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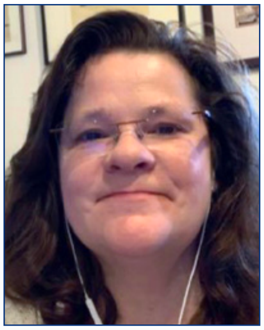

Staci A. Fischer, MD

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Medical Education
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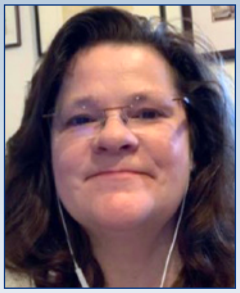

Introduction to the Medical Education Issue: Showcasing Innovations and Initiatives in Undergraduate, Graduate Medical Education

STACI A. FISCHER, MD
GUEST EDITOR

We are excited to bring you a special issue of the *Rhode Island Medical Journal* (RIMJ) this month, dedicated to innovations in medical education. In this issue you will find articles from medical students, residents, fellows and attending physicians here in Rhode Island and elsewhere on innovative approaches to undergraduate and graduate medical education, encompassing topics such as the role of simulation in residency training in surgical specialties and in mass casualty preparedness; data, initiatives and program website promotion of diversity and inclusion in residency training across the United States in several specialties; and the status of international medical graduates in orthopedic training programs in the country.

Under the direction of **B. STAR HAMPTON, MD**, Senior Associate Dean for Medical Education at The Warren Alpert Medical School of Brown University (AMS), we have a number of updates on initiatives at the medical school, highlighting efforts in belonging, equity, diversity and inclusion; improving well-being and addressing medical student mistreatment; and ensuring community engagement in the curriculum.

These manuscripts demonstrate that despite the disruption in usual undergraduate and graduate medical education practices during the height of the COVID-19 pandemic, innovations continued to be developed. We hope that this issue provides new insights into medical education in Rhode Island and beyond.

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A Challenging Future Ahead for Undergraduate Medical Education

B. STAR HAMPTON, MD

Educating and training physician providers, leaders, scientists, advocates, and educators of tomorrow is a daunting task amidst an ever-changing healthcare landscape, political climate in America, and a realization that our healthcare systems of the past may not be best in serving the patients and workers within them, especially as we undertake the critical mission to diversify our physician workforce. This is with the backdrop of – to name a few things – what has been declared a moral crisis for physicians today, the rising costs of education in America, and the emergence from a pandemic that depleted our healthcare systems.

Brown University launched its medical school in 1972. Serving the state for the past 50 years, today The Warren Alpert Medical School of Brown University (AMS) is Rhode Island's only medical school, placing it in a unique position to lead these educational efforts both locally and nationally. AMS undergraduate medical education (UME) leaders are considering many factors as we navigate this treacherous landscape and think about how to best serve our students, faculty, and diverse communities. Our efforts all focus on the goal of taking the best care of patients in the future.

Curriculum review & The Office of Belonging, Equity, Diversity and Inclusion (OBEDI)

The medical school will begin to undertake a curriculum review over the next 12 to 18 months. In doing so, we will think about who we are educating and what we are placing in the curriculum. Our student body today is different from the student body 50 years ago, and our appreciation of the diverse backgrounds and life experiences students bring to AMS that shape how they learn continues to grow. The Office of Belonging, Equity, Diversity and Inclusion (OBEDI), led by inaugural Senior Associate Dean for Diversity, Equity and Inclusion, Dr. Patricia Poitevien, is a national leader and critical for these efforts. The comprehensive goals, programming, and outcomes, all focused on sustainable health equity for individuals and community, are outlined in the article in this edition authored by members of that office.

Community engagement and service learning in AMS curriculum

Our understanding of knowledge areas that are essential to the health of our populations and communities continues to expand and evolve. We know medical school must be more than pathology and organ systems for physicians of tomorrow to be successful. At AMS we continue to integrate essential topics such as population and planetary health, artificial intelligence, professional identity formation, lifestyle medicine and service learning, to name a few, into our curriculum. Within this special edition, our leaders in the Office of Medical Education describe how we have incorporated community engagement and service learning into the AMS curriculum. These efforts can impact professional development and build sustainable, mutually beneficial relationships with our communities, ultimately improving the health of those within the communities.

Student wellness efforts

Along with the who and what, medical education leaders need to think critically and creatively about how we are delivering material, assessing student learning and skills, and handing students off to our graduate medical education colleagues. The article from OBEDI outlines how we are working to achieve inclusive learning and teaching practices, with faculty coaching and mentorship for inclusive teaching and review of student-submitted curricular opportunity forms. Supporting student and faculty well-being is essential throughout. This includes intentional wellness programming alongside safe and positive working and learning environments free of mistreatment. At the forefront of this work at AMS and nationally, leaders from the Office of Student Affairs have outlined their efforts in this space in the article "An Integrative Approach to Addressing Medical Student Mistreatment and Promoting Student Well-Being." A healthy, resilient student body leads to a physician workforce that is well positioned for a challenging future, and better outcomes for patients and communities served.

Yes, the task set in front of us is daunting, and with that comes anticipation and excitement. As you will read, AMS faculty and staff have already made incredible strides in many areas. We are at an inflection point of change. We are positioned to make continued positive impacts in the state and beyond. And we will do so by continuing our legacy of listening to our students, thinking creatively, and embracing innovation.

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The Office of Belonging, Equity, Diversity, and Inclusion in The Warren Alpert Medical School: Aligning Goals, Programming, and Outcomes for Health Equity

ANNE VERA CRUZ, PhD; JOSEPH DIAZ, MD, MPH; TRACEY GUTHRIE, MD; DIOSCARIS GARCIA, PhD; PATRICIA POITEVIEN, MD, MSc

ABSTRACT

Although United States (US) medical institutions discuss the importance of diversity, equity, and inclusion, there is little guidance about the process by which these concepts can be attained programmatically within institutions. The Office of Belonging, Equity, Diversity, and Inclusion (OBEDI) at The Warren Alpert Medical School of Brown University intends to rise to the challenge and share knowledge and experience with other institutions. Program design models, and the alignment of inputs, outputs, and outcomes for the short-term and long-term are illustrated. OBEDI's unique model of how each of these concepts contribute towards health equity, from the individual to the community, is also explained. Finally, OBEDI shares promising practices and future directions.

KEYWORDS: health equity, diversity, inclusion, belonging

INTRODUCTION

In recent years, national institutions such as the Association of American Medical Colleges (AAMC),[1] the American Medical Association (AMA),[2] and the Centers for Disease Control and Prevention (CDC)[3] have highlighted the importance of advancing diversity, equity, and inclusion (DEI) in relation to achieving health equity. While these terms are defined differently by each of the aforementioned institutions, all three have unequivocally argued that programming for DEI is necessary at every level of the medical profession in order to administer patient care with a health equity lens. After all, healthcare professionals are routinely confronted with the effects of health inequities, from differences in maternal health outcomes,[4] life expectancy,[5] and access to healthcare.[6]

While much professional guidance has been provided for both defining DEI terms and suggesting health equity outcomes, little guidance has been provided on what we call "process alignment", namely, connecting DEI goals with programs and resources (inputs), and ultimately with health equity outcomes. For example, in medical schools, DEI professionals are categorically tasked with programming for a wide range of audiences including Undergraduate Medical Education (UME), Graduate Medical Education (GME), and Continuing Medical Education (CME). This task is not as straightforward as it seems. For example, DEI professionals must often support and retain learners who are underrepresented in medicine (UIM) from an institutional perspective while simultaneously engaging K–12 and undergraduate students through "pathway" programs, all towards a goal of diversifying the workforce.[7] In addition, more critical scholar-activists in medicine have rightly called for DEI professionals to think about and plan for what DEI knowledge, skills, and experiences all individual learners, underrepresented or not, must obtain across the professional spectrum, in support of health equity.[8] This requires that the "teachers be taught" and special attention paid to providing supplemental education to those faculty members and supervisors who themselves do not have a strong understanding of DEI.

These diverse audiences create the need for heterogeneous programming at different levels within the institution. Furthermore, there is the wide-ranging challenge of advancing health equity more generally, in our local hospitals, professional organizations, and broader healthcare ecosystem. As such, an institution's process alignment is indispensable to thinking through how our internal outcomes can advance broader changes in the healthcare community – from increased diversification of the healthcare workforce to improvements in real-world health equity outcomes. The Office of Belonging, Equity, Diversity, and Inclusion (OBEDI) at The Warren Alpert Medical School of Brown University intends to rise to this challenge and share our knowledge and experience with other institutions. Collectively, this paper aims to:

1. Share how our definition of diversity, equity, inclusion, and belonging shapes program design and illustrate how this aligns with OBEDI programs (inputs) and its desired outcomes.
2. Discuss promising practices for other institutions working on DEI process alignment and the OBEDI's future directions.

THE VALUES THAT FRAME OBEDI WORK

OBEDI has four main centers that implement various aspects of programming. The Center for Community Engagement and Pathway Programming (CCEPP) focuses on local and regional outreach, often engaging with health centers, learners, and families in order to promote a diverse workforce and support successful community partners in the pursuit of health equity. The Center for Belonging (CB) works with student affinity groups and UME leaders to create community and foster a culture of belonging within the medical school. The Center for Workforce Recruitment and Retention (WRR) works with GME, faculty and clinical departments to attract and retain physicians who are historically marginalized and minoritized. Finally, the Center for Curricular Innovation and Student Achievement supports senior administration and faculty in the design and implementation of programs and curricula that promote social justice and equitable instruction for all learners. The Senior Associate Dean for DEI and the Directors of OBEDI centers often collaborate with external partners at the University, in the Medical School, across the clinical enterprise and within the Rhode Island community to achieve these goals.

The OBEDI fills in gaps of support for historically marginalized and minoritized learners, faculty, and staff, while also providing resources for all members of the community, no matter where they are on their journey towards DEI and health equity. OBEDI believes that programming for all members, regardless of positionality, is important to attain its goals of fostering diversity, equity, inclusion, and belonging within and beyond the institution.

Diversity

The AMA and AAMC[9] define valuing diversity as "recognizing differences between people, acknowledging that these differences are a valued asset, and striving for diverse representation as a critical step towards equity." Though diversity in academic medicine can be narrowly defined as the mere presence of people from underrepresented populations, we expand this definition to include the acceptance of the knowledge and perspectives that come with representation. Practically, this means that we aim to recognize that each student has a unique perspective that could contribute towards a better understanding to the complex problems within healthcare.

Key initiatives supporting workforce diversity are Month of Medicine, The Brown Minority Housestaff Association (BMHA), the Brown Diversity Visiting Scholarship, Black Men in White Coats, and the Tougaloo Early Identification Program. Additionally, the Diversity in Curriculum program focuses on incorporating distinct perspectives throughout the curriculum, for all learners. We use faculty coaching and professional development to deliver education meant to prepare students to care for increasingly diverse patients. The program model for diversity is illustrated in **Figure 1**.

