided open-ended comments. Participants were able to choose from multiple factors (Figure 1), and the responses to the open-ended question were analyzed. An interpretational approach was used for the qualitative analysis of the open-ended answers. Each response was typed on a separate piece of paper and read through. If responses included 2 or more different statements that influenced seeking a different career pathway, they were separated and added to the complete list of qualitative comments. Once all the statements were separated there were 45 statements in total, and each statement was considered as one unit of analysis. The sample statements were read through and organized into categories of reasons participants sought a different career pathway. Two researchers read all of the statements in the initial sample and carried out the analysis separately. The initial analysis generated almost identical sets of categories. The categories were discussed and analyzed. Finally, the researchers grouped the data into three main categories.

Results

The analysis of the 45 statements generated three main categories determining the participant's decision to seek a different career pathway. The 3 main categories were, (a) opportunity, (b) autonomy, and (c) demands. See Table 3 for more details and representative comments from the participants.

Opportunity

The majority of the participants indicated opportunity as the reason they were considering changing career paths. In 29 of the open-ended comments, participants expressed their desire for other career opportunities.

> "I love my job as a respiratory therapist. None of the choices listed above are why I want to further my education and become a PA. I have also done the job as a perfusionist without the pay. I think physicians and health care directors use respiratory therapists as a way to save money on expensive salaries because we tend to be easy to train. I also feel like I have already done everything that I can as an RT, and want to continue growing."
>
> "I am making the same salary as I did at 21."
>
> "There is very little room for advancement in the field of respiratory and in the area in which I work. The salary is not feasible and most RTs work more than one job to support their family."

One participant stated:

> "I have thoroughly enjoyed being a Respiratory Therapist for my short five years. However, as I age in my career [it] is has become glaringly obvious that there is not room for advancement within my field. As my husband is in the military, we move quite a bit allowing me to work all over the United States. A common theme I have noticed is the burnout and the lack of motivation from those having been in the field over ten years. I personally feel that the lack of advancement, autonomy, and respect has led to a lack of motivation from seasoned practitioners. There are no incentives to go to school and further self-education besides going down an

Table 3. Open-ended Question Results

	Example	Number of Statements
Opportunity	"I plan to obtain a PA to work with a pulmonologist to expand my expertise from Respiratory."	29
Autonomy	"Level of autonomy as an RT, as well as workload and conditions, varies massively from hospital to hospital, highly dependent on competent or incompetent managers. Too much of a push to replace RTs with Nurses."	9
Demands	"Weekends and holidays along with 12 hour shifts are not ideal with children."	7

alternative career path. The pay is great starting out but with no room for advancement, all we really see are occasional raises."

Autonomy

Nine of the open-ended comments were related to autonomy.

"We really need to get our career out there and push for therapist-driven protocols so that we can earn the respect we desire."

"Working as a respiratory therapist in a PICU setting has definitely prepared me to make life changing decisions for others. Now I feel that sometimes because of my position I don't get heard as much in important situations no matter how respected I am. Of course, doctors really do listen and take my considerations, but I would like to have more autonomy."

"In reality, doctors and RNs really do not respect the profession unless they are in a bind."

Demands

The researchers concluded seven of the open-ended comments were related to demands. There were comments related to physical, schedule, and workload demands.

"Too often RTs are given workloads so busy that they cannot spend the quality time with their patients to make sure they understand everything completely to reduce readmissions. Hospitals or doctors do not really want RT protocols. (Where is the confidence in the profession and in the RT assessments?)"

Two participants commented on physical demands as a reason for considering changing career paths.

"After working in the field in various areas I began to notice a lot of pain in my ankles and feet, I had to have extensive surgery on my right foot for plantar fasciitis, tarsal tunnel, bone spurs, fibromas, and had to have all of the tendons in my ankle reattached with anchors. I was unable to walk for six months after the surgery and had extensive physical therapy. I still have to undergo the same procedure on my left foot."

"My doctor recommended I change career paths. I love my job, I take pride in my work. I worked in the emergency department, I had gained respect and autonomy with my fellow staff members and doctors, my body just rejected being on my feet for 12+ hours a day with my pedometer registering up to 10 miles on an average day."

Discussion

In the current study, 59% of participants indicated an intention to exit the profession. For a majority of respondents, careers as a physician assistant or clinical perfusionist were considered the most attractive. Factors influencing the decisions of participants were revealed to be the desire for more opportunity and greater earning potential. The data also showed therapists were affected by a perceived lack of respect for the profession by other health professionals, work schedules (12-hour shifts), and the requirement for weekend and holiday assignments. Neither experience nor age were found to be significantly related to career intention, although a greater percentage of younger participants indicated a desire to change careers.

Career change decisions are influenced by elements promoting or detracting from job satisfaction. Among respiratory therapists, job satisfaction has been shown to be affected by quality of supervision, opportunity for advancement, support of co-workers, recognition by nurses and physicians, role clarity, management style and department size.[16,17,18] Other features influencing job satisfaction include salary and benefit structures, workload, and scheduling.[13,14,19] Personal factors may exert effects on job change decisions as well. Concern for personal health, family responsibilities, and the results of stress and burnout have been shown to influence therapists to leave the profession.[14, 19,29] In addition to external and internal factors affecting career change, the variable of age has also been shown to have an influence on career exit decisions. Younger, less experienced individuals have been shown to be more vulnerable to the effects of stress and burnout, management style, and workplace relationships than older, more experienced workers.[9,10,17]

In this study, participants chose the physician's assistant career track as the most popular option. Such a career choice is not surprising considering the desire of participants for more opportunity and greater earning potential. RTs earn median salaries of $60,200 per year compared to physician's assistants (PAs) who earn median salaries of over $108,000; greater practice autonomy is also a feature of this career. The expected growth of PAs in the workforce is expected to be 31% (much higher than average) in the next 10 years compared to a 21% for RTs.19 In contrast to RTs who largely work in hospitals, PAs are primarily employed in the offices of physicians; PAs may also find employment in hospitals, outpatient care centers, and education.[19]

Participants in this research also expressed a desire to move into careers as certified clinical perfusionists (CCPs). This employment track also represents a job with greater earning potential that may also leverage skills of therapists

who are trained to manage extra corporeal membrane oxygenators (ECMO) as a function of their current jobs. Median annual salaries for CCPs are reported to be $124,00 with the bulk of CCPs employed by hospitals and health care systems; employment growth for this career is projected at 13% for the next 10 years.[20]

While the careers described above offer greater earning potential for RTs, they may not fulfill the desires of workers wanting fixed work schedules. Both PAs and CCPs are required to be on call for evenings, weekends, and holidays. When employed by hospitals, long shifts are not uncommon and seasonal variations in patient load may result in increased stress and fatigue.[19, 20]

Interestingly, participants in this study ranked nursing at the bottom of their intended career change options. Such a finding is surprising when one considers the median annual salaries of registered nurses (RNs) is $71,730 and the range of practice opportunities afforded to nurses is much wider when compared to RTs.[21] Moreover, the public holds nurses in high esteem, ranking the profession the highest of any profession in honesty and ethics. With additional training, RNs may become nurse practitioners (NPs) and enjoy practice autonomy in most states. The career is also in demand as the need for NPs is expected to grow 31% in the next 10 years.[22,23]

It is possible that the relative unpopularity of nursing as a profession stems from the familiarity RTs have with the profession. Among other health care professionals, RTs have more daily contact with nurses and are familiar with some of the less attractive features of the profession, many of which are similar to those experienced by RTs. Further, in some practice areas, therapists may function in relationships with nursing staff that are adversarial, such experiences may cause RTs to view nursing as an unattractive career option.[29]

In this research, a larger percentage of younger participants were considering career change compared to older peers. There is limited research available concerning the effects of a respiratory care career on younger workers; however, young, inexperienced RTs have been shown to be more vulnerable to the effects of burnout and career dissatisfaction than older, more experienced practitioners.[17] Among new RT graduates, support of co-workers and respect for clinical skills have been shown to have a positive overall effect on career satisfaction.[28] Persons who have left the profession have noted perceptions of a lack of career opportunity, challenging practice environments (i.e., heavy patient loads, schedules), limited clinical autonomy, and imbalances between workplace demands and compensation.[29]

Among nurses, the research is more abundant, with a number of studies having shown younger and relatively inexperienced nurses being more likely to consider career change than older and more experienced peers.[9,10, 24] Younger, early career nurses have been shown to be affected by perceptions of a lack of support and mentoring, poor practice environments (e.g., under-staffed, ethical issues), and entering nursing as a 'second choice' career.[24] Inadequate social supports and ineffective management styles have also been associated with increased intention to leave nursing as a career.[12]

