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Adapting and Evolving: A Panel Discussion on Respiratory Care Education

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Abstract

Respiratory care education has traditionally relied on a blend of didactic, laboratory, and clinical learning environments to improve the knowledge and skill of the student. As technology advances, the ways education is provided have expanded to include a wide variety of options, including online and blended courses, electronic textbooks, and social media. The purpose of this panel discussion was to explore the future of learning in the context of respiratory care education.

Key Words: higher education, respiratory care education

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Introduction

As technology advances, so does the respiratory care educator's ability to expand the ways in which education is delivered. In that regard, the future of learning is only limited by the speed at which technology evolves. Integrating technology into respiratory care curricula is successful when the media is able to facilitate learning that is important and meaningful to the learner. Learning can occur in a number of venues and through countless media; music, video, interactive gaming, computerized simulations, and interactive online communities are currently used as educational platforms to accommodate the needs of learners. The ability of the educator to adapt to the changing technology and learner needs is vital to the success of student learning. The purpose of this panel discussion was to explore the future of learning in the context of respiratory care education. The panelists discussed student learning, resources, e-learning, and the future role of the respiratory therapist.

What changes have you noticed regarding how students learn and study today versus 10 years ago? What attributes will the student of the next decade need to have to be successful in a respiratory care program?

BEACHEY: I do not believe the way the human brain builds knowledge and gains understanding (learns) has changed a great deal in modern history; what has changed is the way we come into contact with information—its accessibility, and the speed at which it can be accessed. Of course, students differ in preferred learning styles (aural, visual, verbal, alone or in groups, etc.), which means teachers should use a variety of methods, but in the end, cognitive conflict or puzzlement is the stimulus for learning. Lack of puzzlement means nothing new is perceived and nothing is learned. Something new can only be learned if it can be made consistent with familiar pre-existing cognitive structures. Information is not knowledge, and much less, understanding. Teaching for understanding implies the engagement of students in activities that create disturbances in habitual reasoning—something that produces a puzzling result or a question that calls for an answer. The student then tries to modify pre-existing knowledge in such a way that the puzzling thing fits in and makes sense, which generates new, more viable understanding. Learning is best facilitated when the teacher designs authentic activities similar to those students will encounter in the real-world environment, where the new understanding will be used. I believe we learn in this way, regardless of whether the subject matter is presented in face-to face communication, YouTube, text, Snapchat, or some other electronic means. The difference in today's learning environment compared to a decade or two ago is the continuous availability of an overabundance of information, immediately transmissible via mobile technology. Perhaps something teachers must focus on more today is how to help students critically evaluate the legitimacy of information sources.

My personal experience is that in spite of their high degree of technological sophistication, my students still prefer the hard copy of their textbook; they want to physically mark it up with multi-color highlighters. Besides the obvious attributes of curiosity, perseverance, compassion and empathy, successful students have effective human interaction skills, and a desire to continuously learn.

MOSS: Will, You offer a nice summary of a complex process. My students also (so far, anyway) prefer to read hard copies of their textbooks. Much to my dismay, however, sometimes they choose to rent them. This practice may curtail active reading (highlighting, underlining, writing notes in the margin) and reduce retention. It also limits ready availability of important resources for examination preparation and general study.

GARDENHIRE: I agree with Dr. Beachey's assessment of the abundance of technology and assisting students evaluate information. Today, educators are doing this in "flipped" classrooms. Flipped classrooms provide the educator and student with an avenue to utilize technology by listening to podcasts or videocasts before coming to class. The educator then can spend the time assisting students with the information instead of lecturing to them. This time spent on using information will help in the critical evaluation of the topic covered.

BECKER: I do not believe that students learn any differently today than they did years ago. Learning still requires effort and effort takes time. Today's technology does however change how students access information and also influences how some students study. Increased access to information through internet search engines, online videos, and bibliographic databases provides current students with easier access to resources that can clarify content. There is also a greater connectivity among students that permits more potential for group study and problem solving.

The instant access to large amounts of information can also present challenges. Current students are comfortable quickly accessing facts that they need to "know". However, much of respiratory care practice requires that students "know how" to use and apply information. It takes time to process information at this higher level. Current students have less patience making the transition from thinking about knowledge as quick retrieval of information bits to the slower and deeper thinking required for applied knowledge.

Attributes of the successful student in the next decade will require intellectual curiosity, self-discipline, and time management; all skills similar to years past. The growth in technology, however, requires students to be more skilled in information retrieval to take advantage of technology's power and judge the quality of information retrieved. Successful students will also need to be excellent communicators in oral, written, and electronic formats to effectively share their knowledge with others and interact professionally. The future student needs to be aware of the benefits and risks associated with the immediacy and permanence that online sharing presents.

GARDENHIRE: The student today has a large number of technology options to assist in learning and I assume the technology rage will continue for the future. Currently, textbook publishers have numerous online learning options to assist the student that has purchased a textbook. Technology that is free is a popular learning tool among students, such as Quizlet which offers the creation of flashcards as a form of learning. I see students continue to work together offering group learning outside of class that can be helpful to many students. However, simulation will be the gold standard of teaching and learning in the future.

Many respiratory therapy (RT) programs today have some form of simulation to assist student learning. Low-fidelity mannequins, high-fidelity mannequins and trained standardized patients will be the arsenal needed for the future. In caring for the life of a human, we in RT will need more standardized simulated care to reduce mistakes that may contribute to a negative outcome.

RYE: The Millennial (Generation Y) students of today are the most computer literate generation to enter our classrooms and their learning expectations now include web-based tools such as online courses and online journals. This group of students uses multi-media for learning as well as communication via text messaging, instant messaging, e-mail, and participation in chat rooms on their smart phones. Many of them have been raised by "helicopter parents" in an era of instant access resulting in an intense need for interconnectivity and perhaps a sense of entitlement.

BECKER: Dr. Rye points out that our current students are the most computer literate generation to enter the classroom. I agree that this student group has greater computer literacy than in years past, yet most current generation students still do not possess academic computer skills. For example, most students do not spontaneously label files in meaningful ways and often cannot locate the correct file if created a few weeks ago. Many students do not maintain back-up copies. Further, I have not found many current students who are familiar with word processing formatting and editing skills or formula skills in spreadsheets. Thus I think it is important to provide as much computer literacy support to those students in the current generation as we might with a returning adult student.

RYE: Ten years ago, the Generation Xers were perhaps a bit more adaptive to a more structured learning environment. This group of students, however, demanded instructors provide them with carefully laid out policies and procedures of what was expected of them. The Gen X student wanted sequential steps involved in all assignments with the instructor leaving nothing to interpretation. This group of students was a bit rebellious and cynical with a strong desire to create new 'rules'. Moreover, the Gen Xers had fewer opportunities available to them and a lesser sense of entitlement than Millennials.

Generation Xers were rewarded by freedom while the Millennials are more concerned with doing work that has meaning. Generation Xers wanted fast feedback and credit for results while Millennials are more concerned with having supervisors who to get to know their capabilities so that students can be put into roles that push their limits.

The students of the next decade will be more concerned about being able to afford a college education and their college education. A heavy reliance on the use of technology in the classroom will continue and the use of social media is predicted to be even more important to this newer generation of learners. This highly technical dependent group of learners may have developed a tendency to hop from link to link in an attempt to find quick answers to information that they do not understand. This may hinder their ability to comprehend complex information and their ability to focus on single phrases, read between the lines, and understand subtle details. Respiratory Care students of the next decade will be expected more than ever to be prepared for active learning and be self-motivated to acquire knowledge and enhanced skills. Participation in active learning has been shown to stimulate higher-order thinking, problem solving, and critical analysis while providing feedback to both student and instructor.

MOSS: The changes that are most evident to me involve students' use of technology. For example, my current students take notes on their laptop computers, whereas students 10 years ago took notes on a printed copy of my presentation. Rather than drawing equipment (such as a ventilator circuit) in their notes, students are very likely to use their cell phone to simply take a picture of the equipment and upload it into his/her notes.

10 years from now, I expect that successful respiratory care students will seek out peer-to-peer learning opportunities as a way to manage busy lives and crowded schedules. I believe students will expect timely responses from their faculty, even outside regular Monday through Friday school hours. Preferred communication (student to student or between faculty and student) will be faster and more brief (e.g., Twitter). Students will expect to be actively involved in their own learning, rather than passive recipients. Students in the future will continue to be tech-savvy and will prefer learning activities that give them the opportunity to integrate their technology even more than they do currently.

WISSING: Over my 30 plus years in the classroom, I have observed changes in student behavior with the most significant change occurring during the past decade. These "recent" changes may give us pause to consider what the student of the future will be like.

Today's students are less note-oriented and tend to place less value in reading the textbook. I think this is a result of technology and having easy access to information and accepting breadth rather than depth of information. Add to this the overreliance of PowerPoint lectures and instructors testing just the material presented via this format and leaving the textbook unchallenged. This results, in part, students not developing a solid foundation of theory to take into the clinical site. This change in what students' value has evolved over time beginning in early grade school thru secondary education with teachers teaching to standardized testing, overfilling curriculum, and other school district limitations. Today's student comes to our classroom orientated to a different learning style than I had when I went to school.

But it is not all doom and gloom for today's students value real-life learning, peer-to-peer learning and using technology effectively in the classroom. I still see a sense of responsibility, excitement from learning material they see that can be directly linked to clinical practice and a desire for collegiate relationship between student and teacher.

The future student needs to develop a sense of patience to acquire the foundation of theory one needs to be an effective clinician and pursue learning for the sake of learning. Having access to such a volume of information from a variety sources, students need to learn how to discern what is accurate and important versus what knowledge is not usable.

Faculty need to role model the appropriate behavior that promotes life-long learning and engage the student in a manner to promote student curiosity about the material at hand. Relying less on traditional lecture and moving towards authentic learning will help reach these outcomes.

Just as students are evolving with how they prefer to learn, faculty need to recognize this and alter their teaching strategies. I agree with my colleagues in this paper that how student learn today is no different than in past; however, how students are accessing information and how it needs to be delivered is changing.

How can the respiratory care program adapt to the external environment if paper-based textbooks play less of a role in student education than electronically-based resources?

BEACHEY: I really do not see this as a significant adaptation challenge; textbooks are still textbooks, whether on the student's laptop or mobile screen, or a hard copy in the student's hand; textbook format (electronic or hard copy) does not affect teaching and learning. As I previously stated, in my experience students prefer the hard copy. On the other hand, note taking has certainly switched to the keyboard. Electronic test banks and automatically graded online quizzes with scores sent to the instructor have significantly facilitated homework assignments for both teachers and students. Writing assignments have been facilitated as well by uploading papers into the University's online course management system. All handouts, course syllabi, etc. can now be posted online; students cannot lose them. Online videos can supplement the printed word, and can also make classroom lectures continuously available for student review. In the end, the electronic classroom has been a facilitator, not an obstacle or a challenge to overcome.

MOSS: Some electronically-based (computer based) testing programs also offer ready access to item analysis results. With this data, faculty who have even the most rudimentary understanding of point-biserial correlation can improve the predictive validity of their test items and the relevance of their teaching tools.

BECKER: The concept of the textbook as the primary source of information has already begun to change. Students presently seek information readily from a wide variety of electronic resources. Further, the ability to access recently published literature provides students with more current information. Thus, respiratory care programs need to embrace the electronic world. Specific strategies to maximize technology benefits are to help students learn to search bibliographic databases, evaluate the quality of the information they retrieve, challenge students to interpret the information they found, and teach students to give proper attribution to the source's author.