Inclusion

We define inclusion as the policies and structures that shape the culture and behaviors within a space or institution. The AMA and AAMC[9] similarly define inclusion as

> "How our defining identities are accepted in the circles that we navigate. [It] is the process of creating a working culture and environment that recognizes, appreciates, and effectively utilizes the talents, skills, and perspectives of every employee; uses employee skills to achieve the agency's objectives and mission; connects each employee to the organization; and encourages collaboration, flexibility, and fairness. In total, inclusion is a set of behaviors (culture) that encourages employees to feel valued for their unique qualities."

Because different stakeholders, such as learners, faculty, and administrators have different perspectives, OBEDI

Figure 1. Program Design for Diversity

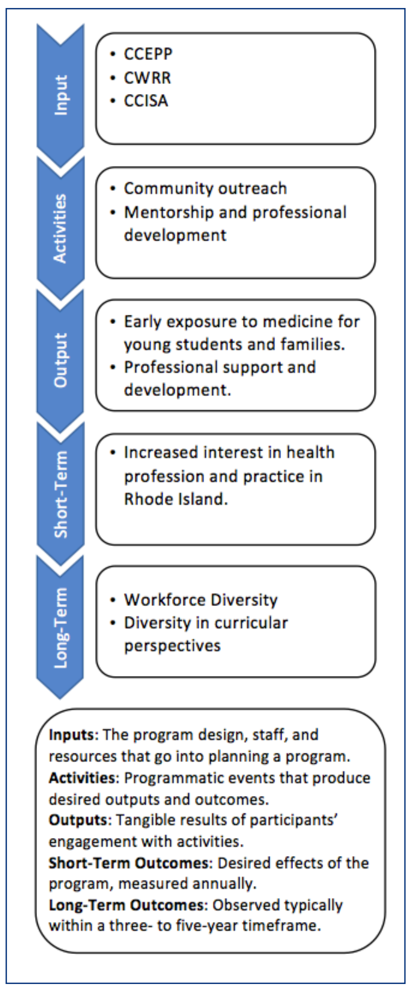
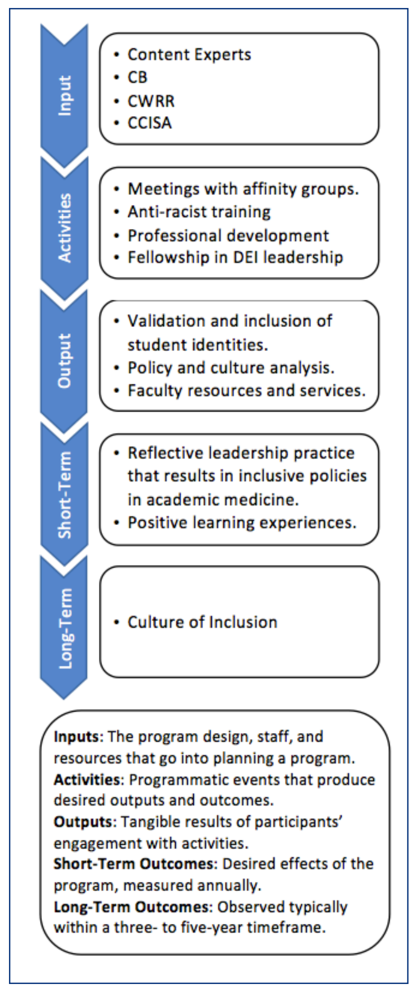


Figure 2. Program Design for Inclusion



assumes that everyone has agency in creating inclusive spaces. However, in recognizing that stakeholders in positions of power have more influence in shaping these spaces, programming intentionally includes the highest-ranking members of the medical school – the Dean's Leadership Council – in anti-racism training in order to promote inclusive decision-making, especially for policy design that leads to better learning outcomes.[10] Interested faculty, another stakeholder in a position of power, are also coached in developing inclusive learning spaces through curricular services and faculty development. Finally, in celebration of learner identities, OBEDI guides and advocates for student affinity groups and also supports a yearlong fellowship for students interested in becoming leaders in DEI, in order to center and amplify student voices and perspectives. OBEDI also provides faculty coaching for inclusive teaching and mentorship. The programmatic model for inclusion is illustrated in **Figure 2**.

Successful diversity and inclusion programming relies on a strong understanding of equity – or the recognition that those who are historically minoritized in medicine have had more barriers to the profession. As such, OBEDI aims to ensure that these differentially positioned populations have equitable access to opportunities. The AMA and AAMC[9] make an important distinction between equality and equity:

> "Equality as a process means providing the same amounts and types of resources across populations. Seeking to treat everyone the "same", this ignores the historical legacy of disinvestment and deprivation through policy of historically marginalized and minoritized communities as well as contemporary forms of discrimination that limit opportunities."

Practically, this means that support is provided to those who are historically minoritized in medicine to redress barriers to opportunities. Key programmatic examples for equity include medical school membership in the Leadership Alliance, Mentoring and Educating Diverse Students and Trainees to Excel as Physicians (MEDSTEP), Together Everyone Achieves More (TEAM), and the Let's Get Out Series, all of which contribute towards social and navigational capital.[11] The programmatic model for equity is illustrated in **Figure 3**.

Belonging is a sense of connectedness to a group or a community that an individual experiences when they view themselves as a respected member of the group and they know their contributions are valued. Sense of belonging impacts academic achievement, choice of profession, self-efficacy, workforce retention, and productivity.[12,13] Individuals who are historically UIM are at a disadvantage when it comes to developing a sense of belonging. Practically speaking this means the OBEDI actively seeks out opportunities to reinforce belonging for learners and faculty with programs like Brother-2-Brother and The Justice, Equity, Diversity, and Inclusion Faculty Association. The OBEDI also collaborates with our clinical partners to quantify and eliminate barriers to belonging such as microaggressions and discrimination, through reporting systems, education, and policy recommendations. The programmatic model for belonging is illustrated in **Figure 4**.

Though OBEDI is conscious and intentional about programming, we recognize that the potential and lived impacts of the work are not easily categorized within the individual, the institution, and/or the community. Instead, we believe that if the "work" is done correctly, in its full complexity, the impacts would span across all three major stakeholders, in multiple directions. In OBEDI's Frame of Work (**Figure 5**), an investment in the "individual", would then have significant impacts on the institution and the community. For

Figure 3. Program Design for Equity

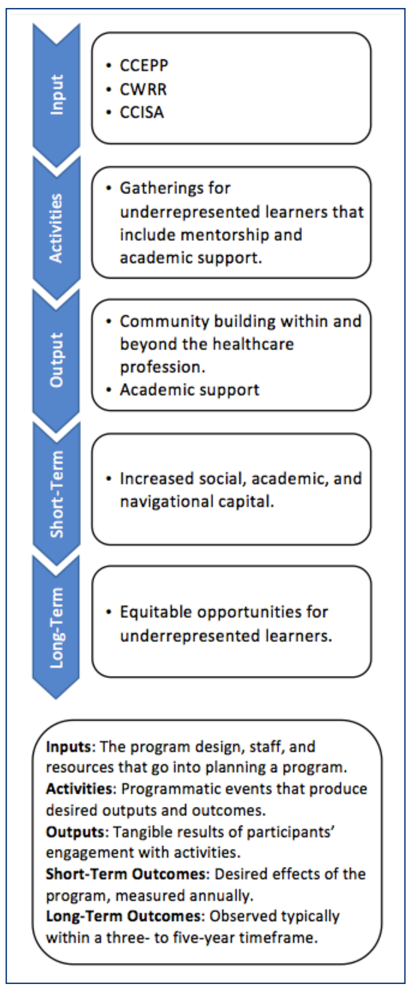


Figure 4. Program Design for Belonging

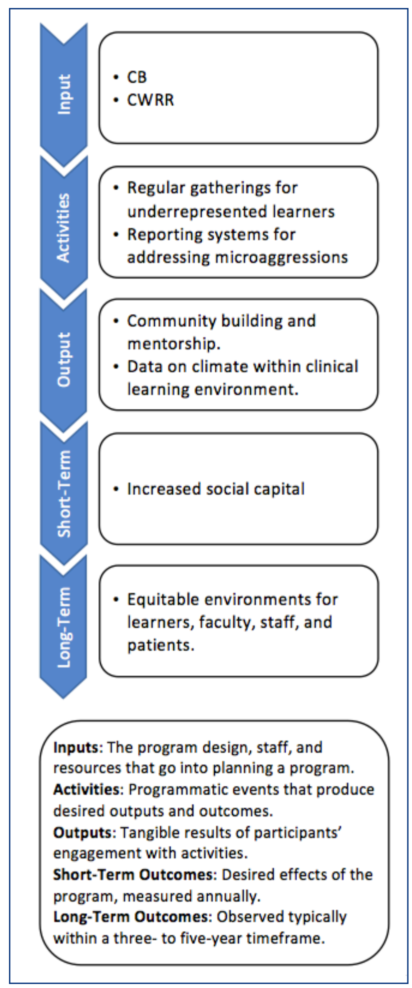
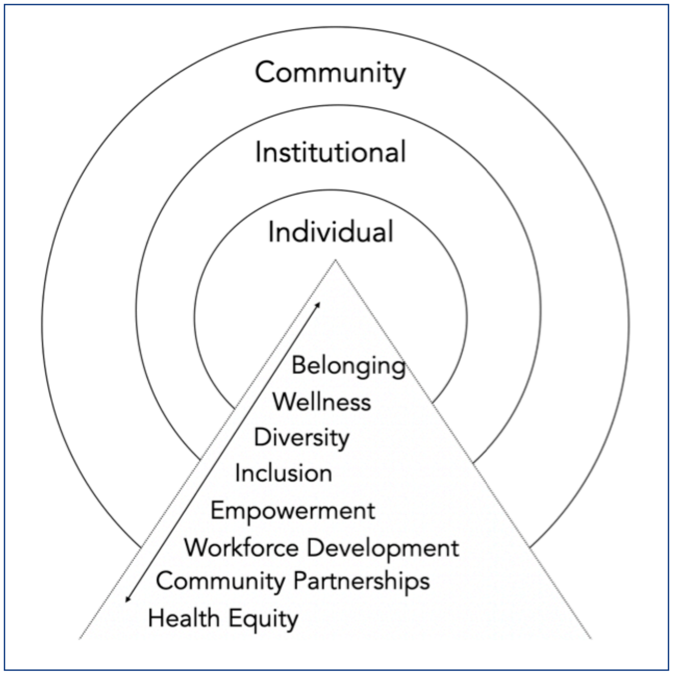


Figure 5. OBEDI Frame of Work



example, OBEDI programming anticipates that fostering true "belonging" for an underrepresented medical student would contribute towards a more welcoming environment institutionally, which would both increase retention for staying within the profession and supporting the community and create an environment that is more welcoming to patients and staff from minoritized backgrounds.