Different strategies have been applied to increasing retention of new graduates in nursing. Standard approaches can include long orientations, additional didactic and clinical instruction, preceptors (multiple or dedicated), formal debriefing sessions, and supportive networks. Such structural supports may include short informal orientations or formal programs lasting from 3 to 6 months.[25] Extended programs will typically provide new graduates with preceptors or mentors who provide one-on-one guidance during the formal period. Programs designed to support and integrate new graduate nurses have been shown to increase retention and reduce labor costs.[25-27]

Respiratory care departments interested in retaining new graduates could incorporate some of the components of preceptor/mentoring programs in addition to adding or enhancing methods currently employed in many departments. For example, clinical ladders have been proposed as a way for therapists to visualize career progression and provide a route to increased responsibility and reward.[15] New graduates should be exposed to clinical ladders early in their employment as a way to highlight the opportunities available within a department or system. Respiratory care protocols offer RTs the opportunity to achieve a measure of practice autonomy and showcase clinical skill. In addition, protocol use has been shown to increase overall satisfaction with respiratory care practice.[30] Protocols can provide a useful teaching tool for new graduates by integrating the didactic instruction received in school with the realities of clinical practice. The involvement of RTs in interprofessional education programs is another approach for increasing visibility and respect for the profession among new graduates. Such programs allow RTs the opportunity to showcase their knowledge and skills in addition to reflecting the values shared by all health care providers.[31]

Educators should also continue to develop an advance practice respiratory therapist (APRT) curriculum and programs. Advance practice respiratory therapy programs could be the next step for therapists who want to become PAs. The Coalition for Baccalaureate and Graduate Respiratory Therapy Education (CoBGRTE) established a committee to create APRT competencies and model

curriculum that can be used in either a 2-year (master's) or 3-year (clinical doctorate) graduate degree program.[33] A recently described AARC scope of practice document for APRTs supports qualified practitioners (under physician supervision or license) being afforded the opportunity to diagnose and treat patients with respiratory diseases.[34]

What appears lacking in many departments, is the use of dedicated mentors or preceptors and the provision of departmental supports for feedback and de-briefing. Daily work as a graduate RT provides abundant challenges and stressors the student RT did not experience.[29] Without a well-defined support network, the new graduate may feel overwhelmed as coping skills and personal resilience are often not well developed, especially in younger workers. Moreover, younger practitioners have a strong need for group affiliation, feedback on performance, and respect from peers; they also tend to have strongly developed success orientations and a desire to understand career progression.[32] Formal mechanisms, such as dedicated mentors/preceptors and well-defined orientation programs, can help provide structured support and career guidance.

Limitations

This study relied on a convenience sample of students from an online degree advancement program located in the South-Central U.S., and although the program serves students from across the U.S. and internationally, the majority of students are from the same general geographic area. As such, the views of the study group may not reflect those of students located in other parts of the country where practice demands and opportunities might be different. The study population included students that were currently enrolled in classes during the study period. The prospect of revealing information regarding future career plans to professors who were also teaching courses might have had an inhibitory effect on survey response rates.

Conclusions

The concept of a graduate RT residency program or an extensively developed orientation framework runs counter to the training model of many respiratory programs and hospital departments. Educators pride themselves on producing graduates that are 'job ready' or, at minimum, require little additional support in order to function competently as graduate therapists. Hospital systems, many with existing shortages of RTs, are eager to have new hires functioning independently as quickly as possible. However, this approach fails to address the needs of new graduates to become fully integrated into clinical practice. A possible solution is to incorporate some of the elements already described (i.e., clinical ladder, protocols), with features common in other (i.e., nursing) models. Thus, a model for graduate RTs might include the following: (a) combined departmental orientation for all new hires (inculcate values and expectations), (b) dedicated mentors or preceptors, (c) monthly new hire luncheon with training, (d) weekly debrief for new hires (one month) and monthly debrief (3- 6 months), and (e) open discussions regarding career progression and expected salaries (with mentors, managers, and HR). Whenever possible, the foregoing elements should include managers and other members of the leadership team in order to foster teamwork and two-way communication. It is also important for educators to provide realistic appraisals of respiratory careers when interviewing potential students and to provide career and emotional guidance as needed during training. Educators should also continue to develop APRT programs and curriculum as a method for increasing the skills and visibility of the clinical respiratory therapist. With appropriate foundational supports, it is believed entry-level RTs can experience greater overall job satisfaction, envision career opportunity, and adopt a more favorable long-term view of the profession.

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Appendix A
CAREER INTENTIONS SURVEY

1. How many years have you practiced respiratory care?
    a. 1 – 5 years
    b. 6 – 10 years
    c. 11 – 15 years
    d. 16 – 20 years
    e. 20 or more years

2. What is your current age?
    a. 20 – 25 years of age
    b. 26 – 30 years of age
    c. 31- 35 years of age
    d. 36 – 40 years of age
    e. 40 or more years of age

3. Do you plan to use the BSRC degree to advance your career as a respiratory care practitioner?
    a. Yes
    b. No

If you answered 'Yes' to the question above please exit the survey. Thank you.
If you answered 'No' to the question above please answer the following questions.

4. Which career listed below represents your intended career pathway?
    a. Nursing (RN, NP, CRNA)
    b. Physician Assistant
    c. Health care related (e.g., case manager, social work)
    d. Perfusionist
    e. Education (not respiratory care)
    f. Other (list)

5. The following factors, identified in previous research, are believed to exert influence on career change decisions in respiratory care practitioners. Please review the list, select the factors most important in determining your decision to seek a different career pathway and briefly describe how the factor(s) influenced your choice.

    Opportunity – Respect – Autonomy – Salary - Work schedule - Workload
    Stress - Physical demands - Burn out - Family needs - Other

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Guidelines for Developing a Critical Thinking Assessment Tool for Respiratory Therapy Education

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Abstract

Introduction: Critical thinking is defined as the ability to apply higher cognitive skills based upon evidence-based practice and is utilized every day in RT clinical practice. Due to the key role critical thinking plays in patient care, its development is a vital aspect of RT education. However, as of now, there is no standardized tool for measuring RT students' critical thinking skills as they relate to the field of respiratory care. The purpose of this study was to identify the guidelines for the development of a critical thinking assessment tool for use in RT education programs. **Methods:** This study was approved by the IRB. Participants in this study were program directors and directors of clinical education of entry-to-practice baccalaureate and master's degree RT programs accredited by CoARC. The research involved surveying participants about how to best assess critical thinking in RT competencies, and the best testing format to assess critical thinking. The responses from the survey can be used as the basis for developing a critical thinking assessment tool specific to RT students. **Results:** Across the four critical thinking domains, clinical simulation was the most frequently selected testing method. Application was the most selected critical thinking domain to assess and measure change in critical thinking for the competencies necessary for the 2015 and beyond RT. Synthesis was also frequently chosen when the competency was information gathering in nature. **Conclusion:** The results of this study can be used as guidelines for creating individualized critical thinking assessment tools for RT education.

Key words: critical thinking, respiratory therapy education, critical thinking assessment tool

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Introduction

Critical thinking is often identified as a required skill for many, if not all, professional careers. As a whole, critical thinking can be defined as the ability to apply higher cognitive skills based upon evidence-based practice.[1] This skill surpasses basic knowledge and comprehension of a topic by applying evaluation, analysis, synthesis, and application of the knowledge.[2] The definition and breakdown of critical thinking is reflective of Bloom's Taxonomy, which is a classification of cognitive skills developed in 1956.[3] Bloom's Taxonomy involves six tiers of cognitive thinking skills that begins with knowledge and progresses to evaluation. These tiers are knowledge, comprehension, application, analysis, synthesis, and evaluation.[3] Once the learner reaches the top tier, evaluation, critical thinking skill is assumed. The four domains of critical thinking that have been identified previously (evaluation, analysis, synthesis, and application) are reflective of the six tiers of Bloom's Taxonomy

Along with the various domains that must be met to achieve critical thinking, augmentation of critical thinking skills occurs over time and may be improved with various teaching strategies. These techniques require a higher order of thinking and include problem sets, written reports, group presentations, laboratory tests, questioning, role playing, case studies, and simulations.[4] By using these techniques in respiratory therapy (RT) education programs, critical thinking skills can continue to be developed. Certainly, there is not enough time in the day to question every judgment call in the clinical environment; however, having well-developed critical thinking skills means that a health care provider is comfortable using a variety of decision-making skills and should be familiar with the situations which would be appropriate to put them into practice.[1] This is a combination of both efficiency and good practice.