GARDENHIRE: Educators need to continue to teach the facts of RT education. The adaptation will be on how to deliver the facts. Most publishers provide an electronic textbook (e-books) as an option to paper. E-books are much easier to search than traditional books. Most offer a search feature that allows the user to type a word or phrase which will provide multiple returns on the word or subject. E-books offer instructors the ability to highlight sections of the text they believe are important and allow instructors to make notes in the text which are viewable and printable to students.

RYE: Respiratory Care educators of today must be prepared to make the switch from paper-based textbooks to electronically-based resources. Instructors who have used eBooks for a number of years indicate that for the most part their instructional strategies are no different than the strategies that were used with print based textbooks. The costs of printed text books have been rising exponentially and the cost of electronic texts is more cost effective for students. Since RC is a rapidly changing field, new equipment and applications often make printed textbooks out of date by the time they are printed.

Educators should be aware that students may need some formal instruction to how to read and use electronic texts more effectively. Students should be made aware that the use of text strings, interactive dictionaries, and digital note taking features are available. It is also possible to more efficiently organize information, gather citation information, and store on-line reading materials for off-line access.

GARDENHIRE: I agree with Dr. Rye that textbooks increase in cost each year; however, the electronic textbook is not and will not necessarily be more cost effective. Today you can find many popular titles of RT textbooks in both print and electronic form with the same price. We might believe that it should be provided at a lower cost; however, if we lower costs, authors of textbooks may find that royalties derived from sales may not be sufficient to continue the material. How would we survive as a profession without the use of great textbooks to supplement our teaching? A more novel approach may be to have educators select specific content or chapters, creating their own specific textbook for their class. How many times have you taught a class and only used half or three quarters of the chapters in the text? Would selecting only chapters you plan to use from a text reduce cost to your student? Textbook companies currently offer this approach in building a specific textbook for your class or program.

MOSS: Respiratory care educators need to be out in front in their use of non-traditional, electronic learning resources. At the same time, educators must be able to identify (and teach) attributes of high-quality sources and must expect students to critically evaluate the electronically-based resources they use. Reference management software (i.e. EndNote, Zotero) is available to help students reduce the tedium of citation and bibliography generation, and EndNote offers a free download of the RC style (http://endnote.com/downloads/style/respiratory-care).

WISSING: I am observing a slow migration from a paper-based textbook to an electronic version. Most students I encounter still prefer the hardcopy. However, what is occurring with a growing number of students is their choice not to purchase textbooks. This primarily due to price of textbooks, less value placed on reading tedious assignments, and often not having reading assignments tested or referred to in the classroom.

On our academic health center campus, the sale of textbooks to allied health, graduate and medical students from our bookstore has dropped from being 80% of the store's sold merchandise to now less than 25% of what is sold. This trend reflects the change in the role of the textbook in the classroom. But yet, an informal survey across all three schools on campus, electronic textbooks are not prevailing as the preferred teaching/learning tool.

I do believe eventually we will be total electronic with teaching materials and students will evolve in becoming effective in using an electronic "textbook" with instant updates and always being current. Electronic books will continue to be coupled with links to on-line material that augments their value.

So perhaps instructors need to help students learn how to actually read and study electronic data since note-taking will be something of the past. Teaching how to highlight, connect information within the text with other sources and utilize the interactive nature of electronic material.

How can faculty more effectively integrate e-learning in the classroom?

BEACHEY: I answered part of this question in my previous response. Faculty members, by and large, are quite familiar with electronic resources and how to use them. Internet videos can be posted online and/or shown in class; research assignments (review of the literature) are greatly facilitated by easy access to full-text resources on the Internet (including the RC journal—all students are AARC members). Students avail themselves of the full range of technology when giving class presentations. It would be hard for me to believe that faculty members today do not integrate e-learning methods in the classroom.

BECKER: Solid instructional design principles make a course effective. Thus, begin by using a needs assessment to determine the learning outcomes needed both across the curriculum and within individual courses. Also, assess the information literacy and technology skills your students already have. Armed with data, you can being to explore where e-learning interventions fit best. Use of technology in learning needs to be purposeful in order to be effective.

GARDENHIRE: Utilization of e-learning is hard work! The work can pay off if done correctly. Department administrators need to recognize the time that is needed to make face-to-face offerings effective e-learning courses. A transition plan should be made to provide enough time to complete all conversions that are needed. Also, altering faculty members teaching loads to work on courses that are deemed priority to be delivered online. Offering faculty members overload (i.e. overtime) pay or summer salary to complete the integration may be necessary. Faculty should network to determine what others are doing at their institution and what options are available. Faculty should understand that they are not alone and integrating even the smallest e-learning option can be time consuming.

RYE: Instructors can begin the integration of e-learning into their classrooms by directing students to specific web sites to read information that is required for successful completion of an assignment. Another strategy would be to create web pages to direct students to the desired online readings. The next progression of this concept would be to use complete electronic text books. Students today are very technologically savvy and there are a number of tools available to assist educators in creating web pages and annotated web pathways. Educators just need to create the appropriate reading lists.

MOSS: First, we need to be willing to discard learning tools that are comfortable and familiar but are also inefficient and ineffective. Abandoning these tools frees up time and energy to explore new and better options. (This exploration will require that we be intellectually curious, however.) Electronic tools are changing too quickly for us to keep up without leveraging the expertise of our school's IT staff, and we need to demonstrate the genuine cognitive humility necessary to seek them out.

WISSING: As I migrate away from traditional lecture and embrace other methods of instruction, I find I am using electronic resources more and more. I have replaced PowerPoint with programs such as mind-mapping (e.g., Coggle), Prezi, animation using Presentation Media software, and internet resources such as YouTube and TED Talks. I use Moodle as an integral part of my class, using several features it offers such as Forum, Chat, Wiki, Workshop and the add on Turn It In as a writing mentor.

Faculty need to make a deliberate effort to engage electronic resources; but yet, use those resources that are shown to be evidence-based and effective. If faculty are trapped in the PowerPoint mode, learning to use this tool effectively needs to be priority—despite this program has been around for many years, it still can be used ineffectively.

As the role of the respiratory therapist expands to cover acute, chronic, and preventative care, how can the respiratory care program incorporate these broader expectations into didactic, laboratory, and clinical education to ensure student excellence in all learning domains?

BEACHEY: This is an important question. The practice of respiratory therapy has undergone profound changes since it's beginnings. The nature of these changes has been the subject of many editorials, white papers, position statements, and notably, the publications arising from the AARC's three RT 2015 and Beyond conferences—not to mention the current AARC position statement supporting the baccalaureate degree for entry into practice. It is almost a cliché to note that respiratory care has evolved from a task-oriented technical occupation, adept at executing orders, to a more autonomous, fully participating member of the health care professions.

Over two decades ago, protocol-driven respiratory care ushered in a new assessment-based "evaluate and treat" paradigm of practice that demanded a deepened understanding of physiology and pathophysiology, and required therapists to understand and use published research to develop best practices. More recently the Affordable Care Act has intensified the therapist's role in improving quality and efficiency of care, e.g. shortened hospital stays, decreased complications, and decreased 30-day readmissions. This role requires graduates to possess a high level of human interaction skills as these skills apply to human motivation, cultural competency, patient education, and disease management.

In contrast to the expansion of required professional competencies, the educational preparation for respiratory therapists remains overwhelmingly as it was in the beginning—at the associate's degree level. To accommodate a burgeoning curriculum, many A.S. degree programs have expanded far beyond the traditional 60-62 credit hours required for the degree. In states that forbid expansion of credit hours, some programs require several prerequisite courses before students can enter the program. The award of only the A.S. degree to graduates of these programs is not only incongruous with the number of credit hours earned, it also devalues the therapist's educational achievement and reinforces the non-professional, technical image of respiratory care in the minds of lawmakers and the Centers for Medicare and Medicaid Services.

It is easy to see why, in the task-oriented phase of the profession's early development, preparation of respiratory therapists was deemed to be more of a technical training process than a professional educational process; the two-year community college and vocational-technical model seemed appropriate. Clearly, respiratory therapy education has grown beyond its training roots; truly effective therapists must possess much more than technical skills and the ability to pass NBRC credentialing exams upon entry into practice.

Regarding the question, "How can the respiratory care program incorporate these broader expectations into didactic, laboratory, and clinical education to ensure student excellence in all learning domains?" the most recent AARC education position statement is a first, absolutely necessary step toward the answer. At minimum, entry-level preparation for respiratory therapists should be at the baccalaureate degree level. The typical two-plus-two B.S. degree model allows two full years for college-level preparation in the basic sciences, the social sciences, and the humanities, followed by a full two years of professional respiratory care courses that do not need to compete for time with general education and other prerequisite courses. The only question regarding a transition to the baccalaureate entry level is whether this change is too little, too late. The Master's entry level would allow for an even more rich professional preparation, including time to expose students to meaningful clinical research and expanded practice opportunities; in the end, the patient would be the primary beneficiary. This change is already necessary if the profession hopes to remain abreast of its allied health/nursing colleagues.

MOSS: I would urge consideration of the teaching and learning that is occurring at the 86% of CoARC-accredited institutions in 2014 that granted the associate degree upon completion (http://www.coarc.com/47.html). Respiratory care stakeholders would benefit from well-designed quantitative and qualitative studies that examine the comparative effectiveness of didactic, laboratory, and clinical education in acute, chronic, and preventative domains for associate, baccalaureate, and master's degree-granting programs.

BECKER: Acute care content has been the mainstay of respiratory care practice and education. Chronic and preventative care are the newer areas that need to be woven into the curriculum. In order to successfully address these two newer areas, students need to learn long-term medical management, care coordination, and patient education skills. The expanding scope of respiratory care practice makes it very challenging to address this additional didactic content in an associate degree program. Thus, this content will likely have greater emphasis in degree programs that have longer length.

Patient education could be role-played in a laboratory setting, however service learning opportunities provide a much better venue for students to practice chronic and preventative care skills. These opportunities empower students to see how they can positively influence others. Also, students very quickly realize the consequences of not recalling key information when they are providing services to members in their own community. Clinical education opportunities are another possibility. Engaging outpatient clinic rotations, rounding with a care coordinator, and adopting internships with respiratory health advocacy groups provide other relevant learning opportunities.

GARDENHIRE: The best resource any program has is their advisory committee. Programs should find advisory personnel that have experience in all areas not currently covered by the program. Another asset to a RT program is the medical director. Utilize your medical director's network and expertise in covering the area which may be needed. Working with the faculty the program director and clinical director can determine the need and the individual best qualified to complete the objective.

RYE: The Respiratory Therapist of the future will be faced with an increasingly complex group of patients who are more engaged in their own care. Instructors will be challenged to transform traditional curricula to better prepare students for success in the healthcare environment that includes acute, chronic, and preventative care. As more and more states are limiting credit hours, this becomes even more challenging for educators. Use of the flipped classroom in which learning content is placed on electronic learning systems for students to learn on their own prior to class time may be an effective way to address the dilemma. In the flipped classroom, class time is utilized to engage students in student-centered learning activities, such as teamwork, debates, self-reflection, case studies and simulations. This type of active learning has been shown to stimulate higher-order thinking, problem solving, and critical analysis. Furthermore, a group of undergraduate students who were surveyed valued the use of e-learning in clinical skills education and rated e-learning just as highly as other traditional methods of clinical skills teaching.

MOSS: The foundation of excellent practice is deliberate attention to the learning of assessment and communication skills—these will transfer from the classroom or lab to any clinical environment. In my opinion, this learning is crystallized in a well-planned, diverse array of clinical practice activities (not just observations) that are structured with clear and comprehensive learning objectives.