This model can also be applied from the community perspective towards the individual. A good understanding of the population that makes up a community (and the unique experiences within), is essential in shaping institutional decision-making for programming. For example, frequent engagement with local schools and community health centers informs OBEDI about necessary partnerships in pursuit of health equity. This not only shapes what learners are taught and how they practice care to influence health outcomes at the population level, but it also fosters care and belonging for each member of the Rhode Island community. Additionally, it facilitates belonging for minoritized students and faculty by connecting their work and education to positive outcomes for community members who come from similarly minoritized backgrounds.

The investment of institutions in this model is essential as it often provides the capital and resources to be able to reach both internal and external stakeholders and communities. For example, The Warren Alpert Medical School, through OBEDI, is able to connect with and provide information about healthcare professions education to youth and parents.[14] This is significant because the self-efficacy and empowerment in pursuit of a health degree increases when young learners meet successful healthcare professionals who have similar, intersectional positionalities.[15]

As the pursuit of health equity is complex and involves societal solutions beyond the field of medicine,[16] institutions play an extensive role in not only creating a vision internally, but consistently seek opportunities to serve its stakeholders through various programming efforts. By leading and being "led", the impact of the institution is bi-directional, bridging both the individual within the medical profession and the community it serves.

FUTURE DIRECTIONS

OBEDI recommends that institutions committed to diversity, equity, inclusion, and belonging carry out a similar design-process-outcome alignment in order to have a clearer sense of desired outcomes and needed infrastructure for successful programming. This leads to a better sense of desired short-term and long-term measures, which are often elusive in health equity work and also allows the team to reflect upon the process by which these measures are achieved. The goal of DEI work should be cultural transformation and must be viewed as mission critical and foundational to the strategic vision of any academic medical center. DEI should be infused in research, clinical care, and education if goals of belonging (individual) and health equity (population) are ever to be reached. As programming is developed and executed, its impact on the tripartite mission and its ability to advance belonging and health equity should be continually evaluated. Finally, this alignment also provides an opportunity for the institution to reflect upon what programming might be needed for the future, for new and ever-evolving audiences.

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A Community-engaged Curriculum at Alpert Medical School: Centering Patient Communities in Medical Education

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ABSTRACT

BACKGROUND: Incorporating opportunities for community engagement into undergraduate medical education (UME) can help learners to identify and address social determinants of health (SDoH). Multiple challenges exist in operationalizing these experiences.

METHODS: Using the Assessing Community Engagement (ACE) model, course directors at the Warren Alpert Medical School of Brown University (AMS) mapped community engagement initiatives to the four-year curriculum.

FINDINGS: Service-learning, community engagement projects, and clinical rotations at health centers and free clinics aim to equip learners at AMS with the necessary skills to address SDoH. Careful consideration should be given to the time and resources required to facilitate relationships with community-based agencies, learner reflection, program evaluation, and community-level outcomes.

CONCLUSIONS: Community engagement activities should be aligned with learning objectives during the pre-clerkship and clerkship stages of the existing UME curricula. Embarking on a curriculum redesign can create opportunities to expand partnerships with local agencies and deepen student engagement.

KEYWORDS: curriculum development, community engagement, service learning, health professions education

INTRODUCTION

It is widely accepted that medical educators share a social responsibility to teach medical students how to care for underserved and marginalized communities.[1] Increasingly, United States medical schools are incorporating social determinants of health (SDoH) and resultant health disparities into undergraduate medical education (UME) curricula. However, more may be needed to move learners beyond a baseline level of awareness.[2] By equipping medical students with the ability to apply knowledge of the SDoH to patient care, future providers may be better prepared to develop more effective treatment plans, ultimately addressing the underlying causes of illness and improve overall population health.[3]

Meaningful community engagement experiences can impact students' professional development, help develop cultural humility, and promote social responsibility, while also having the potential to improve patient outcomes. The National Academy of Medicine's Assessing Community Engagement (ACE) conceptual model proposes that systems change cannot occur without the engagement of those closest to the challenges and solutions–communities themselves.[4] Core principles of this model include ensuring that community engagement activities are grounded in trust, are designed to be bidirectional, are equitably financed, and are characterized by shared governance and endure beyond the project time frame. Operationalizing meaningful community engagement experiences for students, however, is not simple. Identifying local agencies with the capacity to host learners, incorporating these activities into an already packed curriculum, assessing learners on knowledge and skills acquired, and evaluating the impact of community engagement programs are formidable challenges. Using the ACE model as a guiding framework, this article summarizes the integration of community-engaged experiences into the UME curriculum at the Warren Alpert Medical School of Brown University (AMS) and discusses lessons learned in light of the aforementioned challenges, with a focus on potential future directions.

PRE-CLERKSHIP CURRICULUM

Student participation in community engagement at AMS occurs throughout the 4-year curriculum. Opportunities take place in both the classroom and community-based settings. Classroom-based work in the Health Systems Science course during the first semester provides students with a theoretical foundation on the SDoH and how the healthcare system can intervene in the SDoH mechanisms to alleviate differential consequences of ill health. The course also teaches students basic principles in biostatistics and epidemiology.

Parallel to basic sciences courses during the first two years, students participate in clinical skills training courses known as *Doctoring*. A four-semester curriculum, *Doctoring* teaches students foundational and advanced communication skills, physical exam skills, and clinical reasoning. Hands-on practice with standardized patients in a simulation lab and experience working alongside a community-based physician once per week helps reinforce these skills. Weekly didactics focus on increasing awareness of health inequities, barriers to care, and the SDoH, with the goal of providing patient-centered, inclusive care (see **Table 1**). These goals are most effectively obtained in the curriculum when students see and hear the lived experiences of patients and experts.[5] Several times throughout the academic year, guests are invited to AMS to share their insights, experiences, and expertise as either providers or consumers of care. For example, agencies that serve members of LGBTQ+ community, people living with disabilities, people who use drugs, refugees, and people with a history of interpersonal violence reinforce a patient-centered, inclusive approach to care. By participating in either a panel or small group discussion, guests discuss intersectionality, bias, stigma, barriers to care and services, and the role of physician advocacy. Patients affected by health care disparities often share their strengths; how they have learned to navigate the healthcare system; and what they value most in the doctor-patient relationship. Students have shared that hearing real-life scenarios of exceptional and below standard clinical encounters and clinical pearls from providers who care for certain patient populations provide valuable perspective and appreciation for inclusive language and practices that are not found in textbooks or lectures.

Beyond the classroom setting, students are actively engaged in the community through the service-learning curriculum (see **Table 2**). Service-learning is a structured learning experience that responds to a community-identified need. It aims to develop students' professional identities by increasing awareness of cultural differences, instilling humility, and exposing the learner to a team-based approach to patient care. First-year students participate in *My Life, My Story*, an activity which pairs students virtually with older adults in the community with the goal of listening to and documenting the volunteer's life story, in conjunction with the volunteer's feedback. The activity emphasizes active listening, empathy and collaboration as essential clinical skills for patient care, while imparting the importance of the patient's whole life story on their medical care.

In the second semester of *Doctoring*, students chose a service-learning project from a pre-selected list of local nonprofits, schools or pre-clerkship electives with a service component (see **Table 2**) or identify an opportunity on their own. These experiences aim to identify and address community strengths and needs related to economic stability, health care access and quality, education access and quality, neighborhood and built environment, and social and community context while providing a deeper connection to class content by encouraging students to apply their knowledge to a real-world setting. There are similar requirements in the first semester of their second year which offer the potential for longitudinal engagement. Each semester's service-learning project culminates with a reflective writing assignment and small group discussions furthering students' professional identity formation and development.

CLERKSHIP AND POST-CLERKSHIP CURRICULUM

As students enter the clinical environments more regularly in the clerkship and post-clerkship phases of the curriculum,

Table 1. Classroom-Based Community Engagement Opportunities in Years 1-2 at Alpert Medical School

Session (total hours)	Session Objectives	Skill Development	Community Partners
LGBTQ+ Patient Care Didactic Session (4 hrs.)	Review skills and resources for providing inclusive care Recognize appropriate and inclusive terminology Recognize barriers to care	Clinical case discussion	Lotus Noire Health Open Door Health Rhode Island Hospital (Lifespan) Thundermist Health Centers
Disabilities in Medicine Didactic Session and Workshop (4 hrs.)	Compare and contrast medical and social models of disability Recognize appropriate and inclusive terminology Recognize barriers to care Discuss effective communication skills	Clinical case discussion	Gnome Surf Project Let's Erase the Stigma (LETS) RI School for the Deaf RI Special Olympics
Harm Reduction Didactic Session (4 hrs.)	Understand and practice the 5 A's (Ask, Assess, Advise, Assist, Arrange) of motivational interviewing Understand the principles of harm reduction Apply a harm reduction lens to all forms of behavior change counseling	Reflective discussion Practice substance use counseling Pre- and post-test on harm reduction knowledge and skills	Addiction Medicine Consult Service at Rhode Island Hospital (Lifespan) Project Weber-Renew
Transgender Patient Care Didactic Session (4 hrs.)	Define terminology to provide inclusive care and recognize health issues relevant to transgender patient care Recognize barriers to care	Reflective discussion Clinical case discussion	Thundermist Health Centers

Table 2. Site-Based Community Engagement Opportunities in Years 1-2 at Alpert Medical School

Activity	Objectives	Skill Development	Community Partners
My Life My Story Project (Year 1, first semester; 4-8 hrs.)	Develop communication skills Develop active listening skills and empathy Identify patient strengths Increase familiarity with geriatric patient populations	Reflective field note Reflective discussion	Hope Health Lifelong Learning Collaborative National Association of Social Workers (NASW) RI Chapter PACE Organization of RI Pride in Aging RI Saint Elizabeth Village Common of RI Village at Waterman Lake We Can Help You Winslow Gardens
Service-Learning Activity (Year 1, second semester and Year 2, first semester; 8 hrs.)	Health behavior education Develop social justice orientation Identify and address community needs Develop leadership skills Community development and advocacy	Reflective field note Reflective discussion	Be Kind RI Clínica Esperanza Dance for Parkinson's Lotus Noire Health Higher Ground International Hope's Harvest RI House of Hope Community Development Corporation Progreso Latino Providence Neighborhood Planting Program (PNPP) RI Free Clinic RI Medical Society/American Medical Association (AMA) Chapter RI Special Olympics Trinity Rep Active Imagination Network (TRAIN)
RI Medical Navigation Partnership (Year 1, both semesters; 20 hrs.)	Work in interprofessional teams to assist people experiencing homelessness with navigating the healthcare system	Practical healthcare navigation with patients	House of Hope Community Development Corporation RI Medical Navigator Partnership

the opportunities to offer additional community-based activities are balanced with the need for robust clinical training (see **Table 3**). A subset of students in the Primary-Care Population Medicine program at AMS participate in a Longitudinal Integrated Clerkship. This allows students to engage in a longitudinal partnership with community-based organizations as part of their Master's level course, *Population and Clinical Medicine*. Students receive instruction and training in community-based engagement, quality improvement, and are assisted with finding partner organizations. Students engage in a year-long project with local agencies to develop an intervention to address a community-identified need.