Experts promote critical thinking in all health professional careers, with most studies measuring critical thinking found in the nursing literature. Researchers have measured the development of critical thinking as nursing student's progress through a nursing program, in order to determine if the program is adequately preparing their students for the clinical environment. Tools and tests have been developed to assess participants at the beginning and end of the nursing program. Porter[5] found that the development of critical thinking through the educational aspects of a nursing program leads to success on the National Council Licensure Exam (NCLEX). Critical thinking development was measured with various tools such as the Assessment Technologies Institute (ATI) Critical Thinking Exam (CTE), and the Test of Essential Academic Skills (TEAS). Other critical thinking tests that have been developed specifically for nursing and are used to assess nursing students include the Kaplan Critical Thinking Integrated Test[6] and the Nursing Critical Thinking in Clinical Practice Questionnaire.[7]

Attempts have been made in the past to assess critical thinking in RT students; however, the tools that were used were not specific to RT. For instance, the Health Sciences Reasoning Test (HSRT), developed by Insight Assessments, has been used to compare the critical thinking skills between baccalaureate and associate degree RT students.[8] Although Insight Assessments indicates that the HSRT measures critical thinking through application of key theoretical concepts, they are not created specifically for RT. The Watson-Glaser critical thinking appraisal has also been used to assess the critical thinking skills of RT students.[9] Similarly, the test is not made specifically for RT.

The literature has shown that assessment tools should be discipline specific and should be utilized at numerous points throughout the curriculum to truly assess students' critical thinking abilities.[10] Specifically, Oppermann and colleagues[11] determined that RT education would benefit from a critical thinking assessment tool that is specific to the field of RT. In addition, having such discipline specific critical thinking assessment tool would allow for educational programs to measure change over the course of the semesters. Since critical thinking skills are useful to all professionals that work in a hospital setting, it is necessary to assess that these skills are being developed in educational programs.

The purpose of this study is to identify guidelines for the development of a critical thinking assessment tool for use in RT education programs. The research questions addressed with this study were:

1. What testing format do educational experts believe is most appropriate for assessing critical thinking in RT students relative to the four domains of evaluation, analysis, synthesis and application?
2. Which critical thinking domains are best utilized when assessing and measuring change in the critical thinking skills of RT students in relation to RT competencies?
3. What do educational experts believe is an appropriate length for a RT critical thinking assessment tool?

Methods

This study was a non-experimental, descriptive survey, used to gain new insights on the desired criteria for an

RT critical thinking assessment tool. The population of this study was program directors and directors of clinical education of baccalaureate and master's entry-to-practice RT programs accredited by the Commission on Accreditation for Respiratory Care (CoARC). A database of key personnel from baccalaureate and masters entry to practice accredited programs was obtained from CoARC's website. The participants were not randomly selected as they opted to be involved in the study. Surveys from participants that completed at least 75% of the items on the survey were included in the data analysis.

All RT educators in the study database were sent an email describing the purpose of the study and inviting them to participate. The email contained the invitation to participate as well as a link to the survey (Appendix A). The survey instrument collected demographic information from the participants, in addition to opinions on testing format, and recommended length of the test. Participants were also asked to determine which domains of critical thinking would be best utilized to assess and measure change in the critical thinking skills of RT students in relation to the competencies necessary for the 2015 and beyond RT.[12] Content validity was established through consultation of a panel of RT education experts who were asked to verify the survey adequately assessed issues surrounding development of a critical thinking assessment tool in RT education. A follow-up email was sent one week after the initial email was sent to remind participants to complete the survey. Descriptive statistics were used, including frequencies, percentages, and means to summarize survey responses and answer the research questions.

Results

A total of 107 program directors and directors of clinical education were invited to participate in this study. Of these 107 individuals, 25 participants completed at least 75% of the items on the survey.

The first four questions of the survey asked about how each domain of critical thinking should be tested (Table 1). The participants chose clinical simulation as the preferred testing method for all four domains of critical thinking. Case study and open-ended questions were other popular choices for testing method. True or false, matching, and Likert scale were the least frequently chosen testing methods. Demographic information, such as age, gender, job title, years of clinical experience, and years of educator experience, was also collected (Table 2).

Figure 1 displays the responses received when asked to choose the best domain to be used for assessing and measuring critical thinking skills of an RT student based on the 28 identified competencies in this study. Application was most frequently chosen as the best domain for 20 of the 28 competencies. Synthesis was chosen as the best domain to assess and measure critical thinking for 6 competencies that could be grouped into 3 categories: diagnostic testing, administration of therapy, and applying protocols.

Discussion and Conclusions

Critical thinking in RT lays the foundation for clinical practice and enhances thoughtful decision-making skills

Table 1. Preferred Testing Methods for Critical Thinking Domains
Note: Shaded results represent the top three preferred testing method for each critical thinking domain
Note: Due to the "select all" nature of the survey question, percentages may add up to more than 100%.

	Evaluation (%)	Analysis (%)	Application (%)	Synthesis (%)
Multiple Choice	48	56	32	16
Complex Multiple Choice	56	56	64	48
True or False	12	0	0	0
Open-Ended Short Essay	**68**	**68**	56	48
Case Study or Progressing Scenario	**68**	**84**	**80**	**68**
Matching	8	8	4	0
Likert Scale	4	4	0	0
Oral Case Presentation	40	48	56	**68**
Clinical Simulation	**80**	**92**	**84**	**76**

Table 2. Population Demographics

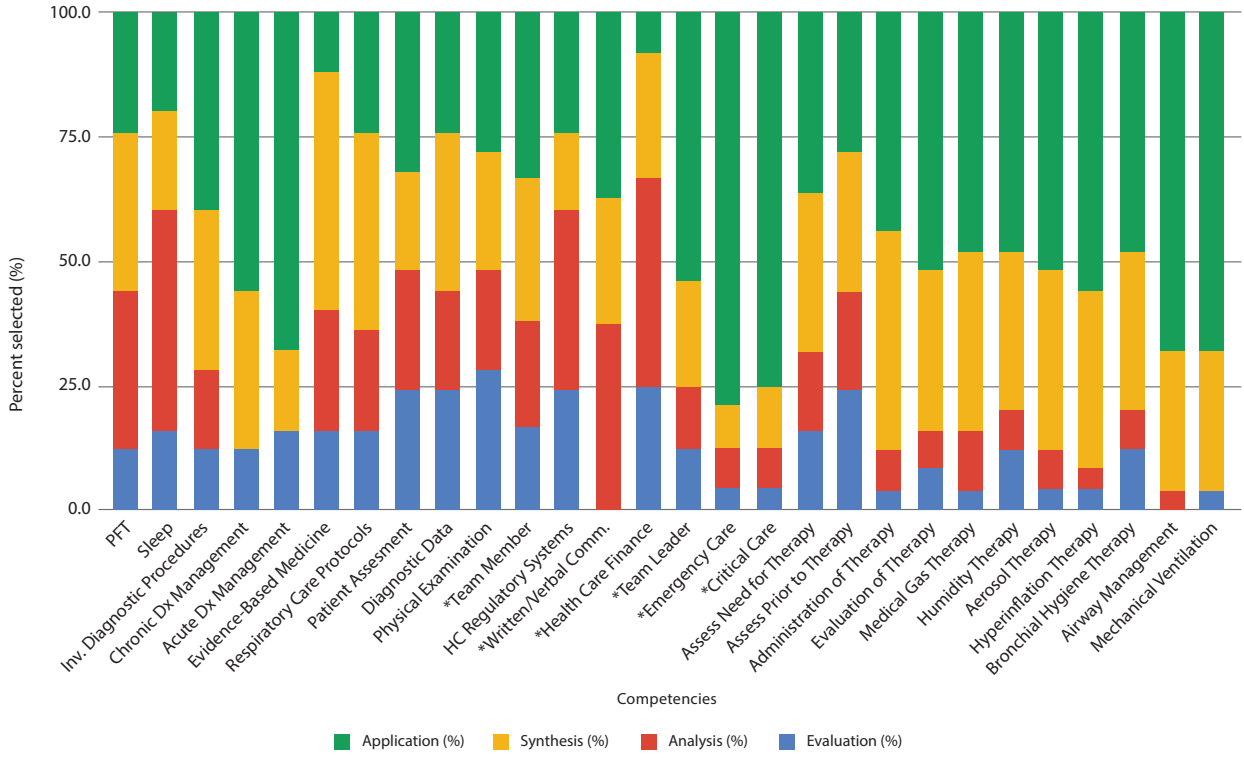
	Participants
Age range (years)	39 - 70
Mean Age (years)	53.5
Gender (%)	66% Female 44% Male
Mean RT clinical experience (%)	17.6
Job Title	72% Program Director 28% Director of Clinical Education

when confronted with challenging situations at the bedside. Rye[13] describes why it is necessary to possess critical thinking in RT. Rye claims that a longitudinal study is of need to assess an RT student's critical thinking capability during time progressive points in their educational program. It is recommended that these skills are assessed at the beginning and end of the program as well as five years into their clinical practice. The design of this longitudinal study will need to effectively evaluate the progression of critical thinking in order to inform educators of teaching strategies that will support the growth of critical thinking the most. In addition, Rye has emphasized that with time the concept of critical thinking in students will grow given the right encouragement, practice and learning environment, but it is with future studies that will prompt students and RTs alike to identify alternate solutions to problems both in clinical settings and in classroom.