WISSING: Respiratory care (RC) education evolves over time as does many other educational paradigms. When I began RC in the 1970s, it was task-oriented, and educational programs were skill oriented. Over the ensuing decades, RC has evolved to now being on the cusp of providing value-driven care and disease management requiring critical thinking and problem solving.

RC educators need to re-think the use of traditional classroom and laboratory teaching. One way to do this is by expanding student exposure to areas outside the acute care hospital, such as in the home setting, outpatient clinics, and industrial settings. Students should also experience service learning, interprofessional education, and engage patient education. Incorporating technology, such as simulation and interactive online programs, to augment didactic teaching remains a priority. Programs should also adopt a public health initiative promoting lung health—curricula often not included in RC programs. RC programs need to educate students to be able to collaborate between acute care hospitals and post-care providers, promote team care, and participate in telemedicine.

Future RC education will extend beyond the brick-and-mortar building. Students will learn in a variety of environments, from simulation to virtual realities. Advances in technology provide unlimited opportunities to expose students to clinical situations in a risk-free but realistic environment.

RC programs should develop career pathways to bring the associate degree students opportunities for undergraduate education, and graduate education to develop the necessary skill set to work in a collaborative environment and disease management to meet the challenge of RC's expanding role. We have come a long way since the 1970s, and opportunity for RC continues to abound.

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The Impact of Interprofessional Clinical Simulation on Attitudes, Confidence and Professional Identity: The Added Value of Integrating Respiratory Therapy

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Abstract

Introduction: Interprofessional clinical simulation for students in health care professions proffers a collaborative and comprehensive approach to patient care prior to clinical rotations, in the safety of the simulated learning environment. Interprofessional clinical simulation has been shown to improve attitudes toward teamwork, improve understanding of professional roles, and facilitate overall communication for coordinated, comprehensive patient care. **Methods:** The purpose of this mixed-methods, descriptive study was to explore attitudes toward interprofessional education through a unique multi-patient clinical simulation. Health professions students from eight different health professions programs completed the simulation, a 2.5-hour experience involving interprofessional rounds and care of two medically complex standardized patients; one who is mechanically ventilated and the other who is post-amputation. The Readiness for Interprofessional Learning Scale (RIPLS) was used to measure attitudes toward interprofessional learning. Audio-recorded debriefing sessions followed each simulation session, which yielded qualitative data. **Results:** A total of 186 students from eight different health professions participated. Understanding the roles of others improved significantly following the simulation experience ($p<0.05$). Participation in the simulations reflected a positive change in attitude on three of the four subscales of the RIPLS: teamwork and collaboration, negative professional identity, and positive professional identity. Additionally, participants noted increased confidence in caring for a patient on a mechanical ventilator post-simulation ($p<0.05$). Qualitative analysis of the debriefing sessions identified four emerging themes: teamwork, communication, preparation and confidence, and professional identity. **Conclusions:** Interprofessional clinical simulations promote enhanced teamwork, professional identity, confidence, communication, and clinical preparation and should be considered for all health profession curricula.

Key words: interprofessional,clinical simulation, teamwork, collaboration

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Introduction

Safe and effective health care requires the collaborative effort of numerous health care professionals, yet evidence indicates that this need may not be consistent with day-to-day practice and is often hampered by poor communication or inaccurate perceptions of other health care team members.[1-4] Researchers have indicated that purposefully integrating training programs for interprofessional care may produce better patterns of communication and collaboration among health care team members.[5-7] Health sciences professional programs provide a prime opportunity to optimize interprofessional education (IPE) experiences at a crucial time in the students' professional development. Interprofessional clinical simulation is an educational strategy used to purposefully train students in interprofessional care through a simulated learning experience. Interprofessional clinical simulation for students in health care professions creates an opportunity for trainees to experience a collaborative and comprehensive approach to patient care prior to clinical rotations and in the safety of the simulated learning environment. The benefits of interprofessional clinical simulation have been noted to include improved attitudes toward teamwork, improved understanding of professional roles, and have been found to facilitate overall communication for coordinated, comprehensive patient care.[8-10]

The Institute of Medicine Committee on Measuring the Impact of Interprofessional Education on Collaborative Practice and Patient Outcomes identified four major areas of need related to "evaluating the impact of IPE on collaborative practice and patient outcomes":

1. More closely aligning the education and health care delivery systems;
2. Developing a conceptual framework for measuring the impact of IPE;
3. Strengthening the evidence-base for IPE; and
4. More effectively linking IPE with changes in collaborative behavior.[11]

The importance of IPE is also recognized in professional standards for accreditation. Respiratory therapy programs are required to include IPE to meet accreditation standards. The Commission on Accreditation for Respiratory Care (CoARC) Accreditation Standards for Entry into Respiratory Care Professional Practice Standard 4.05 states, "Graduates must be able to function within interprofessional teams and communicate effectively with diverse populations. The curriculum must prepare students to work with a variety of populations including, but not limited to, individuals of various ages, abilities, and ethnicities." [12] Though CoARC does not stipulate the method by which programs must meet the Standard, interprofessional clinical simulation is an innovative, yet authentic way to address the requirement.

The AARC's 2015 and Beyond initiative and related manuscripts, also address the evolving role and competencies of the respiratory therapist (RT) in the complex health care environment.[13-15] The manuscripts based on the 2015 and Beyond conferences emphasize that care teams will become the main method of health care delivery and the respiratory therapist will need to have the competencies and communication skills to function as part of the interprofessional health care team. The role of the RT has drastically evolved since its establishment over 60 years ago and will continue to expand for years to come. Interprofessional education provides opportunities to learn about the role of other health care professions as well as opportunities for others to learn about respiratory therapy. In addition, representation of the RT profession in interprofessional education simulations may also allow the health care team to learn more about specific concerns when caring for patients that require mechanical ventilation. There are few studies in the literature that explore the impact of RT student participation on interprofessional clinical simulation. The purpose of this study was to explore the attitudes of undergraduate and graduate students toward interprofessional education through a unique multi-patient clinical simulation focused on collaboration and communication.

Methods

Research design

This was a descriptive study using a mixed-method design. The Readiness for Interprofessional Learning Scale (RIPLS), a nineteen question instrument, was used as the pre- and post-simulation survey to measure attitudes toward interprofessional learning.[16] Audio-recorded debriefing sessions followed each simulation session which yielded qualitative data. The study was approved by the Institutional Review Board.

Study population

The study population included health professions students at a large midwestern university. Participants from a variety of disciplines: nursing, respiratory therapy, medical dietetics, occupational therapy, physical therapy, pharmacy, medicine, and nurse practitioner programs completed the simulation comprising the simulation care team of 10-15 individuals. The actual simulation was a 2.5-hour experience which involved interprofessional rounds and care for two medically complex patients in an acute-care environment. The simulation involved five phases: 1) assessment and patient evaluation, 2) interprofessional care management rounds, which included devising the treatment plan, 3) treatment delivery, 4) rounds to report progress, and 5) debriefing of the simulation by participants. One of the patients required management while on mechanical ventila-

Table 1
Questions for Simulation Debrief

1. **Was the simulation helpful in understanding the other professions' roles?**
   a. **Give examples of mutual respect and understanding.**
2. **Did the collaborative experience increase your confidence in caring for your patients?**
3. **Discuss your views on the interprofessional communication during the simulation.**
   a. **Was it effective?**
   b. **Did you use the ISBAR Identify, Situation, Background, Assessment, and Recommendation?**
   c. **Share examples of effective communication that occurred within the experience.**
4. **What do you take away from this experience?**
   a. **What surprised you?**
   b. **What will you do differently in practice as a result?**
   c. **What was the most difficult part of the experience?**

tion along with assessment for extubation. The "intubated" patient wore an endotracheal tube holder with a shortened endotracheal tube and was connected to a ventilator circuit that was not attached to the ventilator. Taped to this "faux" circuit, another ventilator circuit was attached to the ventilator and connected to a test lung. The other patient was post-amputation and required clinical assessment for pneumonia. Both were played by standardized patient actors. The simulation of the intubated patient scenario posed unique communication challenges for the team because this patient was unable to speak.

Instrumentation

The Readiness for Interprofessional Learning Scale instrumentation for interprofessional clinical simulation was used as the pre- and post-questionnaire for the simulation.[16] The authors' permission was obtained to use the instrument for the study. RIPLS is a validated nineteen question pre- and post-questionnaire consisting of three sub-categories which include teamwork and collaboration, professional identity, and roles and responsibilities sections.[16-18] These questions are graded based on a five-point Likert scale ranging from "strongly agree" (5) to "strongly disagree" (1). McFadyen et al found test-retest reliability to be high with the RIPLS items and subscales.[19] For the current study, subscale internal consistency was reflected through the Cronbach's alpha values ranging from 0.62 to 0.87 for the cluster of items. Additionally, a question regarding understanding other health care professionals' roles was included in the questionnaire. Participants were asked to rate their understanding of each of the other professionals' roles on a scale from 1 to 10, with 10 meaning "understand it well" and 1 meaning "not at all."

All members of the simulation care team (10-15 students) participated in the simulation debrief which was led by a faculty facilitator. The questions are listed in Table 1. The qualitative data collected from the audio-recorded debrief session was analyzed using inductive analysis. Inductive analysis examined data from these specific observations to organize broader generalizations that emerged as themes. The narrative data were carefully read by investigators and systematically analyzed to identify recurrent themes both within and across groups. Researchers read all transcriptions individually and then met to discuss themes and patterns. Responses were organized into categories including, teamwork and collaboration, communication, clinical preparation and confidence, and professional identity.

Results

Quantitative data

The data collected represents one semester of interprofessional clinical simulations. A total of 186 students (78% female, 22% male) from eight different health professions participated during the semester (Table 2). Students ranged in age from 19-43 with an average age of 24.3 (5.86). Comparisons between students in both undergraduate programs (Medical Dietetics, Nursing, and Respiratory Therapy) and post-undergraduate programs (Medicine, Nurse Practitioner, Occupational Therapy, Pharmacy, and Physical Therapy) yielded no significant differences in response, therefore the data for all professional programs were used.

The understanding of each of the respective professions was elicited by asking the participants to rate them on a scale from 10 "understand it well" to 1 "not at all". To provide a more accurate depiction of the mean rating

Table 2
Participants

	MD	Med Diet	NP	OT	Pharm	PT	RN	RT	Total
Male	5	4	5	0	12	3	10	2	41
Female	5	29	8	6	22	14	55	6	145
Total	10	34	13	6	34	17	65	8	186

Table 3
Role Comprehension

	MD	Med Diet	NP	OT	Pharm	PT	RN	RT
N*	171	153	172	173	152	168	121	178
Pre	8.18	6.27	7.29	7.03	7.83	7.67	7.77	7.25
Post	8.98	9.34	8.95	8.14	9.04	8.85	8.90	8.82
p-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

**The analyses for each professional program were performed without the participants in each of the professional programs, indicating other professionals' understanding of that profession. Discrepancies in participant numbers are due to incomplete data.*

for the pre- and post-role understanding portions for each medical profession, only the perceptions of the other professions were included in the analyses. Paired t-tests were used to analyze differences in role understanding ratings from pre- to post-simulation. Each program of study yielded a statistically significant improvement in comprehension of the other medical professions (Table 3).