All other clerkship students who complete the six-week Family Medicine rotation participate in a Social and Community Context (SACC) project. This project allows students to focus on the community at their local Family Medicine clinic site, and identify a relevant healthcare need through conversations with local community members, patients, and their clinic site partners. The project encourages students to propose a potential intervention that could be implemented at their Family Medicine clinic site, though there currently is not capacity for students to lead the implementation of each proposed intervention. All third-year students also participate in a *My Life, My Story* project during the Internal Medicine clerkship, which allows patients to have their life story incorporated into the electronic health record (EHR). Two longitudinal clinical electives in the fourth year of medical school allow students to work at student-run free clinics or provide care coordination for patients with housing insecurity. These long-established partnerships provide exposure to hands-on care for students with a foundation of clinical training, under the supervision of experienced physicians and allied health professionals.

LESSONS LEARNED

Traditional medical education curricula were not designed to include community-engaged and service-learning activities.

Table 3. Site-Based Community Engagement Opportunities in Clinical Years 3 & 4 at Alpert Medical School

Activity	Objectives	Skill Development	Community Partners
Clinical (Year 3)			
Longitudinal Partnership (Year-long; 22-30 hrs.)	Select a community-based site Complete a needs assessment Work with site to complete a project	Needs assessment Community mentor evaluation Presentation of completed/in progress project	Clinica Esperanza/Hope Clinic Dorcas International Hasbro Primary Care (Lifespan) Memorial Hospital Family Care Center (FCC) Gender Clinic RI Department of Health Roger Williams Middle School
Social and Community Context (SACC) Project (6-week Clerkship; 4-8 hrs.)	Identify a specific need/intervention at practice site that could improve the health of the local community	Submission of completed project detailing a proposed intervention	Local Family Medicine primary care offices across RI, MA, CT
My Life, My Story Project (12-week Clerkship; 4-8 hrs.)	Identify and Interview a patient who would like to include their 500-word life story in the EHR	Develop communication skills Develop active listening skills and empathy Identify patient strengths	Internal Medicine Clerkship sites
Clinical (Year 4)			
Clínica Esperanza Clinical Elective (Year-long; 40 hrs)	Students see patients at a student-run clinic	Student performance evaluation	Clínica Esperanza/Hope Clinic
Healthcare for the Homeless Clinical Elective (Year-long; 40 hrs.)	Students provide care coordination for patients with housing insecurity	Student performance evaluation	House of Hope Community Development Corporation RI Medical Navigator Partnership

Educators often retrofit these activities into a UME curriculum that does not account for the time and resources required to facilitate true community engagement, learner reflection, program evaluation, and community-level impact. The Association of American Medical Colleges (AAMC) Center for Health Justice provides a helpful set of resources to engage with the community and build trustworthiness.[6] These principles highlight the most common lessons learned in our experience building such curriculum over the last several years.

Community-engaged education and health initiatives likely already exist within neighboring communities. We identified key experts who are already engaged in this work, rather than trying to reinvent the wheel. These experts are often a good place to start for identifying common barriers to care for marginalized groups, while being mindful of peoples' intersectional identities and the dynamic nature of patient populations. One way to leverage the wisdom of community experts is through focus groups or by creating partnerships with non-medical providers to highlight important topics to include in the curriculum.

Once key topics are established, developing specific learning objectives equip students with concrete strategies to address the modifiable issues that patients face in their interactions with providers or in navigating the health system. Throughout this process, it is important to recognize one's positionality and biases; drawing on the expertise of multiple individuals with lived experience can shed light on perspectives that challenge the preconceived notions of both learners and educators.

Developing a community engaged curriculum is not a one-time effort, but an ongoing, dynamic process. It is important to engage regularly with leadership and liaisons at partner organizations to strengthen relationships beyond a single session or initiative. How can the partnership be strengthened? What human or financial resources will be needed to do so? Set clear expectations for what resources each entity will bring to the partnership, as well as the anticipated level and duration of the commitment. Recognizing that there is often limited curricular space for new initiatives, it is important to be strategic and realistic about what can be accomplished in the time allotted (whether for a didactic session or a longitudinal project) by making connections to the existing material in the curriculum. If entering into a partnership that involves a longitudinal experience for learners, ensure that desired outcomes, including any deliverables, are clearly and mutually beneficial. Examples of outcomes to consider are shown in **Table 4**. Experts who contributed to curriculum development may benefit from relevant summaries of any workshops, course evaluations, or other outcome measures.

Table 4. Example Outcomes for Community Engagement in Undergraduate Medical Education

Learners	Community Organizations
KNOWLEDGE Increase understanding of the SDoH Develop multicultural understanding of community Identify needs/challenges facing community agencies Develop an understanding of health disparities that could be addressed by health education interventions, community partnerships, and changes to policy/legislative mandates Develop an understanding of the legal issues and bureaucratic barriers facing healthcare Increase understanding of limitations that affect rural community health or Indigenous populations ATTITUDES Decrease feelings of burnout Develop compassion, respect, and comfort working with underserved populations Develop an increased understanding of social justice and advocacy Increase appreciation of patient-physician relationships BEHAVIOR CHANGE Develop teaching, presentation, leadership, collaboration, and communication skills Serve as role models for youth Increase future likelihood of providing geriatric or primary care Improve teamwork/interprofessional skills Increase use of health-related technology	Decrease feelings of burnout Improve confidence/trust in learners Improve perception of educational institution's role in improving community health Improve retention rate in Service-Learning Programs Decrease workload/strain on agency staff due to learner presence Improve teaching skills Serve as role model for learners Improve interprofessional teamwork Improve patient/client satisfaction Utilize student-led health behavior interventions Improve patient/client health outcomes

CONCLUSION

AMS has recently reaffirmed its commitment to meaningful community engagement in its pursuit of clinical excellence, delivering innovative medical education programs, and producing evidence-based research to promote the health and wellbeing of individuals and societies. With a planned curriculum redesign over the next several years, AMS aims to expand the depth and breadth of a meaningful community-engaged curriculum that integrates longitudinal experiences for learners that help to address the SDoH in concrete, measurable ways. Building sustainable, mutually beneficial relationships with the local community will require a firm commitment, reflection, and undoubtedly, course correction when needed. While not a small task, AMS's longstanding partnerships with community experts and local organizations have laid a solid foundation for the exciting work ahead.

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An Integrative Approach to Addressing Medical Student Mistreatment and Promoting Student Well-Being

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ABSTRACT

This article reviews the overlapping issues of medical student mistreatment and associated student mental health issues. The Warren Alpert Medical School of Brown University (AMS) has taken proactive steps to mitigate these challenges, focusing on improving the learning environment through mistreatment prevention and response along with efforts to reduce threats to student wellness. By engaging clinical departments and key stakeholders, AMS has launched an integrative approach designed to promote student success.

KEYWORDS: UME, mistreatment, wellness

INTRODUCTION

Amidst the escalating complexity of challenges to wellness in the healthcare landscape, medical students have emerged as a particularly vulnerable population, highlighting the need for proactive and sustainable measures to support their well-being. Investigating the myriad reasons behind the heightened susceptibility of medical students to adverse health outcomes, such as depression, anxiety, imposter syndrome, and suicidality, is a critical and necessary priority area.[1] Mistreatment, defined as unprofessional behavior that negatively impacts a student's ability to learn, is a significant risk factor for adverse mental health.[2,3] Addressing mistreatment is not only a moral-ethical imperative but also a matter of equity,[2] patient safety,[4,5] accreditation, and wellness.[6,7] The prevalence of mistreatment is particularly alarming, as at least 35% of medical students across the country report experiencing this behavior during their undergraduate medical education.[2,8] With national and local initiatives focusing on student wellness and mistreatment, The Warren Alpert Medical School of Brown University (AMS) has adopted an integrative approach, inclusive of mistreatment occurring in the learning environment, to enhance student well-being throughout their journey to becoming physicians. In this article, we assess current strategies at the national level alongside outlining our comprehensive approach at AMS to tackle these dual, interconnected challenges.

KEY STRESSORS, CONSEQUENCES

Medical students experience numerous threats to their well-being during medical school. Literature suggests that the consequences of these threats have been a higher prevalence of depression and anxiety, with levels of psychological distress consistently higher than the general population and age-matched peers by the later years of training.[9] What creates these threats? Key stressors for medical students include national board examinations, performance evaluations and potential biases within them, uncertainty about the future, isolation from loved ones, lack of control over personal schedules, and concerns about workload in residency.[9] Other variables identified as risk factors include disability status, non-male gender, debt, and the clinical phase of school.[10,11]

These barriers are paralleled by experiences that medical students should never encounter, such as mistreatment, which includes microaggressions, public humiliation, and inappropriate identity-based comments. Microaggressions are associated with medical student burnout and positive depression screening.[12,13] Additionally, it has been shown that ethnic minority and/or underrepresented medical students have a lower sense of personal accomplishment and quality of life than nonminority students within the medical school environment, highlighting the differential impact stressors have on minoritized and/or underrepresented individuals.[14] These factors are further exacerbated by the stigma of mental illness within medicine.

STRATEGIES FOR WELLNESS PROMOTION

Depression, anxiety, burnout, and suicide in medical students are known threats to medical student well-being, and accordingly, medical schools have increased access to mental health services and well-being programs. Existing strategies for wellness promotion and suicide prevention have focused on increasing access to mental health providers, creating peer-support programs, training mentor faculty, and embedding wellness programs into the curriculum. While these efforts are to be applauded, our experience suggests that providing resources for students, such as a dedicated mental health counselor, a robust longitudinal advising system, and policies designed to create time for students to address their basic needs (i.e., a personal day during clinical rotations) are insufficient to prevent egregious outcomes, including student suicide. Medical students tend to avoid or postpone asking for help, especially when the University is involved, due to concerns around confidentiality and a perceived risk to their future careers.[15] Protecting student wellness, including suicide prevention, by reducing the aforementioned threats, is among the most important challenges for medical educators today.

To support wellness at AMS, we have launched innovative programming, such as opt-out wellness checks at the start of medical school, mental health and wellness assessments, and student peer counseling. Integral to the wellness of students is the concept of collective care, rather than solely focusing on self-care. Specifically, the wellness of the community of resident learners, faculty, and staff predicts the wellness of each of our students. We have begun to address and prioritize collective care by establishing two key inaugural roles at the medical school - Chief Wellness Officer (CWO) and Assistant Dean for Student Affairs, Learning Environment (ADSA-LE), providing suicide awareness training to faculty mentors and administrators, offering wellness-focused courses through the Office of Biomedical Faculty Affairs, supporting the building of wellness programming within graduate medical education and clinical departments, as well as supporting a medical school staff Wellness Committee.