This study supported earlier findings that there is a need for a direct critical thinking assessment tool in RT education. Across all domains, program directors and directors of clinical education chose clinical simulation as their preferred testing method to evaluate students' critical thinking. This is likely due to the fact that these testing methods are utilized in the NBRC Therapist Multiple Choice (TMC) exam. Additionally, case study, open-ended short essay, complex multiple choice, and oral case presentation were chosen as top ranking testing methods for the critical thinking domains. True and false, matching, and Likert scale were the least frequently chosen testing methods and therefore should not be used in a critical thinking assessment tool for RT education.

The TMC exam tests three levels of difficulty: recall, application, and analysis. Of these levels, application questions appear on the exam most frequently.[14] Overall, across all assessed competencies, application was the most selected domain to assess critical thinking in RT students.

Figure 1: Critical Thinking Domains of the 2015 and Beyond Competencies



This is likely due to the fact that our sample was a group of educators who are inclined to incorporate many application-based questions into their tests to prepare their students for the TMC exam.

Findings revealed that if a critical thinking assessment tool were to be made based on these results, application would be the best domain utilized to assess and measure change in RT students' critical thinking skills. In light of these findings, competencies that include diagnostic testing, administration of therapy, and applying protocols would benefit from synthesis questions because they require assimilating information together. Although there is not an overwhelming response for the need for questions relating to analysis and evaluation, the experts still identified a fundamental need for each domain. Therefore, the majority of questions developed for an RT critical thinking assessment tool should be application and synthesis based, with fewer questions representing the analysis and evaluation domains. The use of analysis and evaluation in an assessment tool reflects the initial definition of critical thinking to encompass all four domains. Due to the lack of specificity of responses in regard to the appropriate length of a critical thinking assessment tool, the final research question was not able to be answered.

This study has several limitations to discuss. Generalizability of the results is limited because of the small sample size and response (n=25; 23.4%), and the lack of randomization. The study's population of educational experts only included program directors and directors of clinical educators of baccalaureate and master's degree entry to practice programs whose contact information was up to date in the CoARC database. Additionally, the ability to identify the guidelines for the development of a critical thinking assessment tool was affected by not having access to several pre-existing critical thinking assessment tools frequently used in medical and nursing education. Access was restricted due to copyright issues and therefore the study was unable to utilize these tools to provide additional guidelines when developing a critical thinking assessment tool specific to respiratory therapy education. Also, our survey population only included program directors and clinical educators of bachelor programs and some contact information was missing which prohibited follow-up. Additionally, the time frame given to those educational experts to respond to the survey was limited to two weeks and as a result only a small number of them elected to participate. Due to the low response, the group sent out a reminder email again to participants and only a few more responded to the survey. This could be due to the impersonal nature of the survey process via email. The length of the survey questions may have also led to the low response rate, causing participants to not answer the questions properly or leave some of them unanswered. Specifically, six competencies in Figure 1 were not answered completely on the survey. Varying interpretations of the questions on the survey could have led to the wide variety of responses. In the future, testing method definitions should be provided to ensure participants interpret survey terms consistently.

These results can be used as a guideline for creating an individualized critical thinking assessment tool specific to RT education. According to the results of this study, a critical thinking assessment tool should use clinical simulation as the main testing method and include questions from all domains of critical thinking, with the majority representing the application and synthesis domains.

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Appendix A
Survey Instrument

Please answer the following demographic questions:

1. What is your age?
2. What is your gender?
3. How many years have you been a respiratory therapy educator?
4. How many years of clinical experience do you have? (working as a therapist)
5. Are you a Program Director or Director of Clinical of Clinical Education?

For the purpose of this study, we define critical thinking as the ability to apply higher cognitive skills based upon evidence-based practice, which includes evaluation, analysis, synthesis, and application of knowledge.

*The definitions below were taken from Williams C. Critical thinking skills: why you need 'em, how to build 'em. Massage & Bodywork. 2018; 33(5): 38-39.[2]

Evaluation definition - defining the problem by gathering facts through the senses and past experience
Ex: The RT is called to the room of a patient whose SpO2is 75% on 3 L nasal cannula. The RT evaluates the situation and concludes that the pulse-ox is not functioning properly.

1. What testing format do you believe is the best way to test a student's ability to evaluate clinical information? Choose all that apply
    a. Multiple choice
    b. Multiple-multiple
    c. True and false
    d. Open-ended short essay
    e. Scenario
    f. Matching
    g. Likert Scale
    h. Oral
    i. Other:
        i. Please describe _____

Analysis definition - asking specific questions to obtain more detailed and useful information
Ex: The RT is called to the room of a patient whose SpO2 is 75% on 3 L nasal cannula. The RT has concluded that the pulse-ox is not functioning properly. The RT troubleshoots the problem and identifies the cause is poor function.

2. What testing format do you believe is the best way to test a student's ability to analyze clinical information? Choose all that apply
    a. Multiple choice
    b. Multiple-multiple
    c. True and false
    d. Open-ended short essay
    e. Scenario
    f. Matching
    g. Likert Scale
    h. Oral
    i. Other:
        i. Please describe _____

Application definition - deciding on, and implementing, a possible solution to the problem
Ex: The RT is called to the room of a patient whose SpO2 is 75% on 3 L nasal cannula. The RT has identified the problem is poor perfusion. The RT removes the finger probe and replaces it with a forehead probe. The forehead probe immediately starts to read a SpO2 of 95%.

3. What testing format do you believe is the best way to test a student's ability to apply clinical information? Choose all that apply
    a. Multiple choice
    b. Multiple-multiple
    c. True and false
    d. Open-ended short essay
    e. Scenario
    f. Matching
    g. Likert Scale
    h. Oral
    i. Other:
        i. Please describe _____

Synthesis definition - involves identifying how these pieces of information relate to each other. Synthesis is finding links between concepts, objects and processes.

Ex: The RT is called to the room of a patient whose SpO2 is 75% on 3 L nasal cannula. The RT has identified the problem and changed the probe location. The RT has a conversation with the RN about leaving the probe on the forehead until the patient's blood pressure has normalized. The RT then helps to develop a protocol for the unit to help determine the best pulse-ox probe placement in the future.

4. What testing format do you believe is the best way to test a student's ability to synthesize clinical information? Choose all that apply
    a. Multiple choice
    b. Multiple-multiple
    c. True and false
    d. Open-ended short essay
    e. Scenario
    f. Matching
    g. Likert Scale
    h. Oral
    i. Other:
        i. Please describe _____

The following competencies have been identified as necessary for the 2015 and beyond respiratory therapist. For each competency listed, please choose the best domain to be utilized when assessing and measuring change in critical thinking skills of a respiratory therapy student specific to that competency.

*Barnes TA, Gale DD, Kacmarek RM, Kageler WV. Competencies needed by graduate respiratory therapists in 2015 and beyond. Respiratory Care. 2015; 55(5): 601 - 616.12

Evaluation definition: defining the problem by gathering facts through the senses and past experience

Analysis definition: asking specific questions to obtain more detailed and useful information

Synthesis definition: involves identifying how these pieces of information relate to each other. Synthesis is finding links between concepts, objects, and processes

Application definition: deciding on, and implementing a possible solution to the problem

*The above definitions were taken from Williams C. Critical thinking skills: why you need 'em, how build 'em. Massage & Bodywork. 2018; 33(5): 38-39.[2]

	Evaluation	Analysis	Synthesis	Application
Diagnostics:				
Pulmonary Function Technology				
Sleep				
Invasive Diagnostic Procedures				
Disease Management:				
Chronic Disease Management				
Acute Disease Management				
Evidence-Based Medicine and Respiratory Care Protocols:				
Evidence-Based Medicine				
Respiratory Care Protocols				
Patient Assessments:				
Patient Assessment				
Diagnostic Data				
Physical Examination				
Leadership:				
Team Member				
Healthcare Regulatory Systems				
Written and Verbal Communication				
Health Care Finance				
Team Leader				
Emergency and Critical Care:				

Emergency Care				
Critical Care				
Therapeutics				
Assessment of Need for Therapy				
Assessment Prior to Therapy				
Administration of Therapy				
Evaluation of Therapy				
Therapeutics-Applications to Respiratory Care Practice				
Medical Gas Therapy				
Humidity Therapy				
Aerosol Therapy				
Hyperinflation Therapy				
Bronchial Hygiene Therapy				
Airway Management				
Mechanical Ventilation				
How many questions do you feel would appropriately assess critical thinking skills in RT students?				