Table 4 is an overview of the RIPLS scores which displays the total RIPLS scores as well as the four individual subscales, both pre- and post-simulation. The changes in mean scores were analyzed using paired t-tests. In each subscale we examined the mean, standard deviation, and statistical significance values for the pre- and post-survey RIPLS scores, as well as in the total of these scores. All subscales yielded a statistical significance except for the fourth subscale, roles and responsibilities, which comprised of three negatively worded questions. These negatively worded questions may have been misinterpreted by the students.

The confidence of the students caring for a mechanically ventilated patient was measured pre- and post-simulation using a Likert scale (1=strongly disagree; 5=strongly agree). All programs of study demonstrated a statistically significant (p<.001) increase of confidence when caring for a mechanically ventilated patient, indicated by a shift from a rather neutral stance (m=2.87) to much stronger agreement (m=3.66). This suggests the incorporation of a mechanically ventilated patient and utilization of respiratory therapists aided in the knowledge base and confidence needed for health care professionals to properly care for a mechanically ventilated patient. It was determined that prior to these clinical simulations the majority of students involved had not had the opportunity to care for an intubated patient or interact with the field of respiratory therapy.

Qualitative data

Qualitative data were derived through inductive analysis of the students' individual comments at the interprofessional debriefing session directly following the simulations. The qualitative data yielded sub categories pertaining to teamwork and collaboration, interprofessional communication, clinical preparation and confidence, and professional identity.

Table 4
RIPLS Scores (Overall and subscales)

RIPLS Subscales	Items*	Range of Possible Points	Pre/Post	Mean (SD)	p-value
Teamwork & Collaboration	1 - 9	9 - 45	Pre	42.27 (3.328)	<.001
			Post	43.85 (2.341)	
Negative Professional ID	10 - 12	3 - 15	Pre	5.10 (2.376)	<.001
			Post	4.25 (2.137)	
Positive Professional ID	13 - 16	4 - 20	Pre	17.44 (2.311)	<.001
			Post	18.90 (1.829)	
Roles & Responsibilities	17 - 19	3 - 15	Pre	9.04 (1.662)	.305
			Post	9.19 (1.987)	
RIPLS Total	1 - 19	19 - 95	Pre	73.84 (5.569)	<.001
			Post	76.18 (4.561)	

** Items scale: 1=strongly disagree; 2=disagree; 3=undecided; 4=agree; 5=strongly agree*

Teamwork and collaboration

Several participants commented in the debrief session that the interprofessional clinical simulation experience allowed them to appreciate the interconnectedness of the health care team when providing patient centered care. The comments frequently noted that the other professions represented in the simulation could be relied upon for additional information or expertise and that they "didn't have to know it all." One student commented:

"You know you can rely on other occupations to fill in the blanks. Like I said earlier, you don't have to try and remember everything. This learning experience teaches us to do that so when we go to work we don't have to do it all by ourselves. We are more likely to seek help from other professions." – Medical Dietetics

Interprofessional communication

Another theme identified in the debrief sessions was that of communication. The participants noted that simulation provided them an opportunity to practice their communication skills. The nature of the rounding simulation allowed the students to understand the impact of clear communication in the interprofessional decision-making process. A representative comment was:

> *"I think this exercise was good just in terms of planning and making communication efficient and knowing what is important to communicate. There is limited time in rounds and being able to say what's important and giving recommendations is key."* – Registered Nurse

Clinical preparation and confidence

There were several comments that discussed the growth that occurred from the experience. Participants noted that they improved their confidence and skills in providing patient care. Others noted how they gained valuable skills, like leadership, from the experience as well. Representative comments are noted below.

> *"This increased my confidence because it's impossible to know everything about everything but you do have those resources, like if I have a question about drugs I can call pharmacy or if I have a question about getting a patient up and moving I can call physical therapy and with nutrition I can call dietetics, so it's a very dynamic setting where you don't have to know everything about everything."* – Nurse

> *"I did this last year as a student in their position and now I'm here this year kind of mentoring them. Just to see from one year to the next how much you learn and how much you actually will be in these scenarios when you get out there and do your clinicals. This was very helpful to prepare me for this year and I would definitely recommend this for future students."* – Respiratory Therapy

Professional identity

The final theme articulated in the debrief sessions was that of professional identity. The participants noted that they were able to learn about the other professions represented and were also able to gain a better understanding of their own professional role. Representative comments were:

> *"It was nice to see with pharmacy the way they came to rounding and had things prepared. I didn't know what they did behind the scenes. It seemed like they would see the orders and then work from those orders, not necessarily be as prepared as they were, so I was interested to see that."* – Nurse Practitioner

> *"I have never really worked with dietetics before so it was interesting to see the scope of their practice and what they do and all their interactions with other fields. I never knew how much they interacted with pharmacy and with all the different regulations on feeding and medications and things like that."* – Medicine

Summary

The entirety of these qualitative findings suggests an enhanced level of communication, teamwork, confidence, clinical preparation, and comprehension of roles among the various programs of study. The broad scope of professions that participated in this simulation contributed to a rich understanding of the multidimensional impact of the interprofessional education experience.

Limitations

There were several limitations to this study. Because the perceptions are self-reported, this information is purely subjective and therefore may not represent the target population. Another limitation is that the sample was a convenience sample of undergraduate students enrolled at a large mid-western university.

Discussion and Conclusions

Interprofessional clinical simulations promote enhanced teamwork, professional identity, confidence, communication, and clinical preparation and should be considered for all health professions' curricula. The utilization of interprofessional clinical simulation that incorporates patient rounds prepares students for realistic clinical interactions and increases levels of professional identity within each program of study. Interprofessional clinical simulations that promote teamwork and collaboration among the health professions are vital to exposing trainees to real-world collaborations and clinical situations prior to experiences in the workplace. The results of the study corroborate findings from related literature in IPE. Interprofessional clinical simulations have demonstrated efficacy in improving professional identity, confidence in self and others, interprofessional communication, teamwork, and clinical preparation.[9, 19-21] This study contributes evidence utilizing a broader scope of represented professions and unique multi-patient scenarios. This study also highlights the contributions of respiratory therapy students to the simulation experience, which has not been extensively illustrated in the literature. Future research is needed to examine the long-term effects of clinical simulations and the translation to professional teamwork and patient care.

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Evaluation of the Inter-rater Reliability of the Clinical PEP Program

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Abstract

Introduction: Clinical supervision plays an important role in the training of respiratory therapy students. Preceptor training is one tool respiratory therapy faculty can use to ensure inter-rater reliability (IRR) among clinical educators. **Methods:** Since 2013, users of the AARC's Clinical PEP program have contributed results of training for composite analysis of IRR. Percentage agreement was calculated for 10 modules. **Results:** 89 preceptors were included in the study. IRR was excellent for nine of the 10 modules and was good for the remaining module. Percentage agreement ranged from 78% - 93%. **Conclusions:** Users of Clinical PEP continue to demonstrate a high degree of IRR which serves to fulfill an important respiratory therapy education accreditation requirement.

Key Words: clinical education, preceptor, respiratory therapy

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Introduction

Clinical supervision plays an important role in the training of respiratory therapy students. However, it is one of the least investigated, developed, and discussed aspects of clinical education. Furthermore, preceptors are often chosen for their clinical expertise rather than for their skills as a clinical educator.[1]

In 2010, the Commission on Accreditation for Respiratory Care (CoARC) standards mandated that respiratory therapy education programs must "develop processes that facilitate the development of inter-rater reliability (IRR) among those individuals who perform student clinical evaluations," and that one way for respiratory therapy programs to demonstrate compliance is to have clinical preceptors complete appropriate training.[2] In response to this mandate and given the fact that directors of both respiratory therapy education programs and respiratory therapy departments reported that there was a need for standardized preceptor training, the authors created Clinical PEP (Practices of Effective Preceptors).[3, 4] While CoARC standard 3.07 requires preceptor training, it also mandates documentation of the IRR of individuals performing clinical evaluations of students.[5] Clinical PEP meets the CoARC requirement for documentation of valid and reliable preceptor training.

Clinical PEP can be completed in person or online, allowing the training of preceptors to be flexible. Successful completion of the course (video and workbook) and testing earns two CRCE® credits. While modules can be done at each learner's individual pace, it typically takes approximately two hours to complete the entire program. The components included in the training modules were based upon principles of adult learning, a review of the medical literature on effective supervision in clinical practice settings, and feedback from three classes of respiratory therapy students and their preceptors at The Ohio State University (OSU).

Based upon analysis of inter-rater reliability and user feedback over a period of two years, the Clinical PEP program was revised and ultimately offered by the AARC in 2013 as a standardized preceptor training program. Clinical PEP includes modules that address principles of adult learning (communication, relevance of assigned tasks, etc.), understanding the learning context, managing the challenging learner, and handling feedback. The instructional videos contain examples of effective and ineffective preceptor behaviors, along with student performance, for standardizing preceptor evaluation. Each ineffective video contains a set number of errors that the student should identify (errors are identified in a key). For example, in the ineffective "Lamentable Labeling" module, which covers some of the principles of adult learning, the preceptor is on the phone, ignores the student, and fails to explain the significance of the student's assigned task. In the effective parallel module, the preceptor welcomes the student and explains the rationale for their assignments. Also included in the Clinical PEP are downloadable workbooks and handouts for preceptors, along with downloadable course management documents for managers and educators use.[6] The program is reviewed and revised annually based on user feedback. Several consumers suggested that examples from a student clinical check-off document would be helpful in reinforcing the preceptor's evaluation skills and representing more practical situations to improve IRR. Clinical skills check-off modules were added to the program in 2015 in response to this recommendation.

Since July 2013, the AARC has sold 337 year-long subscriptions to Clinical PEP to 235 schools and three hospitals. One hundred two schools have renewed the program at least once.[7] The purpose of this study was to evaluate the IRR of the Clinical PEP program based upon data from current users across the United States.

Methods

This study was approved by The Ohio State University Institutional Review Board (IRB). Respiratory therapy programs and departments that adopted the Clinical PEP program were invited to participate in the continuing research study to evaluate the IRR of the Clinical PEP program. Individual preceptors from each participating institution were asked to review each module, watch videos that demonstrate ineffective preceptor behaviors, record errors made by the ineffective preceptor in each one, and then view the parallel videos demonstrating effective preceptor behaviors to see the mistakes corrected. The key for the ineffective videos was produced by the OSU respiratory therapy program and clinical faculty. For each of the ten ineffective videos, the number of correctly identified errors was recorded by each trainee/learner. The errors recorded by the participants were checked against the key either by the program faculty or the researchers.

The two most common ways to measure inter-rater reliability are percentage agreement and correlation. The authors chose percentage agreement over correlation because it is conceptually simpler and easier to calculate. For percentage agreement, the agreement rate (A) was the observed agreement (O) divided by the possible agreement (P). Therefore $A=O/P$.[8] Consensus estimates of inter-rater reliability were determined by percentage agreement. This study reflects follow-up data collection from the first two and a half years of program implementation. .

Results

Four schools participated in the ongoing research project, which included a total number of 89 preceptors. Percentage agreement was categorized as excellent (80-100%), good (60-79%), moderate (40-59%), or slight (20-39%).[9] As reflected in the summary of ineffective behaviors identified by users after they viewed the ineffective preceptor videos (Table 1), nine of 10 modules (90%) reflected excellent agreement. Only one module, "The Clueless Communicator," which portrayed the challenging student/trainee, demonstrated good IRR agreement. Titles for each module (in Table 1 below) reflect the situation portrayed in the videos; the content area addressed in the module is in parentheses. For example, "Faulty Feedback," portrays a preceptor who is evaluating a student on their clinical performance, and the content area represents evaluation and feedback.