These initiatives often do not consider student mistreatment as a modifiable risk factor. We believe the learning environment, work environment, and patient environment are interconnected. By enhancing the learning environment through prevention strategies and timely response to mistreatment, we can improve healthcare delivery for all stakeholders involved, including physicians, other healthcare professionals, and our patients. To create and sustain change across institutions, robust engagement of key stakeholders is needed to understand the scope of the problem, propose solutions, and implement them. Clinical departments, in particular, are critical partners in this process, given their significant impact on student learning and disproportionate influence on student mistreatment. In 2021, The Office of Medical Student Affairs at AMS launched the Program for a Healthy Learning Environment (PHLE) to address medical student mistreatment within the learning environment and our clinical departments.

At AMS, the PHLE recently asked leaders from all clinical departments to complete self-studies about their policies, procedures, and practices for creating a healthy learning environment. The self-study tool was designed by a committee of stakeholders, including AMS administrators, students, faculty, and departmental and health-system leaders. In addition to departmental self-studies, we simultaneously engaged stakeholders in a model of change, Learning Environment Action Plans (LEAPs), characterized by goal setting, data collection, sense-making, and action.[16]

Through a systematic analysis of available internal data related to mistreatment in the learning environment (i.e., sense-making) and the departmental self-study process, we can more fully understand opportunities to mitigate mistreatment. Through this process, we have gained a comprehensive, multi-dimensional understanding of mistreatment in the learning environment, including its most common perpetrators, types, and locations.

By identifying the who, what, where, and when of mistreatment, we can create targeted interventions. to prevent mistreatment from occurring. As part of this effort, the AMS CWO and ADSA-LE have collaboratively launched Wellness and Learning Environment Rounds for third-year students. Wellness and Learning Environment Rounds are designed to: 1) understand current student concerns and experiences, 2) provide immediate student support and connection to resources, and 3) collect data related to wellness and the learning environment for ongoing program development, evaluation, and targeted intervention. While mistreatment is an important issue to tackle across all four years of medical school, the clinical years are a particularly vulnerable time, with the majority of mistreatment reports taking place in the clinical setting. During these Rounds, either the CWO or ADSA-LE meets third-year students at their clinical sites once per Clerkship to facilitate reflection on wellness, discuss any mistreatment concerns, and highlight outstanding educators who excel in fostering a positive and inclusive learning environment. Wellness and Learning Environment Rounds are an important component of broader institutional efforts to improve the learning environment and reduce mistreatment. Additional interventions include educator development on policies related to student mistreatment, information on best teaching practices, 1:1 non-judgmental feedback sessions when mistreatment is reported, and a Learning Environment Liaison pilot program to facilitate communication and collaboration between students, faculty, and administration.

Through these focused and targeted efforts, we aim to foster a supportive, respectful, and inclusive learning environment that promotes the collective well-being and success of all students We anticipate our integrative approach towards wellness, inclusive of the learning environment, will foster resilience without compromising self-care, and promote graduates who are healthy and well-positioned for their future careers.

CONCLUSION

In conclusion, addressing medical student mistreatment and promoting wellness is essential to ensuring a healthy learning environment, effective teaching, and positive patient outcomes. By adopting an integrative approach that involves key stakeholders, targeted interventions, ongoing evaluation, and accountability, AMS aims to be at the forefront of these critical efforts. The next steps include continued program implementation and planning for evaluation. We believe that our comprehensive approach will contribute to a culture of support and respect, better preparing our graduates for successful, healthy medical careers.

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Disclaimer

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The authors report nothing to disclose.

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Cross-cultural Comparison of an American and a Taiwanese Medical School with Longstanding Institutional Ties

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ABSTRACT

Cross-cultural medical education has been suggested to train students to care for diverse patient populations and reform medical education systems. In this article, the authors conduct a cross-cultural comparison between two medical schools with a long-standing relationship – the Warren Alpert Medical School of Brown University in the United States and the School of Medicine of National Cheng Kung University in Taiwan – focusing on history, admissions, and curriculum.

KEYWORDS: Cross-cultural medical education, medical schools, Taiwan, United States

INTRODUCTION

Cross-cultural medical education has been proposed as a means of training students to care for diverse patient populations and recognizing and addressing cultural biases in healthcare.[1,2] Understanding the process of adapting medical education across cultures can also help physicians and medical educators by promoting research collaborations and welcoming exchange students.

The Warren Alpert Medical School (AMS) of Brown University was selected by the College of Medicine of National Cheng Kung University (NCKU) in Taiwan as one of their models.[3] This article provides a cross-cultural comparison between the two medical schools, focusing on history, admissions, and curriculum.

FOUNDATIONS OF RELATIONSHIP

Both universities have long histories, although their medical schools were more recently established. Brown University was founded in 1764 as the seventh college in Colonial America.[4] Brown became the third university in the United States (US) to create a medical school in 1811, although the school was closed 16 years later.[5] In 1972, Brown's medical school was relaunched with new specialists, laboratories, and clinical services.[5] NCKU was created in 1931 as "Tainan District School for Higher Education" and given its current name in 1971.[6] In 1981, the governmental executive branch approved the creation of the NCKU College of Medicine, which formally began admitting students in 1983.[6]

Brown and NCKU have shared several exchange programs at the undergraduate and graduate level since 2008.[3,7] AMS students may take a clinical elective at NCKU for 1-2 months, and AMS students and college students in Brown's combined baccalaureate-MD Program in Liberal Medical Education (PLME) may also take a two-week summer course on Chinese Medicine and cross-cultural biomedical ethics at NCKU.[8] All tuition, room, and board costs for clinical electives and summer courses are covered by NCKU. Likewise, NCKU students are allowed to complete clinical rotations at Brown free of charge. The Luke Charitable Foundation (US) and Ministry of Education (Taiwan) both provide a stipend/scholarship to the participants of this exchange program. In the past decade, 84 Brown and 56 NCKU students have participated in these cross-cultural linkages.

SIMILARITIES AND DIFFERENCES

Table 1 shows a comparison of admissions policies at Brown University and NCKU. Both schools have admission pathways for high school students. For NCKU, this is standard practice; all Taiwanese medical schools primarily admit high school students.[9] However, most American medical schools primarily admit students who will soon or have already completed an undergraduate education.[10] Fifty-eight percent of Brown medical students were admitted through the traditional route as college students and graduates, 37% were admitted through the PLME during high school, and 5% were admitted through the Early Identification Program (EIP) or Postbaccalaureate Linkage Program.[11]

Interviewing has traditionally been a very common admissions tool for medical schools in the US, including Brown.[12] Historically, Taiwanese medical students were only recruited through the national college admissions exam – a process shared with other East Asian countries and derived from a long history of exam-based meritocracy.[13,14] To this day, the Examination Yuan that conducts civil service exams is one of Taiwan's five branches of government. However, criticism by the US National Committee on Foreign Medical Education and Accreditation (NCFMEA) has pushed Taiwanese medical schools like NCKU to integrate personal applications and interviews into their admissions process, following Brown's model.[13]

Table 1. Comparison of Admissions Policies at Brown University and NCKU

	Brown University	NCKU
Admissions: Categories of Students	(1) Fourth-year high school students applying for the PLME (2) Third-year undergraduate students at University of Rhode Island, Providence College, Rhode Island College, and Tougaloo College applying for the EIP (3) Traditional applicants who have completed or will complete college before matriculating to medical school (4) College graduates who enroll in selected post-baccalaureate programs	(1) Third-year high school students in the top 1% of their high school with qualified national GSAT applying for the Stars Program (2) Third-year high school students and university-degree holders who have taken the GSAT personally applying for NCKU (3) High school students who have completed their third year and taken the Advanced Subjects Test
Application Process	(1) PLME applicants submit their ACT or SAT scores and application essays to Brown University and the PLME; interviews changed to a video portfolio due to the COVID-19 pandemic. (2) EIP applicants apply and are nominated by their institutions after a review process and may be selected for a virtual interview by Brown; no standardized exam scores are necessary. (3) Traditional applicants submit their MCAT score, grades, and application essays to AMS and may be selected for a virtual interview by Brown. (4) Postbaccalaureate applicants are nominated by their institutions and may be selected for a virtual interview by Brown; no standardized exam scores are necessary.	(1) Applicants who scored in the top 1% on the GSAT and are recommended by their high schools can apply through the Stars program; they will attend an MMI-formatted interview. (2) Applicants can submit their GSAT score and portfolio to NCKU and will attend an MMI-formatted interview. (3) Applicants submit a 'University and Department preference list' and are matched to an institution, including NCKU, based on their AST score.
Diversity	Brown EIP's mission is to recruit students from groups historically UiM, first-generation college students, and low-income backgrounds. Brown has created an Office of Diversity and Multicultural Affairs and organized a Task Force on UiM Admissions to attract and retain more UiM students.	A major goal of the Stars Program is to encourage rural students to enroll in Taiwanese colleges and medical schools.
International Students	No limit; international medical students must complete one year of education in the US or Canada	Maximum of 7 non-Taiwanese students; quota is determined by Ministry of Education

Abbreviations: AMS, Warren Alpert Medical School of Brown University; AST, Advanced Subjects Test; EIP, Early Identification Program; GSAT, General Scholastic Ability Test; MCAT, Medical College Admission Test; MMI, multiple mini-interview; NCKU, National Cheng Kung University; PLME, Program in Liberal Medical Education; UiM, underrepresented in medicine.

Medical school curricula at Brown and NCKU also show major similarities (**Table 2**). Required and recommended pre-medical coursework overlap at both institutions, including biology, chemistry, physics, writing, and social sciences. Likewise, the medical science curriculum is notably similar at Brown and NCKU, with detailed instruction in pathology, histology, pharmacology, and health systems. In addition, medical licensing exams in the US and Taiwan both cover basic science, clinical knowledge, and skills.

A major reason AMS was selected as a model for NCKU was because of its curricular focus on liberal arts and medical humanities – primary areas of interest for Taiwanese medical educators since the reforms in the early 2000s.[13] The aim of the Brown PLME is to promote student exploration in the liberal arts and sciences,[15] and Brown's 'Open Curriculum' gives PLME students academic flexibility by prohibiting institutional course requirements. AMS offers scholarly concentrations in 'Caring for Underserved Communities', 'Medical Education Medical Humanities and Ethics', and 'Physician as Communicator', among others.[16] The Clinical Arts and Humanities Program at Brown also hosts the Bray Fellowship in Medical Humanities and the Bray Visiting Scholar/Creative Artists Fellowship to integrate the humanities into medicine. NCKU integrated this academic flexibility into its curriculum by providing six elective weeks where medical students may choose to spend their time on any approved task (e.g., conferences, research, workshops).