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Respiratory Therapist Lung Ultrasound Training Program

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Abstract

Background: Over the last decade lung ultrasound (LUS) has been used to assess patients with suspected pulmonary disease. Respiratory therapists (RTs) have the foundational knowledge and skill to learn to perform LUS in the critical care and emergency departments. The Texas Society for Respiratory Care (TSRC) offered a one day continuing education program to teach the clinical use of LUS. This study evaluated the effectiveness of the program in training RTs in LUS. **Methods:** The Lung Ultrasound Training Program, was taught by a multi-disciplinary team of practitioners using didactic lectures, recorded videos, and hands on technical skills. A pre- and post-program knowledge survey was used to determine the effectiveness of the training program. **Results:** Respiratory therapists scored higher on the post-program knowledge survey, following the LUS Training Program, compared to their pre-program knowledge survey. The difference between the mean pre- and post-knowledge scores was significant (50.8% vs 86.7%, p=<.001). **Conclusion:** The Lung Ultrasound Training Program offered by the TSRC is an effective method to assess respiratory therapists' knowledge gains successfully. Further research is needed to evaluate the impact of continuing education programs of this nature regarding retention of knowledge gained, adoption of skills or change in patient outcomes.

Key words: lung ultrasound, standardized patient, lung ultrasound curriculum, technical skills, respiratory therapist

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Introduction

Over the last decade, lung ultrasound (LUS) has been used to assess patients with dyspnea, respiratory failure as well as pulmonary edema, pneumonia or pneumothorax.[1-4] Lung ultrasound is a surface imaging technique performed using a transducer or probe and provides rapid, bedside, noninvasive, radiation-free, diagnostic clinical assessment. Guidelines and standards are published by the British Thoracic Society, European Association for Cardiovascular Imaging, the European Federation of Societies for Ultrasound in Medicine and Biology, the International Liaison Committee on Lung Ultrasound, and the Bedside Lung Ultrasound Emergency (BLUE) protocol, as well as the eight- or twelve-region examination approaches and newly introduced guidelines for LUS with patients diagnosed with COVID-19.[5-9] LUS assessments can be completed in approximately 10-15 minutes when performed by a practitioner with adequate knowledge and skills.[10-12]

The literature is lacking regarding standards for LUS education or skills, the amount of time for training or the timing of follow-up evaluation, and LUS competence for respiratory therapists (RTs) in clinical practice.[2,5,13-18] Hayward[19] describes an LUS Training Program offered to respiratory physiotherapists in the United Kingdom by the Intensive Care Society (ICS) using didactic and hands-on learning experiences and deemed the practitioner competent after completing 10 LUS assessments on patients. While See and colleagues,[20] LUS Training Program for RTs required the RT to complete 10 supervised LUS scans to be considered competent and found a small percent (<2%) of RTs required any assistance with acquiring the image and a small percent (<5%) incorrectly interpreted the image.

RTs have the foundation to complete a cardiopulmonary assessment to identify emergencies based on their knowledge and skills acquired from their academic and clinical experiences. RTs have the clinical expertise to care for cardiopulmonary patients that are acutely ill using their skills to manage mechanical ventilators, therapies, monitor hemodynamic parameters and in few accounts perform LUS independently.[17,20] Furthermore, a recent literature review by Karthika and colleagues[13] recommended LUS training be added to RT educational program curriculum and protocols be developed to support RTs perform LUS.

Aligning with these recommendations and the education goals of the Texas Society for Respiratory Care (TSRC), the TSRC developed this LUS Training Program to provide relevant continuing education for Texas RTs. Continuing education programs that incorporate active learning strategies such as case studies and hands on skills experiences have been described to impact practitioner's performance and outcomes.[21,22] The LUS Training Program consisted of four one-hour presentations that were lecture-based or video recordings and two hours of technical hands-on skill practice using standardized patient volunteers. This program was approved for 6.0 Continuing Education for Respiratory Therapists (CERT) hours by the TSRC. The education goals included providing an opportunity for RTs to attain LUS knowledge and skills. The primary aim of the LUS Training Program was to evaluate the effectiveness of the Training Program using a pre- and post-knowledge survey.

Methods

The Lung Ultrasound Training Program's curriculum consisted of 6 main components: 1. Lecture; 2. Hands-on exercises using the devices and LUS scenarios performed on a standardized patient volunteer; 3. Recorded video lectures; 4. Pre- and post-program surveys; 5. Self-Evaluation Survey and 6. The LUS Training Program evaluation of the presenters. The LUS curriculum was developed by seven Subject Matter Experts (SMEs) that included two pulmonary and critical care physicians who are registered diagnostic cardiac sonographers, an intensivist physician, a registered respiratory therapist, a board-certified vascular access registered respiratory therapist, and two registered radiologic technologists who are registered diagnostic medical sonographers. The SMEs identified the curriculum topics to include in the Training Program provided in Table 1. These topics included the pathophysiology identified with LUS; review of anatomy and physiology of the thorax, diaphragm, lungs and heart; basic ultrasound physics, use of the equipment and probes/transducers, probe and patient positioning, LUS interpretation (A-lines, B-lines, consolidation, lung sliding, and artifact). The didactic curriculum was lecture based using Microsoft PowerPoint® presentations by the SMEs. The LUS imaging and interpretation video recordings were used for one didactic session and focused on some of the most important concepts associated with LUS.

The hands-on experience used the same equipment and supplies that would be used in the patient care settings. The ultrasound machine and probes used for this training were Fujifilm SonoSite, Inc. (FUJIFILM SonoSite, Inc. Bothell, WA) equipped with Phased Array P19, Curved C11 and the Linear L25 Probe/Transducer. Standardized patients were volunteers with normal anatomy that helped preserve the authenticity of the imaging process and provided a safe environment for learning. The SMEs

Table 1. Curriculum Topics

Didactic Lectures	Video Recordings & Technical Skills Experiences Video
History of Ultrasound	Ultrasound Settings
Technical aspects of ultrasound	Probe Selection
Physiology of Heart & Lungs	Probe Placement Zones Lung Slide (Pneumothorax) Diaphragm (Pleural Effusion)
Criteria & Indications	Identify Anatomy Trachea Esophagus lung
Equipment overview	
Imaging zones	
Baseline imaging – B mode, A line, Lung sliding, quad sign, sinusoid sign, shred sign, tissue like sign, B line artifact, absent lung sliding, lung point	
Limitations of the use of lung ultrasound	

evaluated the learner's ability to perform the following skills: entering patient information; probe/transducer selection; choosing the correct examination presets; image optimization (gain and depth) and storage of images, probe placement zones to assess for pneumothorax (lung slide using the Linear L25 probe/transducer), pleural effusion (Diaphragm-Phased Array P19 Probe and Curved C11 Probe), and placement of an endotracheal tube (Neck-Linear L25 Probe).

The use of pre- and post-program knowledge assessment after a daylong workshop to measure knowledge gained is supported in the literature.[23] The SMEs developed a 6-item knowledge survey that was administered to the learners immediately before and at the completion of the education day. The knowledge survey was based on the LUS Training Program objectives and hands-on skills experience. The knowledge survey was used to measure learning gains from the LUS Training Program and is displayed in Appendix A. Examples of items on the knowledge survey included identification of the appropriate probe to assess for specific pathology; interpretation of the LUS images, and patient position during the LUS. A maximum of 6 points could be obtained. For single-answer questions, the learner would receive one full point if the question were correctly answered. For the one item that required two answers, the learner received either one full point for correctly answering, 0.5 point for answering one of the two correct answers or no point for incorrectly answering the question. No points were awarded for completely incorrect or skipped questions. The criterion of success was set at 70% to demonstrate a passing score. In addition to assessing knowledge gained, we also assessed the learner's perceptions using the LUS Training Program Self-Evaluation Survey displayed in Figure 1. This survey used a Likert scale of Strongly Agree (5 points), Agree (4 points), Disagree (2 points) and Strongly Disagree (1 point) and did not include a neutral score to avoid all neutral responses.

This study was submitted for review by the Texas State University Institutional Review Board and determined to be an exempt study protocol.

Figure 1. Lung Ultrasound Training Program Self-Evaluation

Evaluation Item	Strongly Agree	Agree	Disagree	Strongly Disagree
Course developed my ability to apply theory to practice				
Course provided the opportunity to practice the skills required in the course				
Course allowed me to synthesize fundamental knowledge and skills				
Course gave me a deeper insight into the topic				
Course met my expectations				

Statistical Analysis

Statistical Package for Social Sciences (SPSS®) version 25 (IBM®, Chicago, IL) and Microsoft Excel for Microsoft 365 were used to analyze the quantitative data. One factor t-tests were used to compare pre- and post-program knowledge survey scores with the criterion of success (set at 70% for this survey). A two tailed paired t-test was used to compare the pre- and post-program knowledge scores.