Discussion

Prior to the CoARC standards introduced in June 2010, respiratory therapy education programs were not required to demonstrate evidence of inter-rater reliability among preceptors in order to obtain or maintain accreditation. Therefore, the medical literature lacks studies on the subject of inter-rater reliability among respiratory therapy clinical preceptors.

The Clinical PEP program is revised every year based on user feedback. Programs that participate in the program and evaluate the IRR of their preceptors may use the data to determine specific areas that need improvement among their preceptors. Program administrators may also use the results to design follow-up training that addresses areas where preceptors underperformed.

Clinical PEP meets the CoARC requirement for documentation of valid and reliable preceptor training, but it does not meet the requirement for documentation of IRR of preceptors who evaluate students in the clinical setting. Programs could meet the latter requirement by applying the same measures of percentage agreement described above.

Since the Clinical PEP program has been offered by the AARC as standardized preceptor training, 54% of respiratory therapy programs nationwide (45/50 states) have utilized it. According to our analysis, users of Clinical PEP continue to demonstrate a high degree of inter-rater reliability among preceptors who complete the program.

Table 1

Inter-rater Reliability of Respiratory Therapy Preceptor Behaviors

Module Title (Topic area covered in module)	**Errors identified (mean) (n=89)**	**Errors present (#)**	**Preceptor Agreement (%) (n=89)**
Lamentable Labeling (Principles of adult learning)	3.6	4	89
The Terrible Treatment (Principles of adult learning: remembering what it's like to be a student)	4.2	5	83
The Miserable MDI Instruct (Remembering what it's like to be a student)	2.8	3	93
The Shaky Set-Up (Remembering what it's like to be a student:evaluation and feedback)	2.7	3	88
The Oblivious Oscillator (Remembering what it's like to be a student)	3.4	4	86
Catastrophic Career Choice (Remembering what it's like to be a student)	1.8	2	91
The Clueless Communicator (Challenging students/trainees)	3.9	5	78
Totally Textbook (Challenging students/trainees)	4.0	5	81
The Pitiful Performance Evaluation (Evaluation and feedback)	3.3	4	83
Faulty Feedback (Evaluation and feedback)	3.4	4	86

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High-Fidelity Simulation Versus Low-Fidelity Simulation: Which is Better for Airway Management Training?

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Abstract

Introduction: Simulation-based education (SBE) is used routinely in medical training. This teaching method has the potential to improve learner knowledge, skills, and attitudes by providing a standardized environment that may influence the learner's clinical skills. The purpose of this study was to compare high-fidelity and low-fidelity simulation for training airway management skills such as bag-mask ventilation (BMV), laryngeal mask airway (LMA) insertion, and endotracheal intubation via direct laryngoscopy. **Methods:** A pre-post test design was developed and subjects included first and second year respiratory therapy students and licensed respiratory therapists (n=28). Following consent, subjects were randomized to receive training in either a high-fidelity simulator or low-fidelity simulator group. Multiple choice tests and Likert scale surveys were administered before and after the intervention to assess knowledge and confidence level. Approximately one week later, the samecohort was evaluated to assess psychomotor skill retention following the intervention. **Results:** No difference was found between high- and low-fidelity simulation with regards to confidence, knowledge, or skill with BMV, LMA placement, or endotracheal intubation via direct laryngoscopy. Conclusion: These findings suggest that high- and low-fidelity simulations are equivalent when training respiratory therapy students and practitioners on airway management.

Key words: laryngeal mask airway, bag-mask ventilation, respiratory therapy, simulation training, airway management, intubation, endotracheal

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Introduction

The use of simulation-based education (SBE) for training health care providers is increasing. The growing use is due to inconsistent teaching in clinical education, technological advancement, need for competency assessment, emphasis on patient safety and team dynamics, and the concept of deliberate practice.[1] Barriers to educating health care providers, such as lack of time and inconsistent teaching practices, have opened the door to SBE by providing a standardized, mistake forgiving, safe environment where a learner is able to practice without placing patients at risk.

Simulation training is not new; in fact, its roots can be traced to medieval times when knights used mounted objects for lance practice. Simulation also has a significant history in aviation as it has prepared pilots for high-risk, low-frequency situations.[2] In the context of medicine, these simulation concepts are still applicable. Clinicians use simple task-trainers (low-fidelity simulation), such as lifelike models of arms or torsos, to practice certain skills pertaining to that anatomical region. They also use complex models of whole human bodies with physiologic feedback (high-fidelity simulation), such as the iStan® Patient Simulator (CAE Healthcare, Saint-Laurent, Quebec, Canada) to navigate high-risk, low frequency scenarios. Data supporting the use of simulation in medical education is evolving. For example, simulation-enhanced training with medical residents for central venous catheter (CVC) insertion confirmed that clinical skills can be significantly increased.[3] A meta-analysis conducted by McGaghie et al concluded that SBE with deliberate practice is superior to traditional clinical education in relation to clinical skills.[4] Cook et al reported in a meta-analysis involving 289 simulation-based interventions, the positive effect of simulation-based modalities on the education and training of health care professionals.[5]

In regards to educating the learner about airway management, data are also supportive of the use of simulation. In 2005, Hall et al reported no significant difference between performance of endotracheal intubation via direct laryngoscopy using manikins (87.5%) versus humans (84.8%) ($p = .42$).[6] The results showed the benefit of using SBE as opposed to human subjects. Using SBE may be beneficial in eliminating the risk of complications found when using human subjects. Kory et al demonstrated that the use of SBE with a computerized simulator in the training of internal medicine residents in airway management was more effective than the traditional method in 8 of 11 steps involved with responding to a respiratory arrest scenario. The simulation-trained group had an 88% success rate in correct insertion of an oral airway opposed to a 20% success rate of oral airway insertion in the traditionally trained group ($p < .001$).[7] These studies suggest a benefit in utilizing airway management simulation-based training for health care providers.[7-12]

Although simulation research on clinical practices has been shown to be effective, [4, 13, 14] there is a paucity of data on the use of simulation-based modalities to train respiratory therapy students and respiratory therapists. Since both high-fidelity simulation (HFS) and low-fidelity simulation (LFS) are available in our institution, we sought to compare them for training airway management skills related to bag-mask ventilation (BMV), laryngeal mask airway (LMA) insertion, and endotracheal intubation via direct laryngoscopy.).

Methods

Research design

This study was a randomized two-armed, pre- and post-experimental design using convenience sampling of respiratory therapy students enrolled in an entry-level baccalaureate and master's degree program along with practicing respiratory therapists at a large academic medical center in the midwest (n=28). As subjects arrived at the study site, they were randomized into one of the two groups: group A and group B. The use of a numbered attendance sheet for the study subjects to sign in on arrival allowed us to divide the two groups by odd and even numbers. The names next to an odd number on the sheet were in group A and received high-fidelity airway management training with the iStan Patient Simulator. Those who signed in on an even number on the sheet were in group B and received low-fidelity training on the Laerdal® Airway Management Trainer (Laerdal, Wappingers Falls, NY). The independent variable was the type of simulator used by the subjects who received training, and the dependent variable was gained knowledge, confidence, and psychomotor skills. All subjects were consented and this study was approved by our Institutional Review Board.

Study procedures

All subjects completed an affective survey using a 5-point Likert scale and a 25 question multiple choice cognitive pre-test to assess attitude and knowledge of BMV, LMA placement, and endotracheal intubation. Once the affective survey and cognitive pre-tests were complete, subjects watched instructional videos demonstrating the correct methods of BMV, LMA placement, and endotracheal intubation.[15-17] Following the videos, group A received airway management training on the iStan Patient Simulator and group B received training on the Laerdal Airway Management Trainer. The HFS allowed the subject to

Table 1
Psychomotor Checklist for Bag-Mask Ventilation

Case: ________________________ Group: ____________ Date: ______________

SKILL	BMV			
Task	Definition	Done	Not done	Done incorrectly
1. Recognizes need for BMV	a. No breathing b. Intubation/sedation attempt c. Overdose 4 bpm (bradypnea), 100% NRB SpO2 84%			
2. Assembles equipment	a. Correct size mask b. Correct bag (adult vs. pediatrics) c. Connects reservoir d. Connects O2 e. Correct O2 flow (more than 10 L/m)			
3. Positions patient's head	Use head tilt chin lift/jaw thrust. Use pillow under the shoulders.			
4. Uses correct mask holding techniques	E-C techniques techniques			
5. Manually ventilates	Rate of 10-12 bpm			
6. Assesses adequacy of ventilation by chest rate	Visualize chest rise			
7. Duration 5 minutes	Manually ventilate at 10-12 bpm to maintain a SpO2 >92%.			
Total				

monitor heart rate and rhythm, SpO_2, and blood pressure, whereas the LFS did not have this capability. The training for both groups consisted of a period of familiarization with equipment, instruction from study staff, and practice using the same pre-determined case scenario. Identical checklists were utilized for training both groups to ensure equal content coverage (Tables 1 and 2). Following the two-hour training, subjects completed a survey and cognitive test, identical to the one before the intervention, to assess changes that may have resulted from the training.

All subjects were asked to return one week later to participate in the second half of the study. Upon return, all subjects demonstrated airway management skills on a METIman® Patient Simulator (CAE Healthcare, Saint-Laurent, Quebec, Canada) during a pre-determined clinical scenario. This high-fidelity encounter served as an assessment of psychomotor skills and was evaluated by an expert who was blinded to which training model (HFS vs LFS) the participant previously received. The skills were evaluated using the same checklists that were used to guide the training process. The study procedure is shown in Table 3.

Data collection

Demographic data, pre- and post-affective surveys, pre- and post-cognitive tests, and psychomotor checklists were collected. Demographic variables included age, gender, years of experience as a respiratory therapist, and years of other health care experience. Both group A and group B participated in pre- and post-assessments including: 25 question cognitive LMA/intubation tests, 25 question cognitive BMV tests, 8-question affective LMA/intubation surveys, and 8-question affective BMV surveys with anchors of 1 "very low" confidence and 5 "very high" confidence (Tables 4 and 5). All cognitive tests were scored by computing the total score of correct answers. The affective surveys were scored by taking the sum of all responses. The psychomotor checklists were scored based on three variables: Done, Not done, and Done incorrectly. Done=1 point, Not done=0 points, and Done incorrectly=.5 points. Both psychomotor checklists were scored by computing the total score of correct answers. The content of the cognitive tests were all reviewed and agreed upon by three respiratory care program faculty members that have at least 10 years of respiratory critical care experience. The 5-point Likert scale affective survey and the psychomotor checklist were