The Brown-NCKU exchange has impacted medical education at Brown as well. Two years before the Brown-NCKU exchange agreement was signed, Brown established an elective course in Medical Chinese to educate preclinical medical students on communicating with Mandarin-speaking patients. This course has provided an important pipeline for AMS students in the Brown-NCKU exchange. Developing an international exchange program with NCKU reinforced Brown's curricular reforms to teach medical students to care for patients from diverse cultures and backgrounds.

The US and Taiwan both require that physicians pass medical licensing exams, although both countries have been moving away from exam-based curricula. The US Medical Licensing Examination (USMLE) Step 1 transitioned to a pass/fail grading system as of January 26, 2022.[17] Taiwan changed their medical licensing Stage 2 exam to incorporate Objective Structured Clinical Examinations (OSCEs) and improve patient care.[18] Notably, OSCEs were used in both countries, despite low reliability.[19,20]

Brown has more flexible grading policies than NCKU, reflecting cultural attitudes towards exams. For example, the USMLE has higher pass rates for first-time takers (92–96%) than Taiwanese national licensing exams (61–91%).[21]

Table 2. Comparison of Curriculum Policies at Brown University and NCKU

	Brown University	NCKU
Duration	8 years	6 years
Annual Cost of Attendance[a] (Tuition + others)	*Undergraduate:* USD $82670 / NTD 2314760 *Medical:* USD $93970 / NTD 2631160	*Locals*: USD $2825 / NTD 79100 *International students*: USD $5135.07 / NTD 143782
Premedical Curriculum	*Required:* 4 chemistry/ biochemistry courses; 2 biology and physics courses; 1 math course *Recommended:* Writing and social science coursework	3 general education courses; 2 physical education, service learning, sociology, and biology courses; 1 Chinese, English, organic chemistry, and medical physics course
Preclinical/ Translational Curriculum	Pathology, Histology, Pharmacology, Health Systems, Anatomy, Physiology	Anatomy, Histology, Physiology, Pathology, Pharmacology, Global Health System, Block Curriculum (11 sub-blocks) including at least 8 credits of medical humanities electives
Clinical Curriculum	2–week clinical skills clerkship, doctoring program	2–week 'clinical skills for clerkship' workshop, 'On Doctoring' program
Grading	Premedical students can choose to be graded on the A(90+)/B(80–89)/C(70–79)/NC(<70) or S(70+)/NC scales. Preclinical years are graded on the S/NC scale. Clinical years are graded on the Honors (top 30% of class)/S/NC scale. The minimum passing grade is a 70.	All students are graded on the following scale: A+ (90–100), A (85–89), A– (80–84), B+ (77–79), B (73–76), B– (70–72), C+ (67–69), C (63–66), C– (60–62), F (<59), and X (0). The minimum passing grade is a 70.
Clinical Evaluation	Student evaluations by preceptors across nine competencies, OSCEs, national standardized subject–based exams, assignments, and presentations	Written exams, PBL and small–group assessments, OSCEs, national standardized subject–based exams, and research performance evaluations by preceptors
Class Rank	No class rank; undergraduate students in the top 20% are designated as "Magna Cum Laude"	Students were numerically ranked prior to 2016; now, transcripts display rank percentiles for top 5%, 10%, 20%, 30%, 50%, and 75% instead of numerical-order class ranking indicators.
Licensing Exams in Medical School	United States Medical Licensing Examinations (Steps 1 and 2)	Medical Licensing Examinations (Stages 1 and 2)
Licensing Authority	Federation of State Medical Boards and National Board of Medical Examiners	Ministry of Examination (governed by Examination Yuan)

Abbreviations: NC, no credit; NCKU, National Cheng Kung University; OSCE, Objective Structured Clinical Examination; PBL, problem-based learning; S, satisfactory.
[a] An exchange rate of 1 USD:28 NTD was used for currency calculations.

Unlike NCKU, AMS does not rank students and implements exclusive pass/fail grading in the preclinical years, de-emphasizing grades and competition. However, during the clinical years at AMS, at least the top 30% of students in clerkships are awarded Honors grades; students in electives have no limits on Honors grades.

Both universities provide ample opportunities for students to engage in research, especially during the pre-clinical years. AMS provides PLME and medical students with summer research funding, programs to match students with faculty mentors, and course credit for research; AMS also offers a Scholarly Concentration for medical students interested in basic and translational research. NCKU provides summer and year-long research funding, offers a research elective, and helps match medical students with international research projects. Of note, NCKU encourages medical students to conduct research in the summer during their preclinical years.

LESSONS LEARNED

Medical education is remarkably similar at NCKU in Taiwan and AMS in the US, partly due to recent Taiwanese and NCKU curricular reforms. Culture and history influenced different approaches to medical education at both institutions, demonstrating several important lessons for cross-cultural medical education.

First, education reforms led by the Taiwanese government successfully led to the cross-cultural adoption of the US model with a distinct Taiwanese flavor. Cultural understanding is essential when adapting medical education models across cultures. The US also has much to learn from Taiwan; healthcare services are considerably more expensive in the US despite similar medical education systems and wider accessibility in Taiwan.[22]

Second, medical schools in different cultures with similar curricula are well-suited for international exchange programs that can last over a decade and introduce medical students to patient care in another healthcare system.

American medical students who rotate internationally may improve their care for patients of different cultures.[1,2]

Third, exposure to different systems can inspire reform at partner institutions. NCKU changed its admissions and curricular policies using AMS as a model; AMS and NCKU have taken steps to de-emphasize exams for accreditation and admissions, and both have focused on supporting humanistic-oriented medical education. Areas of curricular change pioneered at NCKU include course requirements in physical education, public service, and environmental medicine courses.

LOOKING AHEAD

The partnership between Brown and NCKU has been fruitful for students and educators. Looking forward, more can be done to strengthen existing ties and promote the exchange of knowledge. Expanding visiting faculty and student exchange programs can help Brown and NCKU share institutional knowledge and experience. Brown currently has a faculty exchange program with Tougaloo College in Mississippi and a visiting research fellowship program for international graduate students. Visiting professorships[23] are a low-cost mechanism for improving collaboration,[24] mentorship, and professional development for physicians and researchers. Through the Brown-NCKU exchange program, 4 Brown and 3 NCKU faculty members have visited NCKU and Brown, respectively. Given the COVID-19 pandemic, a broader faculty exchange program could be developed and implemented more easily through virtual learning.

Additionally, Brown and NCKU can host joint international conferences on scientific research or medical education. Clinical departments at both institutions frequently hold grand rounds that can be coordinated together, and Brown organizes annual student research conferences. Virtual conference software can be utilized to share novel research findings while eliminating conference travel expenses,[25] reducing logistical costs, and lowering carbon emissions.

Notably, COVID-19 has had a larger impact in the US than Taiwan. Admissions and curricular policies at NCKU have therefore been mostly unaffected by the pandemic. By contrast, Brown has shifted many courses online at the undergraduate and medical school levels and adopted virtual interviewing.[26] As variants of COVID-19 continue to emerge, longstanding institutional linkages can help NCKU remain aware of viral threats and adapt to pandemic changes with the advice and support of its partner, Brown.

CONCLUSIONS

Curricular reform at NCKU modeled upon that at AMS serves as a prominent example of cross-cultural adaptation of medical education systems. Furthermore, international linkages between Brown and NCKU medical schools promote cross-cultural understanding of medicine for American and Taiwanese medical students. There are opportunities to further nurture this dynamic partnership by building faculty exchange programs, hosting joint conferences, and conducting collaborative research.

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Specialties with Few Underrepresented Applicants Lack Diversity Information on Residency Websites

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ABSTRACT

INTRODUCTION: With the advent of virtual interviews and the increasing accessibility of internet resources, students increasingly rely on program websites for residency application decisions. In this cross-sectional study, we evaluated the presence of diversity or inclusion information in the least diverse US specialties' residency program websites, including dermatology, orthopedic surgery, otolaryngology, plastic surgery, and urology residency programs.

METHODS: Two authors independently reviewed each Accreditation Council for Graduate Medical Education-accredited non-military US residency program website and ranked the websites' diversity and inclusion information using six pre-determined criteria based on previous studies in the literature.

RESULTS: This study reveals that more than half of residency programs of each specialty met zero of the diversity and inclusion information criteria.

CONCLUSIONS: Residency program websites in the least diverse specialties are lacking important information for prospective applicants that may help signal programs' commitment to inclusivity and attract a diverse candidate pool.

KEYWORDS: diversity, inclusion, residency, medical education, online, virtual resources, websites

INTRODUCTION

Expanding the diversity of the health care workforce is crucial for the delivery of culturally competent care.[1] In light of the recent Supreme Court's ruling on affirmative action, it is crucial to understand contributing factors of a culture of diversity and inclusion in medical training. Studies have found that plastic surgery, otolaryngology, orthopedic surgery, dermatology, and urology specialties have some of the lowest underrepresented in medicine (URM) representation among applicants.[2,3] With the advent of virtual interviews and the increasing accessibility of internet resources, students increasingly rely on program websites for residency application decisions.[4]

Prior studies have found that URM students weigh residency program factors related to inclusion, diversity, and culture more than others.[5,6] A program website can open a window into these factors and influence applicants' decisions to apply.[7] In this study, we evaluated the presence of diversity or inclusion information in US plastic surgery, otolaryngology, orthopedic surgery, dermatology, and urology residency program websites.

METHODS

The Fellowship and Residency Electronic Interactive Database (FREIDA™, American Medical Association, Chicago, Illinois, accessed via FREIDA™ AMA Residency & Fellowship Programs Database (ama-assn.org) was searched for a complete list of 143 dermatology, 209 orthopedic surgery, 131 otolaryngology, 139 plastic surgery or integrated plastic surgery, and 150 urology Accreditation Council for Graduate Medical Education (ACGME)-accredited US residency programs in September 2022. Residency programs that did not have a website, overlapped with another program (i.e., institutions with both plastic surgery and integrated plastic surgery programs), or were a military program were excluded. Two authors independently reviewed each website and ranked the websites' diversity and inclusion information using six pre-determined criteria defined by previous studies in the literature.[8-10] Linked websites and information that was not readily available were not included. Data was obtained between September 2022 and December 2022.

The criteria included the presence of (1) a commitment to, or value toward, diversity in the residency program mission statement, program director's message, or department chair's message, (2) a separate diversity mission statement (stand-alone statement of the same commitment elsewhere on the site), (3) rotations or fellowship opportunities for underrepresented minority medical students, (4) diversity initiatives (any resource dedicated to promoting diversity or inclusion within a program, e.g., mentorship programs, newsletter, certificate program), (5) a diversity page or section, and (6) appointed diversity leadership position(s) or committee(s).

RESULTS

Table 1 displays the number of programs and percentage of programs that meet each criterion by specialty. Urology residency program websites had the highest percentage of programs that met at least one diversity or inclusion criteria (63/139; 45%), and plastic surgery had the lowest percentage (26/85; 31%). Dermatology residency programs had the highest percentages across all specialties in all but one criterion.