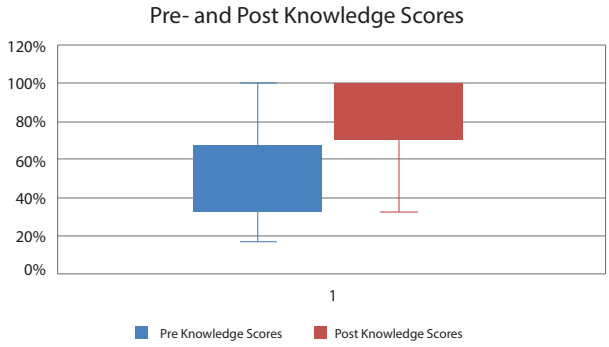
Results

A pre- and post-program knowledge scores analysis was performed to measure learning gains in the LUS Training Program. Of the 21 learners, only 20 completed the pre- and post-program knowledge surveys. Total mean pre- and post-program survey knowledge scores are displayed in Table 2 and Figure 2 depicts the distribution of the total mean scores.

Table 2. Total Mean Pre- and Post-Program Knowledge Survey Scores

N=20	Pre-Scores	Post-Scores	Difference	% Changes
Total Mean Scores	3.05	5.2	2.15	70.5%

Figure 2. Lung Ultrasound Training Program Pre- and Post-Knowledge Scores



The mean pre-program knowledge survey score was 3.05, SD=1.3 and 2 (10%) learners met or exceeded the criterion of success for the pre-program knowledge survey. The difference between the pre-program knowledge score and the criterion of success was statistically significant: t(19)=-3.45,p<0.005. The difference between these scores had a medium effect size (Cohen's d=-0.77). The pre-program survey scores fell short of meeting the criterion of success.

The post-program knowledge survey score was 5.02, SD=1.2 and 15 (75%) learners met or exceeded the criterion of success for the post-program knowledge survey. The difference between the post-test score and the criterion of success was statistically significant: t(19) = 3.74, p<0.005. The difference between these scores had a large effect size (Cohen's d=1.75). The post-program knowledge scores greatly exceeded the criterion of success.

There was a statistically significant increase between the mean pre- and post-program knowledge survey scores (35.8%) using a two-tailed paired t-test: t(19), 6.0, p<0.001. The magnitude of this difference has a large effect size (Cohen's d=1.75). Knowledge was gained between the start of the course and the end of the course.

Prior to the LUS Training Program 25% (n=5) of the learners were unfamiliar with when to use the linear probe to assess a patient during LUS and 40% (n=8) of the learners were unfamiliar with the presence of B-lines while performing LUS. However, prior to the Training Program, 45% (n=9) of the learners were familiar with the appropriate position to place a patient being evaluated for a pleural effusion during LUS. We observed 90% (n=18) of learners' knowledge was gained to identify the primary use of the linear probe to assess the lung. While, 85% (n=18) of learners' knowledge increased related to the LUS mode to use to document the presence or absence of a pneumothorax.

Of the 21 learners that completed the learner's perceptions using the LUS Training Program Self-Evaluation Survey, 100% strongly agreed the Training Program developed their ability to apply theory to practice. However, 19 (90.4%) strongly agree the LUS Training Program met their expectations and they had the opportunity to practice the skills required. Regarding the Training Program allowing the learner to synthesize fundamental knowledge and skills as well as giving the learner a deeper insight on the topic of LUS, 18 (85.7%) strongly agreed.

Qualitative feedback included one learner stating, "movement of the probe is a difficult skill to become proficient in and more hands-on with this will be beneficial" while four learners stated they would "like to have PowerPoint material for review prior to the program." One learner stated, "The center needed a better sound system" and "It was a very good program and learned something about ultrasound. Would like to know more."

Discussion

This LUS Training Program offered by a multidisciplinary team comprised of didactic lectures, video recordings and hands-on technical skills experience demonstrated RTs knowledge was gained. Based on the knowledge scores, it is feasible to conclude training

programs like this one can provide guidance for RTs to develop additional skills. The authors recommend a quarterly offering across the state of Texas and to expand the hands-on skills stations with more advanced simulation. It is reasonable to consider RTs with this type of training as vital to the emergency department and critical care units when evaluating patients with signs and symptoms associated with pneumothorax or pleural effusion quickly to determine a plan of care. The ability to perform procedures like the LUS can be time sensitive and life saving for patients. Areas for further research focused on the use of LUS are in telehealth or telemedicine and exploring the use of LUS with patients suspected of having the novel 2019 coronavirus (COVID-19).

The goal of this LUS Training Program was not to establish competency, the goal was to provide an opportunity for learning LUS skills and gain knowledge. The Training Program knowledge survey results indicate the RT's knowledge significantly increased following the Training Program. See[20] and Wong[17] support trainings like this one be done in a short period of time with appropriate didactic learning and hands-on demonstration experiences with the LUS equipment under direct supervision. Moreover, training programs that involve active learning strategies and hands-on learning result in improved outcomes and learner satisfaction.[21,22] Our findings may be concordant with other studies demonstrating positive results of RTs and respiratory physiotherapists knowledge and skills gained following a training program.[17,20,24]

The authors propose further evaluation of a robust training program with simulation and debriefing model and the addition of standardized patients with cardiopulmonary diseases. This would allow the learners to obtain more hands-on clarification of normal versus abnormal pathologies. The authors also recommend frequent follow-up with the learners to assess how these new skills and knowledge have or have not been implemented into practice. This type of follow up would provide a deeper understanding of short- and long-term impact of these types of training programs. Like Karthika and colleagues,[13] we also recommend LUS education be integrated into entry to practice respiratory care programs and protocols focused on RTs performing LUS be developed and implemented.

Limitations

This LUS Training Program did have a few limitations; first, a small number of learners participated due to the limited number of SMEs for training, space, and equipment to offer sufficient time for learners to have hands-on practice and skill training. Second, the pre- and post-knowledge survey did not undergo reliability and validity testing, nor was there a control group. Third, the program aimed to improve knowledge and gains in learning on a short-term basis and follow-up long-term to measure knowledge retention and skills was not feasible. Fourth, we were not able to evaluate the impact of the LUS Training Program on the RTs clinical practice. Last, we also recognize the LUS Training Program does not deem LUS skill competence and RTs require extended supervisory practice after attending this training program.

Conclusion

The LUS Training Program offered by the TSRC increased the respiratory therapists' knowledge, as well as provided an opportunity for the RTs to apply their new LUS skills with standardized patient volunteers. Overall, the use of this one-day LUS Training Program met the expectations of the training program successfully.

Acknowledgement

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Appendix A
Lung Ultrasound Training Program Pre- and Post-Program Survey

1. The optimal probe to use for lung sliding is:
    a. Linear probe
    b. Phased array probe
    c. Curvilinear probe
    d. All the above

2. What do A-lines represent?
    a. Pulmonary edema
    b. Pleural effusion
    c. Pneumothorax
    d. Normal lung

3. What do B-lines represent?
    a. Alveolar interstitial fluid
    b. Normal lung
    c. Pneumothorax
    d. Pleural effusion

4. The M-mode may be used to document the presence and/or absence of what pathology?
    a. Pleural effusion
    b. Pneumothorax
    c. Pulmonary edema
    d. Atelectasis

5. What is represented in the image below?
    a. A-lines
    b. B-lines

6. How should the patient be positioned when doing an evaluation for a pleural effusion? (Choose all that apply)
    a. Supine
    b. Upright leaning forward slightly
    c. On the suspected side
    d. Prone

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Integration of an ECMO Course into an Entry-to-Practice Bachelor of Science Respiratory Care Program

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Abstract

Background: An extracorporeal membrane oxygenation (ECMO) course was integrated into an entry-to-practice Bachelor of Science in Respiratory Care (BSRC) program. The primary goals of this manuscript are to share the details related to the integration of this ECMO course and to measure the differences in knowledge gained between entry-to-practice respiratory therapy students and health care practitioners (respiratory therapists (RTs) and nurses (RNs)) with at least two years of Intensive Care Unit (ICU) experience becoming ECMO specialists. **Methods:** A multi-disciplinary team of practitioners taught the same ECMO course to both entry-to-practice RT students and health care practitioners asynchronously. A paired t-test was used to compare the entry-to-practice RT student post-course comprehensive knowledge scores to skilled health care practitioners' scores. **Results:** A total of 19 entry-to-practice RT students and 19 experienced health care practitioners mean comprehensive knowledge scores were compared. The entry-to-practice RT student's comprehensive knowledge mean score was 86.11%; (SD±4.13%; range 80-94%) and 90.92%; (SD±5.58%; range 80-100%) for the skilled health care practitioners (P=0.002). **Conclusion:** A BSRC entry-to-practice program successfully integrated the same Extracorporeal Life Support Organization guideline based ECMO course used to train health care practitioners to become ECMO specialists. The entry-to-practice RT students met or exceeded the established knowledge and wet lab standards to commence bedside training as ECMO specialist. Although the RT students met the standard, they scored less than experienced practitioners. Further educational research is required to establish the need for integrating ECMO courses into entry-to-practice respiratory care programs.