Table 2
Psychomotor Intubation/LMA Checklist

Case: ___________________________
Subject ID: _____________________

SKILL	**DIRECT LARYNGOSCOPY**			
Task	Definition	Done	Not done	Done incorrectly
1. Assemble and prepare equipment	Subject should gather all of the following equipment: functioning laryngoscope (handle and blade), ETT cuff (checked), syringe, $EtCO_2$ detector, tube securing device, stylet, bag/mask, suction, oral airway, drugs, and gloves.			
2. Wash hands/apply gloves	Wash hands with soap and water or apply alcohol-based hand sanitizer. Apply gloves.			
3. Examine patient airway	Subjects should acknowledge that they would examine the patient's airway including: tongue, Mallampati score, and dental examination.			
4. Monitor vital signs	Subjects should acknowledge that they would monitor the patient's vital signs including: HR, RR, BP, and SpO_2.			
5. Position patient	Place in sniffing position with bed at comfortable height for laryngoscopist.			
6. Pre-oxygenate	100% O_2 for 3 minutes, or 100% O_2 8 VC breaths over 60 seconds			
7. Open patient's mouth	Use scissor technique with right hand..			
8. Visualize vocal cords	With laryngoscope in the left hand, place blade in right side of patient's mouth, sweep tongue left by moving blade to midline, and don't lever blade on teeth or gums.			
9. Insert ETT into trachea	Advance tip past vocal cords. After insertion, firmly grasp tube and note cm marking.			
10. Remove stylet	Complete task while keeping ETT secure and in place.			
11. Inflate ETT cuff	Minimal pressure required to prevent leak with positive pressure. Remove syringe.			
12. Ventilate patient	Full one-hand squeeze			
13. Verify ETT placement	$EtCO_2$ positive after 3-5 breaths, colorimeter changes, listen for breath sounds over epigastrium (one breath), then to each hemithorax in the midaxillary line (one breath on each side)			
14. Secure ETT	Secure ETT with tape or ETAD.			
15. LMA placement	With patient's neck flexed and head extended, press the laryngeal mask airway into the posterior pharyngeal wall using the index finger.			
16.	With patient's neck flexed and head extended, press the laryngeal mask airway into the posterior pharyngeal wall using the index finger.			
17.	Guide above tongue and down through oropharynx in a smooth, continuous motion until resistance is encountered.			
18.	Inflate laryngeal mask airway.			
Total				

Table 3
Study Procedure

Encounter 1: Initial day	
A. Experimental Group (high-fidelity)	BMV/LMA/Intubation 25 question cognitive LMA/intubation pre-test 25 question cognitive BMV pre-test 8 item affective BMV survey 8 item affective LMA/intubation survey New England Journal of Medicine BMV/LMA/intubation videos Psychomotor skills training with iStan® Patient Simulator 25 question cognitive LMA/intubation post-test 25 question cognitive BMV post-test
B. Control Group (low-fidelity)	BMV/LMA/ Intubation 25 question cognitive LMA/intubation pre-test 25 question cognitive BMV pre-test 8 item affective BMV survey 8 item affective LMA/intubation survey New England Journal of Medicine BMV/LMA/intubation videos Psychomotor skills training with Laerdal® Airway Management Trainer 25 question cognitive LMA/intubation post-test 25 question cognitive BMV post-test
Encounter 2: Approximately one week later	
A. Experimental Group (high-fidelity)	BMV/LMA/Intubation on METIman® Patient Simulator® Psychomotor LMA/intubation checklist Psychomotor BMV check list
B. Control Group (low-fidelity)	BMV/LMA/Intubation on METIman® Patient Simulator Psychomotor LMA/intubation checklist Psychomotor BMV check list

reviewed by six licensed respiratory therapists, each with more than 10 years of experience in airway management to establish content validity. These respiratory therapists were asked to rate the importance of tasks on a Likert scale with anchors of 1 “Not important at all” and 5 “Very important”. These results were averaged and scores of 4 “Important” and 5 “Very important” were used to create the final documents.

Data analysis

Descriptive statistics were used to describe age, gender, years of experience as a respiratory therapist, and years of other health care experience. For variables that were not normally distributed (age, years of experience as a respiratory therapist, and years of other health care experience) median (median) and interquartile ranges (IQR) were reported. A Mann-Whitney U test was used to determine the difference between groups in terms of age, years of experience as a respiratory therapist, and years of other health care experience. The total scores of the affective surveys, cognitive tests, and psychomotor checklists were reported as two nominal variables, high and low scorers. This was done by dividing subjects within both group A (n=13) and group B (n=15) by using median scores of each assessment from all study subjects (n=28). The subjects scoring at or higher than the median score were placed in the high scorer group and those scoring lower than the median score were placed in the low scorer group. The frequency of high versus low scorers for HFS versus the LFS for the pre- and post-cognitive tests, the pre- and post-affective tests, and psychomotor checklists were assessed using a chi-square test. All statistical analyses met the assumptions for Mann-Whitney U test and chi-square and were conducted by using IBM® SPSS® Statistics 23.0 (IBM Corporation, Armonk, NY) and a p-value of $< .05$ was considered statistically significant.

Results

Subjects

The study was conducted over a two-year period with a total of 30 study subjects enrolled between August 2014

Table 4
Affective BMV Survey

Use this scale to indicate your confidence regarding each item below. Circle your answer.

	Very low	Low	Moderate	High	Very high
1. Ability to recognize a patient in need of manual ventilation.	1	2	3	4	5
2. Monitor and interpret patient's vital signs.	1	2	3	4	5
3. Gather/ assemble equipment for airway management.	1	2	3	4	5
4. Be able to optimize patient position for manual resuscitation.	1	2	3	4	5
5. Bag-mask ventilate patient.	1	2	3	4	5
6. (Effectively) BMV for more than 5 minutes alone.	1	2	3	4	5
7. Recognize hazards/complications of BMV.	1	2	3	4	5
8. Recognize equipment malfunction (trouble-shoot).	1	2	3	4	5

Table 5
Affective Intubation/LMA Survey

Use this scale to indicate your confidence regarding each item below. Circle your answer.

	Very low	Low	Moderate	High	Very high
1. Assembling intubation equipment.	1	2	3	4	5
2. Performing an airway assessment.	1	2	3	4	5
3. Using a Macintosh blade/laryngoscope.	1	2	3	4	5
4. Using a Miller blade/laryngoscope.	1	2	3	4	5
5. Inserting ETT into airway.	1	2	3	4	5
6. Verifying ETT placement.	1	2	3	4	5
7. Securing ETT.	1	2	3	4	5
8. Inserting a LMA.	1	2	3	4	5

Table 6
Demographics

	Group A	Group B	*P*
Median age (years)	29, IQR 24.5-40	25, IQR 23-35	.56
Median RT experience (years)	3.5, IQR 0-13.5	2, IQR 0-7	.30
Median other health care experience (years)	0, IQR 0-1	0, IQR 0-0	05

and September 2014, as well as, May 2015 and June 2015. Two subjects withdrew due to inability to participate in the post one week skills testing. The study population consisted of 28 subjects divided into group A: high-fidelity (n=13) and group B: low-fidelity (n=15). Both groups were found to be similar in terms of age, past experience as a respiratory therapist, and years of other health care experience. These demographic variables were not normally distributed for either group. A Mann-Whitney U test revealed no difference in age between group A (median 29, IQR 24.5-40) and group B (median 25, IQR 23-35). There was also no difference in years of health care experience as a respiratory therapist for group A (median 3.5, IQR 0-13.5) and group B (median 2, IQR 0-7). Lastly, there was no difference in health care experience outside of respiratory therapy between group A (median 0, IQR 0-1) and group B (median 0, IQR 0-0) (Table 6).

Bag-mask ventilation

When comparing high pre-training affective survey scores (≥ 33 out of 40) between the groups, both groups were similar (HFS=53.8%, median 34, IQR 30-37; LFS=46.7%, median 31, IQR 27-37). Post-training, no difference was found between the two groups in terms of the frequency of higher affective scores with these high scorers being those that achieved a score of 36 or greater (HFS=53.8%, median 36, IQR 32-40; LFS=53.3%, median 37, IQR 31-40). BMV cognitive pre-test scores with the high scorers being those that achieved a score of 18 or greater out of a possible 25. After the training, the higher scorers were those that achieved a score of 20 or greater. There was no difference between the two groups in regards to the frequency of higher scores on the BMV cognitive post-test (HFS=38.5%, median 19, IQR 17-21.5; LFS=66.7%, median 18, IQR 19-21). Lastly, high BMV psychomotor checklist scores showed no difference in the frequency of high scorers being those that achieved a score of 6 or greater out of a possible 7 when comparing HFS vs LFS groups (HFS=61.5%, median 6, IQR 5.25-6.5; LFS=66.7%, median 6, IQR 5.5-6.5).

Laryngeal mask airway placement and endotracheal intubation

When comparing LMA/intubation pre-training affective survey scores, the frequency of higher scores were similar between the groups with the high scorers achieving greater than 28 out of 40 (HFS=46.2%, median 27, IQR 21-36.5; LFS=66.7%, median 30, IQR 23-34). After the training, there remained no difference in the frequency of higher affective survey scores between the groups with the high scorers being those that achieved a score of 34 or greater (HFS=53.8%, median 34, IQR 29-40; LFS=46.7%, median 33, IQR 31-38). When comparing the frequency of higher scorers on the LMA/intubation cognitive pre-test scores, there were no differences between the groups with the high scorers being those that achieved a score of 18 or higher out of a possible 25 (HFS=53.8%, median 18, IQR 15-20; LFS=60.0%, median 18, IQR 16-21). After the training, there remained no difference in the the frequence of higher scorers between the two groups of high LMA/intubation post-test scores with the high scorers being those that achieved a score of 19 or greater (HFS=46.2%, median 16, IQR 15-19.5; LFS=53.3%, median 19, IQR 16-20). Intubation/LMA checklist scores, with the high scorers being those that achieved a score of 16 or greater out of a possible 17, showed no difference in the frequency of higher scorers between the high-fidelity (53.8%, median 16, IQR 14.25-16.5) and low-fidelity (46.7%, median 15, IQR 13-16.5) simulation groups.

Discussion

The purpose of this study was to evaluate the effect of two different types of simulation technology on airway management training. While it has been convenient to have these resources available at our facility for training purposes, it was unclear if one offered an advantage over the other. We also understand that other facilities may not have HFS due to cost. Because of this, we anticipated that this study would offer further insight on the impact of simulation fidelity on learner performance.

Our results suggest that there is no difference between the use of high-fidelity and low-fidelity simulation when teaching proper technique for BMV, placement of LMA, and endotracheal intubation via direct laryngoscopy to respiratory therapy students and practicing respiratory therapists. These findings are consistent with other studies comparing HFS and LFS Norman et al showed that HFS and LFS results showed improvements in learner performance in tasks such as surgical techniques, auscultation skills, and cardiac resuscitation. This analysis noted that there was no dispute that HFS improved knowledge and performance of clinical tasks when compared to "nothing" or to "usual care". However, when compared, HFS showed no significant advantage over LFS in the aforementioned clinical skills.[18] The authors suggest that the context effect (making the environment as real as possible) on training may not be as substantial as educators might assume. In fact, it may be best to focus on the accuracy of the simulation that will elicit specific behaviors to complete a clinical task or objective. Interestingly, their findings also suggest that educators need to focus on critical elements of a procedure, like the "feel" of the tools/instruments, rather than the "look" of the trainer. In addition, Norman et al. propose that the complexity of a simulation may actually detract from the overall learning objectives due to the inability to process the large volume of information. Finally, they conclude that simulation fidelity and learning are not directly linked; admitting that this was previously demonstrated in the field of aviation.[18]

In contrast to the analysis by Norman et al, a study in 2006 found that when assessing the management of shoulder dystocia using HFS or LFS training, both groups showed an improvement. However it is noted that in this study, the HFS group had a higher successful delivery rate than that of the LFS group.[19]

The primary aim of this study was to determine if a difference between HFS and LFS existed in airway management training, in which no difference was found. We were pleased to observe that the majority of our study subjects gained knowledge and confidence as demonstrated by improved post-intervention test and survey scores.