Table 2 shows the proportion of programs by the total number of criteria met. The majority of program websites in all five specialties did not meet any diversity or inclusion criteria. Nine (7%) programs in dermatology met all six criteria, while orthopedic surgery, otolaryngology, plastic surgery, and urology did not have any programs that met all six. Only one plastic surgery program and one urology program met more than two criteria.

Table 1. Diversity or Inclusion Criteria Met on US Residency Program Websites by Specialty

Diversity or Inclusion Criteria	Dermatology No. (%)	Orthopedic Surgery No. (%)	Otolaryngology No. (%)	Plastic Surgery No. (%)	Urology No. (%)
Total No. of Programs	136	201	121	85	139
Any of the criteria:	57 (42)	64 (32)	49 (40)	26 (31)	63 (45)
Stand-alone equal opportunity or nondiscrimination statement	40 (29)	14 (7)	13 (11)	6 (7)	21 (15)
Mention of diversity in mission statement, program director's statement, or department chair's message	40 (29)	40 (20)	30 (25)	10 (12)	20 (14)
Separate diversity section/page	31 (23)	30 (15)	28 (23)	6 (7)	7 (5)
Appointed diversity-related leadership positions	26 (19)	7 (4)	5 (4)	2 (2)	3 (2)
Rotations/ Fellowships for underrepresented in medicine (URM) students	20 (15)	11 (5)	13 (11)	5 (6)	9 (6)
Diversity initiatives	24 (18)	22 (11)	12 (10)	3 (4)	14 (10)

Table 2. Number of Criteria Met by Residency Program Websites

No. of Criteria Met	Dermatology (n=136) No. (%)	Orthopedic Surgery (n=201) No. (%)	Otolaryngology (n=121) No. (%)	Plastic Surgery (n=85) No. (%)	Urology (n=139) No. (%)
0	79 (58)	137 (68)	72 (60)	59 (69)	76 (55)
1	16 (12)	29 (14)	23 (19)	18 (21)	54 (39)
2	8 (6)	8 (4)	12 (10)	7 (8)	8 (6)
3	7 (5)	6 (3)	5 (4)	1 (1)	0 (0)
4	11 (8)	16 (8)	6 (5)	0 (0)	1 (1)
5	6 (4)	5 (2)	3 (2)	0 (0)	0 (0)
6	9 (7)	0 (0)	0 (0)	0 (0)	0 (0)

DISCUSSION

Our study demonstrates that the majority of US residency program websites among US specialties with the least URM representation, including dermatology, orthopedic surgery, otolaryngology, plastic surgery, and urology, do not include any form of inclusive messaging or information on program diversity and inclusion opportunities and initiatives.

Program websites are one of the most accessible ways to obtain reliable information on residency programs. Students depend on them when deciding which programs to apply to, where to interview, and how to rank programs.[7] Residency programs can encourage and recruit URM applicants by providing more complete information on diversity efforts and demonstrating their commitment to inclusivity on websites.

There are several limitations of our study. It should be noted that program website diversity and inclusion information is not limited to the criteria used in this study. Furthermore, programs with a culture of inclusion may not represent it on their website. For example, programs with fewer resources may not have the funds or time for more complete website development; as a result, their websites may not be as representative of their mission and inclusivity. While residency websites can help with URM applicant recruitment, factors, such as strong mentorship and an inclusive curriculum, are important for fostering diversity and equity within programs.

CONCLUSION

This study reveals that US residency programs with the least URM representation in the applicant pool lack information on diversity and inclusion on their websites. Many programs have room to highlight their commitment to inclusivity on their websites for prospective applicants. This is one method that can be implemented in a multifactorial approach to attract and support candidates from diverse backgrounds.

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Barriers to Buprenorphine Prescribing Among Attending Physicians in an Academic Residency Program – Implications for Increased Buprenorphine Usage

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ABSTRACT

The need for outpatient management of opioid use disorder with medication-assisted treatment has continued to rise yet physician comfort with prescribing buprenorphine remains low. A survey assessing comfort prescribing was disseminated to attending physicians in the Division of General Internal Medicine at an academic medical center followed by semi-structured qualitative interviews. The majority of respondents (71%) reported that they had not prescribed buprenorphine in an outpatient setting despite being trained and 67% stated that they felt "uncomfortable" or "very uncomfortable" doing so. However, almost all survey respondents (89%) reported comfort precepting residents prescribing buprenorphine. Attending physicians attribute this differential comfort to structural forces including a lack of team-based care, time, and psychosocial support services in their own practice as compared to the academic residency clinic. These findings highlight the barriers to prescribing buprenorphine and challenge the existing notion that academic centers are not suitable places for substance use treatment.

KEYWORDS: buprenorphine, substance use disorder, prescribing, academic medical center, academic residency clinic

INTRODUCTION

Demand for treatment of opioid use disorder (OUD) far surpasses the current maximum potential treatment capacity in the United States. Expanding access to buprenorphine, a life-saving medication that can be prescribed in the outpatient setting, is an essential component of the comprehensive response to the opioid overdose crisis, which saw a total number of at least 105,452 deaths in 2022.[1,2,3] However, despite the high demand, prescribing rates have remained relatively low.[4,5] The perceived barriers that physicians face in providing medication-assisted treatment (MAT) for OUD include lack of clinical experience, lack of access to substance use disorder experts, concerns about difficulty of induction, and other logistics.[6,7]

The Drug Administration and Treatment Act (DATA) of 2000 enabled the use of buprenorphine for treatment of OUD in the outpatient setting.[8] This required providers who intended to treat patients with buprenorphine to submit a Notice of Intent (NOI) to the Substance Abuse and Mental Health Services Association's (SAMHSA) Center for Substance Abuse Treatment. This was in addition to their DEA registration, which allows providers to prescribe controlled substances, and included a mandatory 8-hour training. Upon completion, a DATA waiver was awarded, enabling physicians to begin prescribing buprenorphine to patients with OUD. Legislative changes in 2021 generated an alternative type of NOI that could be submitted without undergoing the 8-hour training if a provider wished to be eligible to treat only up to 30 patients.[9] In 2023, federal legislation was further modified via Section 1262 of the Consolidated Appropriations Act to remove the requirement for practitioners to submit any NOI at all in order to prescribe buprenorphine.[10] Instead new or renewing DEA registrants as of June 27, 2023 are required to reach one of the following educational requirements: total of eight hours of training from certain organizations on opioid or other substance use disorders, board certification in Addiction Medicine or Addiction Psychiatry, or graduation from a medical, nursing or physician assistant school in the U.S. that includes at least eight hours of substance use disorder curriculum.[10] Any practitioner that is a DEA registrant, meaning authorized to prescribe controlled substances, can now immediately prescribe buprenorphine.

In spite of the prior mandated 8-hour DATA waiver training, which provided practical teaching on various aspects of OUD ranging from diagnosis to buprenorphine pharmacology to treatment, rates of buprenorphine prescription remain disproportionately low. Physicians have reported numerous barriers to prescribing buprenorphine for OUD, including lack of clinical experience, lack of access to substance use disorder experts, and concerns about difficulty of induction, among other factors.[6,7] With the 8-hour DATA waiver training now obsolete, the question of how to improve physician comfort with buprenorphine holds immense relevance in the new clinical landscape.[7,11]

To our knowledge, there has not been an assessment of the facilitators and barriers to prescribing buprenorphine among physicians working with trainees in academic medical settings. Yet, academic medical centers take care of a sizable portion of the population. Moreover, with removal of the DATA waiver requirement, buprenorphine prescribing is now accessible to all resident physicians. In this study, we seek to understand the barriers and facilitators to subsequent buprenorphine usage through a quality improvement survey of attending physicians followed by a targeted semi-structured interview.

METHODS

A survey was created using Qualtrics XM survey software and disseminated to attending physicians in the Division of General Internal Medicine at an academic medical center. This data was collected prior to the new legislation in 2023 removing DATA wavier requirements for buprenorphine prescribing. All attending physicians precept Internal Medicine residents at the outpatient academic residency clinic. Additional clinical responsibilities include practicing direct primary care at the private faculty practice, precepting residents on the inpatient medical service, or both. The academic residency clinic is located in Providence, Rhode Island, and serves approximately 9,000 patients. Residents are not currently allowed to prescribe buprenorphine to patients with OUD. Rather, these patients are referred to a confined program in the academic residency clinic that takes place one half day a week and includes a collaborative team composed of an attending physician, pharmacist, peer recovery specialist, and addiction medicine fellow.

This study was determined to be non-research in nature and classified as quality improvement based on a comprehensive assessment of the project's goals, methodology, and intended outcomes. SQUIRE guidelines were used to inform the presentation of data as a tool for quality improvement efforts to increase buprenorphine usage by both attending and resident physicians. The survey was anonymous and confidential; it consisted of 25 questions that collected characteristics of the respondents and their familiarity with and perceived barriers to prescribing buprenorphine. The questions were majority "yes/no" or multiple choice in format with three "check all that apply" questions and one free response.

After the survey data were analyzed, the authors determined that follow-up was needed to clarify why attending physicians felt comfortable precepting residents but were not comfortable prescribing buprenorphine themselves. Semi-structured interview questions were administered to 10 attending physicians. The interview questions asked participants to clarify the reasons behind their responses, reflect on why other physicians might have responded in this fashion, and expound upon the general significance of the results. The responses were independently coded by three researchers (JS, RV, MG) to achieve saturation and reconciled through an iterative process. Themes were extracted utilizing reflexive thematic analysis and were reviewed using member checking with DGIM faculty members and triangulation between coders in order to maximize qualitative validity.[12,13]

As these data were collected for quality improvement as a mixed methods paper with a central qualitative element, their utility is to provide nuanced and in-depth insight regarding the issues around buprenorphine prescribing in a particular setting, not to make transportable claims across settings. Such context-specific and nuanced findings, although not generalizable, can provide insights into phenomena not visible in larger, representative samples.[14,15]

RESULTS

Thirty-two (32) respondents completed the survey while 10 participated in semi-structured qualitative interviews. The characteristics of the respondents are shown in **Table 1**. The respondents predominantly self-identified as female (69%) and between the ages of 35–54 (51%). Themes from the qualitative interviews are highlighted in **Table 2** along with corresponding quotes and the number of interviews these themes were mentioned in.