Key Words: Extracorporeal membrane oxygenation course, curriculum, respiratory therapy education, entry-to-practice respiratory therapy student

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Introduction

Extracorporeal Life Support (ECLS) temporarily supports the heart or lung function during cardiopulmonary failure using several mechanical devices resulting in organ recovery or replacement.[1] Extracorporeal Membrane Oxygenation (ECMO) is a common form of ECLS. Because ECMO is used to provide care to patients with life-threatening conditions, the practitioners, like respiratory therapist (RTs), must have strong critical thinking skills and knowledge of cardiopulmonary physiology as well as the ability to manage and troubleshoot highly technical equipment.[1] The ECMO content was traditionally taught in this Bachelor of Science in Respiratory Care (BSRC) entry-to-practice program as a module in the critical care course by a member of the ECMO team. However, the module only provided an overview of the topic and did not incorporate hands-on experience with the equipment. Since RTs have a significant role in managing patients who are receiving ECMO, and about one third of all ECMO teams are led by RTs who have become ECMO specialists,[2, 3] it may be beneficial to incorporate this training into the curriculum. There is no existing literature describing the integration of a formalized ECMO course as part of an entry-to-practice BSRC curriculum.

The faculty collaborated with one of our clinically affiliated ECMO teams to integrate the same ECMO course into the BSRC program's final semester that a group of health care practitioners (RTs and nurses (RNs)) took a week prior to the BSRC course. This ECMO course is currently used to train practitioners with at least two years of ICU experience to become ECMO specialist. This ECMO course is based on the Extracorporeal Life Support Organization (ELSO) principles and include didactic and hands-on simulation experiences.[4] The ECMO course used an in-house post-course knowledge assessment because ELSO does not offer a comprehensive assessment tool but recommends having an oral or written knowledge assessment for new learners.[5]

This led us to ask the following question: Can entry-to-practice RT students learn the didactic principles and pre-bedside skills at the level required to become ECMO specialists and if so, how do their results compare to those of the health care professionals who completed the same course and assessment? Therefore, following the two courses, we planned to compare the post-course knowledge assessment scores for the health care practitioners to the entry-to-practice RT students.

Methods

Objectives

The main objectives of this study were to share the integration of the ECMO course curriculum and to compare entry-to-practice RT student course knowledge scores to those of skilled health care practitioners becoming ECMO specialists.

Design

The ECMO course offered by our clinical affiliate to train health care practitioners to become ECMO specialist was used to teach the entry-to-practice BSRC students during their final semester. The ECMO course was based on the ECMO guidelines and the *ECMO Specialist Training Manual, 3rd Edition* and provided by content experts (cardiothoracic surgeons, pediatric intensivists, neonatologists, ECMO coordinators (RN and BSRC RRT), and a cardiovascular perfusionist) using the same lectures, equipment, simulations, debrief, game, and knowledge assessment.[4, 6] The curriculum was taught over four days using lectures, hands-on simulation activities, and a jeopardy game to review and test knowledge. The fifth day was dedicated to a large-scale simulation and administration of a post-course comprehensive knowledge assessment. The ECMO program, course curriculum, game, simulation, and post-course comprehensive assessment are described below. This study was submitted for review by the University of Texas Health Science Center at San Antonio Institutional Review Board and determined to be exempt from institutional review board approval.

Educational Program

The ECMO course offered to the practitioners and entry-to-practice RT students consisted of 4 main components: 1. An intensive didactic ECMO course curriculum; 2. Dedicated hands-on simulation exercises on the ECMO circuit and ECMO scenarios performed on a low fidelity mannequin (ECMOJO) which reflected real-life bedside experiences; 3. Debrief sessions followed to review the case scenarios; 4. Post-course comprehensive knowledge assessment.

Didactic Curriculum

The didactic curriculum included lectures covering a wide range of ECMO topics including the pathophysiology of common diseases requiring ECMO, ECMO circuit anatomy and cannula placement, ECMO physiology, special indications for ECMO, and case studies. Another important segment of the curriculum dealt with the medical ethics associated with ECMO, including the patient's best

interest, shared decision making, which patients should be offered ECMO, and when is it appropriate to withdraw ECMO. A complete list of topics covered in the ECMO course is provided in Table 1. Clinical scenarios, games, laboratory exercises, and didactic materials used in the hospital setting with the practitioners were also used for the RT students. Take home readings and handouts were provided. At the end of each day the ECMO coordinators incorporated simulations and case scenarios that highlighted potential problems that might arise during ECMO and how to troubleshoot and resolve these issues.

Table 1. Curriculum Topics

History & future of ECLS	Blood product administration
Criteria & Contraindications	Veno-Venous (VV) vs. Veno-Arterial (VA) ECMO
Physiology of Neonatal Respiratory Failure	Special Considerations for Cannulation
ARDS & Other causes of respiratory failure	Daily management of the ECMO patient
Physiology of ECMO	ABG analysis on ECMO
Equipment overview & circuit configurations	Management of Complex cases
Vascular Access for ECMO	Medical emergencies in the ECMO patient
Coagulation & Anticoagulation	Medical emergencies & the Circuit rupture
Ethical Considerations in ECMO	Medical Administration on ECMO
Renal Failure and Renal Replacement Therapies	Cardiac ECMO
ACT & Heparin Management	ECMO transport
Short and long-term developmental outcomes of ECMO patients	Pediatric Case Studies
Family centered care of the ECMO patient	Neonatal Cases
	Adult Cases
Note: ECLS = Extracorporeal Life Support; ECMO=Extracorporeal Membrane Oxygenation; ARDS = Acute Respiratory Distress Syndrome; ABG= Arterial Blood Gas; ACT=activated clotting time	

Simulation Hands-On Laboratory

The simulation laboratory experiences were structured hands-on time with an ECMO circuit (i.e., wet laboratory) and a low fidelity mannequin (ECMOJO). They were conducted during the last day of the ECMO course in the respiratory care simulation laboratory. The same equipment and supplies a patient would require were used to maintain authenticity. The health care practitioners and the RT students had hands-on practice in every aspect of the official ECMO training from repairing circuit ruptures, changing out oxygenators, to "walking the racetrack." The "wet lab" or "simulation day" is always designed as a safe environment to reduce anxiety, maximize learning in this exercise prior to a final ECMO course comprehensive post-course knowledge assessment. Health care practitioners and RT students were introduced to the low fidelity simulator (ECMOJO) pictured in Figure 1. This simulator was constructed by the ECMO Team Coordinators and included a baby cardiopulmonary resuscitation (CPR) mannequin with ECMO cannulas attached to an ECMO circuit and pump to simulate veno-arterial cannulation of a patient. A monitor was created using a Microstoft PowerPoint® slide projecting the ECMOJO vital signs, hemodynamic values, arterial blood pressure, end tidal carbon dioxide values and electrocardiogram readings in accordance with the given scenario. The hands-on experiences reinforced the technical skills required to troubleshoot ECMO circuit complications.

Figure 1. ECMOJO

Debriefing

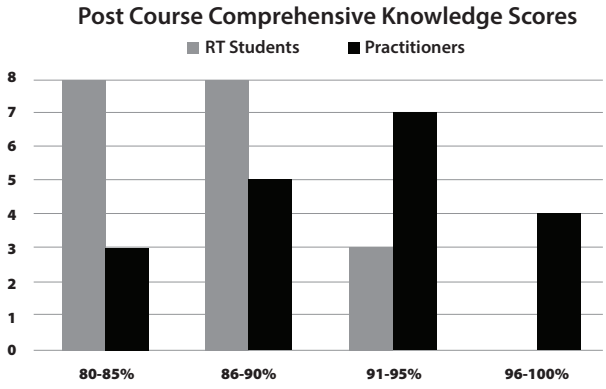
After each simulation case scenario, the RT students and practitioners participated in a 20 to 30-minute debriefing. During these skill-focused debriefing sessions, the ECMO coordinators reviewed common mistakes made

by RT students and practitioners during the simulated scenario and reviewed relevant skills to apply clinically or troubleshoot equipment failures. The debrief sessions helped to stress the performance standards.