Limitations

There were several limitations to this study. First, the study had a small sample size and convenience sampling. The recruitment of study subjects was challenging due to time constraints associated with classroom and clinical schedules. The subjects' previous training and high ability to perform the tasks may have impacted the results. Secondly, the simulation lab at our facility had just completed new construction. There were several technical difficulties related to equipment during the HFS training and testing portion of the research. This could have impacted communication and the overall abilities of the high-fidelity simulator, as the study staff had to interrupt the skills testing to troubleshoot mechanical issues. Thirdly, the published training videos utilized and the intubation cognitive pre-test or intubation cognitive post-test exam did not perfectly align, as the tests sought more detail that the videos described. If the experts considered the items on the test critical, a new video more reflective of the examination content should have been created. Another limitation was the use of two different instructors during the airway management training portion of our research. One instructor used HFS and the other used LFS. Although both instructors used the checklist as a guide to training, it is possible their individual approach impacted the study results.

Conclusion

When training respiratory therapy students and practicing respiratory therapists on airway management skills such as bag-mask ventilation, laryngeal mask airway placement, and endotracheal intubation, both high- and low-fidelity simulation may be considered. More research is needed to understand if skill simulation fidelity impacts knowledge retention over time and whether critical thinking or troubleshooting is enhanced more by high-fidelity versus low-fidelity simulation.

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Comparison of Self-Inflating and Flow-Inflating Resuscitation Device Utilization and Evaluation of a Training Program To Enhance Manual Ventilation Skills

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Abstract

Introduction: Respiratory therapists provide manual ventilations in clinical settings using self-inflating (SI) and flow-inflating (FI) resuscitation devices. This study evaluated the performance of respiratory care (RC) students when using the two types of resuscitation devices and then developed and evaluated a training module designed to improve student performance. **Methods:** RC students from the class of 2015 provided manual ventilations to an intubated RespiTrainer® Advance manikin and QuickLung® precision test lung with a tidal volume (VT) of 500 ml and a frequency of 10 bpm using SI and FI bags. Data were analyzed using a paired t-test with an alpha level of 0.05. Data from the class of 2015 indicated a need to create a training module for students to improve their performance using FI bags. Data regarding performance using FI bags from the classes of 2016 and 2017 were collected following administration of the training module and were compared to the 2015 data using the MANOVA and Tukey post-hoc statistical methods with an alpha level of 0.05. **Results:** Class of 2015 mean±standard deviation VT using SI resuscitation bag was 504.43±75.46 vs. 443.2±98.56 using FI bag ($p = 0.007$), respiratory rate was 10.1±2.91 using SI bag vs. 9.61±3.14 using FI bag ($p = 0.447$) and minute ventilation was 5±1.25 using SI bag vs. 4.12±1.25 using FI bag ($p = 0.005$). Following the training module, statistical differences were found for mean VT and minute ventilation between classes of 2015 and 2016 ($p<0.05$) and between classes of 2015 and 2017 ($p<0.05$). Statistical differences were not found between classes of 2016 and 2017 ($p>0.05$). Conclusions: The RC class of 2015 demonstrated more effective manual ventilations with a SI resuscitation bag versus a FI resuscitation bag. Future RC student classes would benefit from training modules specifically designed to improve student performance using FI resuscitation bags.

Key Words: manual ventilation, self-inflating, flow-inflating, resuscitation bags, learning module

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Introduction

Manual ventilation via a resuscitation device is a common procedure within the critical care setting which includes patient transport, cardiopulmonary resuscitation, and emergency situations.[1] Inadequate ventilation and improper technique of providing manual ventilation may lead to adverse clinical outcomes such as tissue hypoxia, gastric insufflation, pulmonary aspiration, increased intrathoracic pressure, and barotrauma.[1-4] The American Heart Association and the European Resuscitation Council state that adequate tidal volume (VT) and ventilation when providing manual ventilation should be 6-7 ml/kg and 8-12 breaths per minute (bpm).[1-2] Providing manual ventilations within these ideal parameters could be affected by the respiratory care clinician's training, technique, and experience.

Currently, manual ventilation can be provided by using a self-inflating resuscitation bag or flow-inflating resuscitation bag. A self-inflating semi-rigid silicone resuscitation bag will re-expand due to its own elastic recoil following compression. These devices do not provide positive end-expiratory pressure (PEEP) without the addition of a PEEP valve.[5-6] Flow-inflating resuscitation bags, also known as anesthesia bags, require a gas source to re-inflate the resuscitation bag following compression and breath delivery.[5] Flow-inflating resuscitation bags allow a practitioner to provide varying levels of PEEP by adjusting the rate of gas escape from the resuscitation bag.[5,7] Respiratory therapy educational programs usually provide training to students using both types of resuscitation bags. However, students may not receive the same experience using both resuscitation bags during their clinical rotations. Furthermore, the use of flow-inflating resuscitation bags requires training and skill to use properly[6] and health care practitioners who do not regularly use flow-inflating resuscitation bags state they are more difficult to use than self-inflating resuscitation bags.[5] This led to the following research questions: 1) are respiratory care students competent in providing manual ventilations using self-inflating and flow-inflating resuscitation bags, and 2) will the development of a training module improve student performance of providing manual ventilations?

The aim of this study was to 1) evaluate student performance when using self-inflating and flow-inflating resuscitation devices, 2) develop a training module for future students if a deficiency is found, and 3) evaluate student performance following the training module to determine the efficacy of the training module.

Methods

This study was performed in two phases and the Texas State University (TSU) Institutional Review Board (IRB) approved each phase. The first phase of the research involved the recruitment of student participants from the RC class of 2015 at TSU using an email invitation. Informed consent was obtained from each participant prior to data collection. A RespiTrainerÒ Advance multi-skill airway and ventilation trainer manikin (IngMar Medical, Pittsburgh, PA) was intubated with a size 7.5 mm internal diameter endotracheal tube (SunMed, Grand Rapids, MI) and then connected to a QuickLungÒ precision test lung (IngMar Medical, Pittsburgh, PA) to mimic an adult model. Prior to data collection, the RespiTrainer Advance manikin was calibrated per manufacturer recommendations and the QuickLung test lung was set to a compliance of 50 ml/cmH_2O and an airway resistance of 5 cm H_2O/L/sec. During the first day of data collection, participants were asked to provide manual ventilations for five minutes using a 2 liter self-inflating resuscitation bag (Ambu, Ballerup, Denmark) to the simulated adult model with a frequency of 10 bpm and a VT of 500 ml. Participants were then asked to return on another day that was scheduled at each participant's convenience for further data collection. During the second day of data collection, participants were asked to provide manual ventilations for five minutes using a 2 liter flow-inflating resuscitation bag (Vital Signs, Inc., Totowa, NJ) to the adult model with a frequency of 10 bpm and a VT of 500 ml. Data were recorded on two separate days as a way to minimize muscle fatigue of the participant. The mean VT, respiratory rate, and minute volume were measured by an internal pressure manometer within the RespiTrainer Advance and recorded by the RespiTrainer Advance proprietary software. Participants were blinded to the collected data while providing manual ventilations.

Statistical analysis was performed using IBM SPSS Statistics Version 20 (IBM, Armonk, NY). A paired t-test was used to compare mean VT, respiratory rate, and minute ventilation for each resuscitation bag at an alpha level of < 0.05.

Following data analysis for the first phase of the study, the investigators determined a deficiency in student use of the flow-inflating resuscitation bag and the faculty from the Department of Respiratory Care at TSU designed a learning module to enhance and improve student performance using the flow-inflating resuscitation bag. The training module was developed with three main learning objectives: 1) students should be able to assemble a flow-inflating resuscitation device, 2) students should be able to provide adequate tidal volumes and an adequate respiratory rate when providing manual ventilation, and 3) students should be able to identify and troubleshoot inadequate ventilations when providing manual ventilation.

The designed training module consisted of students viewing a recorded video describing the components and proper operation of flow-inflating resuscitation bags including bag sizes for each patient population, operation of the bleed valve, gas flow rate adjustment, and making adjustments to provide adequate ventilations. Students then received one-on-one instruction with a RC faculty member while providing manual ventilations to an intubated RespiTrainer Advance manikin as a way to enhance learning. During the one-on-one instruction, students visualized the VT, respiratory rate, minute ventilation, and inspiratory pressures being delivered to the simulated adult model to allow students to correct inefficient and improper technique when using the flow-inflating resuscitation bag. Faculty members would also attempt to further enhance student learning by reducing distraction during the learning module with a faculty to student ratio of 1:1, providing explicit learning objectives, and providing the opportunity for discussion regarding the proper technique of manual ventilation using a flow-inflating resuscitation bag.

The second phase of the research consisted of recruiting student participants via email from the respiratory care class of 2016 at Texas State University during the spring semester and from the respiratory care class of 2017 during the summer semester. Informed consent was obtained and students participated in the designed training module as previously described. Following the training module, the investigator instructed the student participant to disassemble the flow-inflating resuscitation bag to establish a baseline as if the student was providing manual ventilations for the first time to the simulated adult model. The student participant was then asked to assemble the flow-inflating resuscitation bag and provide manual ventilations for five minutes with a VT of 500 ml and frequency of 10 bpm to an intubated RespiTrainer Advance manikin and QuickLung test lung, which was calibrated per manufacturer recommendations and set to a compliance of 50 ml/cm H_2O and a resistance of 5 cm H_2O/L/sec. The manikin was intubated with a 7.5mm internal diameter endotracheal tube. Student participants were blinded from the data and the RespiTrainer Advance proprietary software was used to record the mean VT, respiratory rate, and minute ventilation for each participant session.

Data gathered from student performance when providing manual ventilations using a flow-inflating resuscitation bag from the respiratory care classes of 2015, 2016, and 2017 were compared using the MANOVA and Tukey post-hoc statistical methods with an alpha level of 0.05.

Results

Thirty student participants were recruited from the respiratory care class of 2015 consisting of 10 males and 20 females. Table 1 displays the inter-individual variability of performance for each student participant from the RC class of 2015 when using self-inflating and flow-inflating resuscitation bags. Results indicated that 50% of student participants obtained a VT between 450 ml and 550 ml when using a self-inflating resuscitation bag compared to 30% of students when using a flow-inflating bag. Eighty percent of participants achieved larger tidal volume ranges of 450 ml to 649 ml when using a self-inflating bag. This was in contrast to the flow-inflating bag volumes, where a majority of the participants (83.3%) achieved smaller tidal volumes of 250 ml to 549 ml (Table 1).

Mean delivered respiratory rate results (Table 1) from the RC class of 2015 when using self-inflating and flow inflating resuscitations bags were similar. Fifty percent of student participants achieved the recommended respiratory rate range of 8 to 12 bpm when using each resuscitation bag. Furthermore, 83.3% of participants achieved a respiratory rate range of 4 to 12 bpm when using a flow-inflating bag versus 73.3% of participants who obtained a higher respiratory rate range of 8 to 16 bpm when using a self-inflating bag.

Table 1
The 2015 cohort inter-individual variability of student performance for tidal volume (Vt), respiratory care (RR) and minute volume (MV) when using self-inflating and flow-inflating resuscitation devices.

	Resuscitation Device	
	Self-Inflating n (%)	**Flow-Inflating n (%)**
Mean Vt 250-349 ml	1 (3.3%)	7 (23.3%)
Mean Vt 350-449 ml	5 (16.7%)	9 (30%)
Mean Vt 450-549 ml	15 (50%)	9 (30%)
Mean Vt 550-649 ml	9 (30%)	5 (16.7%)
Mean RR 4-8 bpm	7 (23.3%)	10 (33.3%)
Mean RR 8-12 bpm	15 (50%)	15 (50%)
Mean RR 12-16 bpm	7 (23.3%)	3 (10%)
Mean RR > 16 bpm	1 (3.3%)	2 (6.7%)
Mean MV < 2.5 L/min	0 (0%)	1(3.3%)
Mean MV 2.5-3.49 L/min	4 (13.3%)	9 (30%)
Mean MV 3.5-4.49 L/min	10 (33.3%)	12 (40%)
Mean MV 4.5-5.49 L/min	6 (20%)	3 (10%)
Mean MV 5.5-6.49 L/min	6 (20%)	4 (13.3%)
Mean MV 6.5-7.49 L/min	3 (10%)	0 (0%)
Mean MV > 7.5 L/min	1 (3.3%)	1 (3.3%)

Table 2
The mean, standard deviation (SD) and p values obtained from a paired t-test analysis for tidal volume (Vt), respiratory rate (RR) and minute volume (MV) when comparing the 2015 Respiratory Care cohort performance of manual ventilations with self-inflating and flow-inflating resuscitation bags.

	Resuscitation Device		
	Self-Inflating n (%)	**Flow-Inflating n (%)**	***P-Value***
Mean Vt ± SD (ml)	504.43 ± 75.46	443.2 ± 98.56	0.007
Mean RR ± SD (bpm)	10.1 ± 2.91	9.61 ± 3.14	0.447
Mean MV ± SD (L/min)	5 ± 1.25	4.12 ± 1.25	0.005

Table 3
The 2015 and 2016 cohort inter-individual variability of student performance for tidal volume (Vt), respiratory rate (RR) and minute volume (MV) when using flow-inflating resuscitation devices.

	Cohort	
	2015 n (%)	**2016 n (%)**
Mean Vt 250-349 ml	7 (23.3%)	0 (0%)
Mean Vt 350-449 ml	9 (30%)	4 (15.4%)
Mean Vt 450-549 ml	9 (30%)	14 (53.8%)
Mean Vt 550-649 ml	5 (16.7%)	4 (15.4%)
Mean Vt 650- 750 ml	0 (0%)	3 (11.5%)
Mean Vt > 750 ml	0 (0%)	1 (3.8%)
Mean RR 4-8 bpm	10 (33.3%)	3 (11.5%)
Mean RR 8-12 bpm	15 (50%)	20 (77%)
Mean RR 12-16 bpm	3 (10%)	3 (11.5%)
Mean RR > 16 bpm	2 (6.7%)	0 (0%)
Mean MV < 2.5 L/min	1(3.3%)	0 (0%)
Mean MV 2.5-3.49 L/min	9 (30%)	3 (11.5%)
Mean MV 3.5-4.49 L/min	12 (40%)	5 (19.2%)
Mean MV 4.5-5.49 L/min	3 (10%)	11 (42.3%)
Mean MV 5.5-6.49 L/min	4 (13.3%)	4 (15.4%)
Mean MV 6.5-7.49 L/min	0 (0%)	1 (3.8%)
Mean MV > 7.5 L/min	1 (3.3%)	2 (7.7%)

Minute ventilation results from the RC class of 2015 (Table 1) indicated a majority of participants achieved a minute ventilation range of 3.5 to 4.49 L/min when using each resuscitation device. Seventy percent of participants achieved a minute ventilation range of 2.5 to 4.49 L/min when using a flow-inflating resuscitation bag, whereas 73.3% of participants achieved a larger minute ventilation range of 3.5 to 6.49 L/min when using a self-inflating bag.

Table 2 displays the means, standard deviations, and p-values obtained from the paired t-test analysis for VT, respiratory rate, and minute ventilation when delivering manual ventilations using self-inflating and flow-inflating resuscitation devices. Significant differences were found in delivered VT (p = 0.007) and minute ventilation (p = 0.005) when comparing the performance of the 2015 RC class' use of self-inflating and flow-inflating resuscitation bags. Significant differences were not found in delivered respiratory rate (p = 0.447) when comparing the 2015 RC class' use of self-inflating and flow-inflating resuscitation bags.

Twenty-six student participants were recruited from the respiratory care class of 2016 consisting of six males and 20 females. Twenty students were recruited from the RC class of 2017 consisting of six males and 16 females. A total of 46 students received the designed training module. Table 3 displays the inter-individual variability of performance using a flow-inflating resuscitation bag for the RC classes of 2016 and 2017 that received the training module and the RC class of 2015 that did not received the training module. During manual ventilation, using a flow-inflating resuscitation bag, 53.8% of student participants from the RC class of 2016 and 50% of student participants from the RC class of 2017 provided a VT of 450-550 ml compared to 30% of student participants from the 2015 cohort. Seventy-seven percent of students from the class of 2016 and 80% of students from the class of 2017 provided a respiratory rate of 8-12 bpm compared to 50% of students from the class of 2015. Forty-two percent of students from the class of 2016 and 60% of students from the RC class of 2017 provided a minute volume of 4.5-5.49 L/min compared to 10% of students from the RC class of 2015.

When comparing student performance using the flow-inflating resuscitation bag between the respiratory care classes of 2015, 2016, and 2017, a significant difference was found using the MANOVA statistical method with a p-value of 0.006. Table 4 displays the mean and standard deviation for VT, minute ventilation, and respiratory rate for each RC class. Significant differences were obtained when comparing the mean VT from the classes of 2016 (p = 0.001) and 2017 (p = 0.005) to the mean VT obtained from the class of 2015 and when comparing mean minute ventilation from the classes of 2016 (p = 0.015) and 2017 (p = 0.023) to the mean minute ventilation obtained from the class of 2015. A significant difference was not found when comparing the mean respiratory rate from the classes

Table 4

The mean, standard deviation (SD) and p values obtained from an unpaired t-test analysis for tidal volume (Vt), respiratory rate (RR) and minute volume (MV) when comparing the 2015 and 2016 Respiratory Care cohorts performance of providing manual ventilations with flow-inflating resuscitation bags.

	Flow–Inflating Resuscitation Device		
	2015 Cohort	2016 Cohort	*P-Value*
Mean Vt ± SD (mL)	443.2 ± 98.56	537.27 ± 94.88	0.001
Mean RR ± SD (bpm)	9.61 ± 3.14	9.61 ± 1.67	0.998
Mean MV ± SD (L/min)	4.12 ± 1.25	5.14 ± 1.62	0.01

of 2016 (p = 1) and 2017 (p = 0.998) to the mean respiratory rate from the class of 2015. A significant difference was not found in VT (p = 0.938), respiratory rate (p = 0.997), and minute ventilation (p = 0.999) when comparing performance from the class of 2016 to the class of 2017.

Discussion

Respiratory therapy clinicians have the option to utilize either self-inflating or flow-inflating resuscitation bags when providing manual ventilations in the clinical setting and each type of resuscitation bag can be found in neonatal, pediatric, and adult clinical settings. The popularity of flow-inflating resuscitation bags has been attributed to the ability of clinicians to "feel" changes in pulmonary compliance when providing manual ventilations, which has been referred to as the "educated hand."[7] However, previous research has shown that even experienced health care clinicians may have difficulty "feeling" changes in pulmonary compliance and may provide ineffective manual ventilations.[7] Egbert and Bisno found when anesthesiologists were asked to provide manual ventilations to a test lung with a VT as close as possible to 350 ml while investigators changed pulmonary compliance of the test lung, errors as great at 50% were common.[8] Spears et al. found anesthesiologists providing manual ventilations using a neonatal flow-inflating resuscitation bag had difficulty detecting large changes in pulmonary compliance and occlusion of the endotracheal tube.[9] Bowman et al. recruited experienced neonatal respiratory therapists, physicians, registered nurses, and neonatal nurse practitioners in a study involving the use of infant-sized flow-inflating and self-inflating resuscitation bags and found that participants showed a greater ability to compensate for changes in pulmonary compliance with self-inflating resuscitation bags than flow-inflating resuscitation bags.[10] Bowman et al. concluded that health care clinicians should not use the "educated hand" as a rationale for selecting flow-inflating resuscitation bags when providing manual ventilation.[10]

Multiple studies have outlined the difficulties in accurately using manual resuscitation devices. Zmora and Merritt investigated the ability of nurses and physicians to accurately maintain low peak inspiratory pressure during manual ventilation.[11] Results indicated that both groups were unable to maintain low peak inspiratory pressure without the use of a pressure manometer.[11] A study performed by Dawson et al. asked neonatal health care clinicians to deliver manual ventilations using self-inflating, flow-inflating, and t-piece resuscitators and reported manual ventilations with flow-inflating bags resulted in the greatest variability of VT.[12] Unfortunately, no previous research has investigated the accuracy of respiratory care students by measuring delivered tidal volume, minute volume, and respiratory rate when using flow-inflating and self-inflating bags.

The results of our current study revealed similar variances in outcomes when comparing student performance of manual ventilation between the two resuscitation devices. Significant differences were found when comparing the mean VT and minute ventilation between student use of self-inflating and flow-inflating resuscitation bags. No significant difference was found in delivered respiratory rate between the self-inflating and flow-inflating resuscitation bags. Respiratory care students from the class of 2015 appear to have been more accurate when using self-inflating resuscitation bags by providing an adequate VT and minute ventilation and may not be prepared to use the flow-inflating resuscitation bag following graduation. Students would benefit from additional education and training regarding the use of flow-inflating resuscitation bags. Hussey et al stated that performance using flow-inflating resuscitation bags is dependent on health care provider training and practice.[6] Due to this, the investigators wanted to develop an additional training module for respiratory care students regarding the use of flow-inflating resuscitation devices, prior to graduation. While our investigators have not received negative feedback regarding past graduate performance when using flow-inflating resuscitation bags, the faculty at Texas State University strive to thoroughly prepare students for their careers.

Data comparison between the classes of 2015, 2016, and 2017 revealed a higher accuracy of target ventilation after students participated in the designed training module. A significant difference was found in VT and minute ventilation when comparing the use of flow-inflating bags between the classes of 2015 and 2016 and the classes of 2015 and 2017. Students' ability to maintain an appropriate breath frequency when providing manual ventilations was unchanged when comparing all respiratory care classes before and after the training module and this skill may have been gained during clinical rotations and lab activities prior to the training module. Student performance of providing manual ventilations using the flow-inflating resuscitation bag improved for two consecutive years for the RC classes of 2016 and 2017 when compared to the RC class of 2015. Subjectively, the investigators felt student participants responded well to the training module while students stated their confidence regarding the use of flow-inflating resuscitation devices improved following the training module.

Limitations

This study only evaluated the respiratory care class of 2015 as a needs assessment for additional training by intra-related comparisons. Due to the deficiency in student performance using a flow-inflating resuscitation bag upon evaluation of the class of 2015, the training program was developed for the use of a flow-resuscitation bag only. Student performance of manual ventilations using a self-inflating resuscitation bag was not evaluated for the classes of 2016 and 2017. The efficacy of the training program was evaluated using inter-related comparisons to the class of 2015.

This study evaluated the performance of providing manual ventilations to an intubated manikin and did not collect data with the use of a facemask. Leaks around a mask when providing manual ventilations can also contribute to inadequate ventilations.[5]

This study used convenience samples of students attending classes in the Department of Respiratory Care at Texas State University. Assessment of student performance in providing manual ventilations using self-inflating and flow-inflating resuscitation bags may be beneficial to determine how well respiratory care programs prepare students to provide manual ventilations in the clinical setting. Furthermore, providing the training module at other RC programs may be beneficial to further determine the efficacy of the developed training module.

Conclusion

While respiratory care students show competency when providing manual ventilations with a self-inflating resuscitation bag, students would benefit from additional training as a way to improve their use of flow-inflating resuscitation bags before entering the profession. RC students demonstrated improvement in their ability to achieve target ventilation goals following participation in a designed training module.

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