Post-Course Knowledge Assessment

Prior to offering the post-course knowledge assessment to the practitioners and entry-to-practice RT students, a jeopardy game was administered to review the most

Figure 2. Post Course Comprehensive Knowledge Scores for Entry to Practice Respiratory Therapy Students and Practitioners



important ECMO concepts. The post-course knowledge assessment consisted of 50 items. The post-course knowledge assessment was completed during the last 2 hours of the last day of the course. The questions were compiled by the ECMO faculty and aligned with the presentations, case scenarios and hands-on simulation laboratory experience. These post-course knowledge scores were collected and de-identified. Since a score equal or above 80% is required by practitioners to receive the certificate of completion, RT students with similar scores were eligible for the certificate of completion. Comprehensive knowledge scores of RT students were compared to those obtained by practitioners who had just completed the same ECMO course.

Statistical Analysis

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS®) version 25 (IBM®, Chicago, IL). Descriptive data is expressed as means and standard deviations. Post-course comprehensive assessment knowledge scores from RT students and practitioners were compared with a student's T-test. Statistical difference was defined as a P value <0.05.

Results

A total of 19 senior RT students participated in an ECMO course offered to 19 practitioners (14 RTs, 5 RNs) a week earlier as a requirement to become ECMO specialists. All RT students participating in the ECMO course had less than a year of ICU experience in the ICU, while practitioners had between 2 and 15 years. There was a statistically significant difference between mean comprehensive assessment scores between RT students (86.11%; SD+4.13%; range 80-94%) and practitioners (90.92%; SD+5.58%; range 80-100%) (P=0.002). Only 36.8% (n=4) of the RT students scored a 91% or better compared to 57.9% (n=11) of practitioners. No RT student had a score 96% or better compared to 4 practitioners (21.1%) who did (Figure 2).

Discussion

This study described the integration of an ECMO course into an entry-to-practice Bachelor of Science in respiratory care program and compared post-course knowledge scores of entry-to-practice RT students to health care practitioners with two years or more of ICU experience after participating in the same ELSO-guided ECMO course. The results demonstrated entry-to-practice BSRC students attained the required score of 80% on the post-course knowledge survey; thus, reflecting their ability to understand the didactic principles and pre-bedside skills to the required level to become ECMO specialists.

According to our findings, the health care practitioners mean post-course knowledge scores were higher than the entry-to-practice RT students' mean post-course knowledge scores. While a 4-5% increase in post-test scores may be statistically significant, its practical significance and ability to competently provide ECMO needs to be evaluated. Clearly, experienced practitioners often have relevant knowledge obtained in the critical care setting or had better foundations on which to build ECMO knowledge. Our results were in accordance with a study by Kim & Kim[7] where an ACLS course was offered to nurses working in the critical care unit and nursing students. The RN students did well but their scores were less than that of RNs that took the same course.[7] Furthermore, a study conducted in Saudi Arabia compared professional nurses to nursing students' knowledge of basic life support (BLS) and found professional nurses have higher knowledge of BLS than the nursing students and the difference between the group was statistically different (p=0.001).[8] Therefore, we might conclude the health care practitioners' knowledge

acquisition is influenced by their critical care experience.

Looking at the ECMO curriculum, these simulation experiences are well suited to RT students and practitioners learning and practicing new skills in a deliberate and repetitive manner without distractions or concerns of a real patient. ECMO is a high-risk procedure with a significant level of mortality and morbidity, often due to mechanical failures, pump malfunction, oxygenator failures, or tubing rupture. ECMO simulations help the learner develop critical thinking skills, an understanding for the patient-pump physiology, and a systematic approach to real time changes in ECMO flow.[5] Several studies have reported how the use of physiologic feedback during the ECMO simulation enhances the reality and applicability of the simulation to patient situations, thus increasing learner knowledge, self-confidence and overall outcomes.[9-12] Having the ECMO coordinators available to troubleshoot the ECMO circuit was critical for the RT students and practitioners to maximize simulation learning. These activities led to greater competency during the hands-on simulation with ECMOJO when psychomotor and technical skills were observed. Although ELSO has endorsed this learning model, there are no specific strategies or curriculum for running the simulation except to use small groups to allow each learner to have hands-on experience.[13] A realistic course gains the student ECMO experience in a controlled, supervised environment without actual risk to an actual patient.[14] This course may have increased RT students' and practitioners' comfort in caring for these patients.

An integrated ECMO curriculum like the one described here is not an accreditation requirement nor is it directly tested on the Therapist Multiple Choice (TMC) or the Clinical Simulation Examination (CSE) National Board for Respiratory Care (NBRC) examinations.[15, 16] Much of the content taught in this ECMO course (Table 1) (i.e., physiology of respiratory failure, acute respiratory distress syndrome (ARDS), vascular access, coagulation and anticoagulation, ethics, renal failure and replacement therapies, family centered care, medical emergencies, and blood product administrations) reinforce critical and clinical content listed on the TMC and CSE Detailed Content Outlines as expected knowledge (i.e., evaluation of patient records and perform clinical assessment, perform procedures to gather clinical information, evaluate procedure results, ensure modifications are made to the care plan based on the patient response, management of ARDS, discontinuation of treatment based on patient response, provide respiratory care techniques in high-risk situations to include cardiopulmonary emergencies excluding CPR, assist a physician/provider in performing procedures such as insert arterial or venous catheters, ethics, and pharmacotherapies).[16, 17] Furthermore, ECMO is directly tested on the Adult Critical Care Specialty (ACCS) and the Neonatal Pediatric Specialty (NPS) examinations.[18, 19] These two examinations assess the RT's ability to manage ventilation and oxygenation using ECMO in the critical care area that is above and beyond that which is required to earn the Registered Respiratory Therapy (RRT) credential.[18, 19] The ACCS examination requires the entry-to-practice RT graduate to have earned the RRT credential and have one year of experience prior to attempting the examination. On the other hand, the NPS examination requires the entry-to-practice RT graduate to have earned the RRT credential without any experience requirements. Our results indicate the entry-to-practice RT students have gained the knowledge to manage ventilation and oxygenation using ECMO. This may be a benefit to integrating the ECMO curriculum.

The entry-to-practice respiratory therapist competencies are outlined in the American Association for Respiratory Care (AARC) Taskforce on Competencies for Entry into Respiratory Therapy Practice document.[20, 21] These competencies are acquired before or after entry into respiratory care profession. The competencies to be acquired before entry into professional practice (i.e., pharmacology, patient assessment, develop administer, evaluate and modify respiratory care plan, use evidence base medicine protocols and clinical practice guideline, utilize appropriate diagnostic and monitoring tools) are reinforced in this integrated ECMO curriculum.[20, 21] On the other hand, the competencies to acquire after entry to RC professional practice (i.e., conduct monitoring and follow up evaluation, invasive diagnostic procedures, and identify indications for circulatory gas exchange devices) are also reinforced in this integrated ECMO course curriculum.[20, 21] The authors believe integrating this ECMO curriculum into the entry-to-practice BSRC program expands the knowledge and heightens the students awareness about their future role in the ICU and caring for patients receiving ECMO. This was emphasized in a study by Li et al, who reported RTs who graduated from a bachelor's degree program in China were involved in advanced procedures such as ECMO management.

Limitations

This study has several limitations. The small sample size prevents generalization of results. ELSO does not have a validated course assessment; thus, each hospital and school-based program establishes their own examination. This course offered the written post-course

assessment as the last activity of the course, unlike other life support training programs in neonatal and pediatric resuscitation that offer the assessment before moving on to the hands-on and technical practice to confirm the students has a basic comprehension of the content. These programs utilize assessment early in the curriculum to increase information retention and allow the student to recognize areas of weakness that can be addressed in later phases.[23] Finally we recognize the entry-to-practice RT student will not be an ECMO specialist at the end of the course due to the lack of actual pump time and critical care experience. Johnston and colleagues[24] recommend novices spend 16-32 hours of supervised clinical practice accompanied by an ECMO specialist.

Conclusion

A BSRC entry-to-practice program integrated the same ELSO guideline-based ECMO course used to train health care practitioners to become ECMO specialists. Results demonstrated students were adequately prepared to meet the same standards as experienced practitioners but scored significantly lower on the final assessment. Much of the ECMO curriculum aligns with the competencies for entry into the respiratory therapy professional practice so it directly ties to enhancing board preparation. Furthermore, the ECMO curriculum prepares the entry-to-practice RT students for an advanced skill that has become essential in special clinical conditions and allows them to be at the forefront of applicants when there are openings on an ECMO team.

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