Eighty-two (82%) percent of the respondents had completed the DATA waiver training course. Of those who completed the training, 46% had their DEA waiver number accessible, 35% did not have it, and 19% were unsure if they had been issued a DEA waiver number. None of the waivered providers had listed their names on the Rhode Island Department of Health's website as a prescribing provider accepting new patients for buprenorphine treatment

Table 1. Survey Respondent Characteristics

Characteristic	Response (N=32 attending physicians)
Age	
<35yo	13 (41.94%)
35–54yo	16 (51.61%)
>54yo	2 (6.45%)
Self-Identified Gender	
Male (including transgender male)	10 (31.25%)
Female (including transgender female)	22 (68.75%)
Primary Practice Location	
Academic Residency Clinic	3 (10.00%)
Private Faculty Practice	18 (60.00%)
Hospitalist (inpatient only)	6 (20.00%)
Other	3 (10.00%)
Interviewed	10 (31%)
Private practice physician and precept at the Academic Residency Clinic	7 (70.00%)
Hospitalists and precept at the Academic Residency Clinic with no private practice	3 (30.00%)

Table 2. Themes and quotes from qualitative interviews (N=10)

Theme Subthemes	Number of Interviews mentioned in	Quotes
Desire for real-time, in-person prescribing expertise		"I don't feel as alone at the [academic residency clinic as compared to the private practice clinic]. If there are questions I can't answer, there are always other preceptors who can help."
Troubleshooting difficulties	0	
Preference for in-person consultation on prescribing	5	
Coverage (vacation & after hours)	4	
Relying on resident's knowledge	3	
Relying on residents for continuity, flexibility, and time	1	
Feeling Isolated in private practice	3	
Overwhelmed/Lack of Bandwidth/Exhausted		"I also think the cognitive load of learning something new – or becoming certified in something new – feels like a Herculean task – just because it's one of many things to do."
No bandwidth for anything new	4	
Particular Hurdles Related to Prescribing Buprenorphine		"Demoralized at jumping through hoops"
Induction	2	
Waiver*	2	
Titration	1	
Urinalysis	1	
Specialization		"While I do think it would be great to have more buprenorphine prescribers/opportunities for patients to get treatment for OUD, I do think there is something valuable to having "specialization" in this."
Patients have easy access through another provider	2	
Loss of skills through infrequency of prescribing	3	
Constrictions through Primary Care Schedule		"When we see anywhere from 12 to 16 patients in a session, how does one find the time?" "Residents have so much more time with patients than I do. It can be hard to envision how I would fit all that counseling into a 15-minute visit."
Anything outside comfort zone takes more time	1	
Fitting counseling in	1	
Induction perceived as requiring more time than a routine 15-minute visit	2	
Lack of Nursing or Case Manager Support	2	
Lack of Mental Health or Social Work Services	4	
Ensuring Quality, Avoiding Complications	1	"And I also want it to go perfectly"

*No longer necessary as of June 2023

at the time of survey completion. However, upon learning about this patient-facing resource, half of waivered providers were willing to have their name listed. The majority of providers (71%) reported that since undergoing the DATA waiver training, they had not prescribed buprenorphine in an outpatient setting. Fourteen percent (14%) of respondents had prescribed to 1–3 patients, 3% to 4–10 patients and 11% had prescribed to 10+ patients in an outpatient setting. More prescribers reported ordering buprenorphine in the inpatient setting with 36% reporting ordering for 1–3 patients, 7% for 4–10 patients and 14% for 10+ patients. Forty-six percent (46%) of respondents reported they had not ordered buprenorphine in the inpatient setting. Regardless of whether or not the respondents had, in fact, prescribed or ordered buprenorphine, the majority endorsed buprenorphine as an effective treatment for OUD, with 67% reporting "strongly agree" followed by 21% reporting "agree" as the next most common answer. Two individuals (7%) selected "strongly disagree." Despite the majority of respondents having completed the DATA waiver training, when asked if they were comfortable starting a patient on buprenorphine, the largest percentage of respondents reported that they were "uncomfortable" (50%), with the next most common response being "very uncomfortable" (17%). In contrast, more providers were "neutral" (35%), "comfortable" (29%), or "very comfortable" (25%) maintaining a patient on buprenorphine. Screening for OUD as well as comfort interpreting urine toxicology reports were both high among the respondents. The patients that the respondents were most comfortable prescribing to were "patients already on my personal panel" (26%) and "patients of other physicians in my clinic" (23%). The most commonly cited barrier to prescribing buprenorphine was "lack of confidence/experience" (33%). The next most agreed upon responses were "lack of psychosocial support" (21%), followed by "time constraints" (17%).

Almost all survey respondents (89%) reported being comfortable precepting residents who see patients with

OUD on buprenorphine. When asked about perceived barriers to precepting residents who see patients with OUD on buprenorphine, the most common response remained "lack of confidence/experience" (36%), with the next most common response being "lack of consistent follow-up" (21%). The respondents then rated a selection of four potential interventions to support providers in prescribing buprenorphine, including a Whatsapp group text message with fellow buprenorphine prescribers in the Division of General Internal Medicine, brief instructional videos, a telephone-based warmline similar to the National Clinician Consultation Center at the University of California San Francisco, where providers can speak to a live addiction specialist, or a local warmline with fellow buprenorphine prescribers in the Division of General Internal Medicine. The option rated as most helpful was to have a Whatsapp group text with colleagues, with the second being a local warmline with the same colleagues. Instructional videos were rated as the least helpful.

In the semi-structured qualitative responses, all 10 respondents identified lack of support from other providers as a reason for not prescribing buprenorphine in their direct primary care practice setting – a private faculty practice. The main areas where respondents wanted greater support included: troubleshooting issues that come up in induction or titration (50%); advice from providers with greater experience prescribing (40%); and coverage after hours or during vacation (30%). In contrast, precepting in the teaching setting of the academic residency clinic was identified as ensuring the presence of more knowledgeable providers as well as residents. Notably, the buprenorphine program that takes place one-half day a week at the academic residency clinic was not explicitly mentioned in survey responses. Three respondents pointed to the difficulty of managing induction, given constraints of primary care schedules (with back-to-back 15-minute slots) and discussed the greater flexibility of residents' schedules and their ability to spend more time with patients. Three respondents pointed to the lack of mental health or social work supports in their primary practice site and two respondents pointed to the lack of nursing support. Four providers described feeling too overwhelmed by their existing work responsibilities to incorporate anything new into their practice. Only three providers pointed to regulatory requirements specific to buprenorphine as reasons for not prescribing, and these were presented in the larger context of the general lack of support or existing workload.

DISCUSSION

Attending physicians who have undergone DATA waiver training are known to go on to prescribe buprenorphine at low rates.[4,5] In our study of faculty in a Division of General Internal Medicine, this held true, with the reasons being similar to that found in the existing literature: lack of confidence, time constraints, and inadequate psychosocial support. However, the marked increase in comfort prescribing buprenorphine among attending physicians in the context of precepting residents at the academic residency clinic as compared to their own primary care practice is a new and important addition to the literature. This is especially true in light of recent legislative changes that make direct prescription of buprenorphine substantially more accessible to resident physicians and challenges the prevailing narrative that the DATA waiver was the primary barrier to prescribing.

A concern among residency programs has been that residents have limited clinic availability for primary care patients in general and that patients receiving buprenorphine must be seen frequently. Another concern is that residents' schedules will result in poor continuity of care for patients who might see several different residents. However, our qualitative data highlight a strong contrast between attending physicians' lack of support at their site of primary care, where they are sometimes the only provider utilizing buprenorphine, work within a constricted schedule, and feel pushed to the maximum of their abilities, and the academic residency clinic, where there is a strong perceived sense of team-based care and more time to spend with patients. This challenges the existing notion that academic centers, and residents, are not suitable for substance use treatment as they may in fact increase buprenorphine prescribing. A study of BupEd, a buprenorphine training curriculum for primary care internal medicine residents in Bronx, NY, also showed that providing residents with supervised clinical experience in treating opioid dependent patients is feasible without compromising patient outcomes.[6] Importantly, retention in buprenorphine treatment was similar between patients of residents and attending physicians. Additionally, the vast majority of inductions now occur outside a healthcare setting, in places such as their home or where those who are street homeless are spending the most time, and thus buprenorphine prescribing mainly focuses on maintenance doses, a less complex or time intensive process than induction. This is because nearly all patients have taken buprenorphine before and understand how to start taking a very small dose of this medication when they start to experience withdrawal.

There has been increasing pressure over the past two decades to make primary care more collaborative, both in terms of the creation of interdisciplinary care teams and the value of non-physician counterparts. For instance, the presence of collaborative practice agreements (CPA) allowing pharmacists and other disciplines to assist with co-management of chronic conditions such as diabetes and hypertension has become commonplace. Thus, it is not surprising that, in considering integrating MAT into their day-to-day practice, attending physicians prefer a team-based approach over one that solely relies on their own expertise and capacity.

Our results suggest that an alternative, and potentially more successful approach to increasing buprenorphine prescribing, is by focusing on the creation of team-based units dedicated to the care of patients with OUD, similar to what has been done with regard to diabetes, hypertension, obesity, and other chronic diseases and what is seen in academic residency clinics. To increase the capacity of primary care clinics to integrate team-based programs to care for their patients with OUD, leadership could consider well-established processes to improve prescribing of targeted drugs such as academic detailing and collaborative practice agreements.[16]

Next steps include gathering further data and exploring the facilitators and barriers to creating team-based approaches to OUD management in primary care settings, ranging from academic residency clinics to private faculty practices to federally qualified health centers. Residency programs considering integrating buprenorphine prescribing into academic residency clinics should be confident that assembling a group of providers across disciplines to provide this service is one route to increasing buprenorphine prescribing among providers who otherwise may not have independently prescribed.[6] These data shine light on a unique way forward for integration and increase of buprenorphine prescribing following removal of the DATA waiver without significantly overtaxing an already overwhelmed primary care workforce.

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Multiple Hospital In-Situ Mass Casualty Incident Training Simulation for Emergency Medicine Residents: A Sarin Bomb Scenario

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ABSTRACT

INTRODUCTION: We simulated an on-site, multi-hospital mass casualty incident (MCI) to educate emergency medicine providers in the principles of trauma resuscitation and collaboration with administration and staff during an MCI.

METHODS: We implemented high-fidelity manikins, inflatable manikins, and actors to simulate a sarin gas bombing. Learners triaged patients at a decontamination tent using the simple triage and rapid treatment (START) tool, or they participated in a simulation in a resuscitation bay.

RESULTS: Forty participants anonymously rated the learning impact of the exercise, the clinical relevance to emergency medicine, and the effectiveness of the faculty facilitation and debriefing on a 1–5 Likert scale. The average responses to all questions were 4.45 or greater, and 98% of respondents recommended adding the scenario to the standard curriculum.

DISCUSSION: We successfully executed a novel, multi-hospital, MCI drill that was rated to be a better alternative to sequential simulation in a simulation center.

KEYWORDS: simulation, mass casualty incident, sarin, emergency medicine, toxicology

INTRODUCTION

Disasters are defined as events which exceed the capacity of the local community to mount an adequate response.[1] Disaster preparedness, specifically regarding mass casualty incidents (MCIs), has been a topic of much discussion over the past 20 years, especially in the light of the COVID-19 pandemic. Chemical, biological, radiological, nuclear, and explosive (CBRNE) modalities are all scenarios for which healthcare providers must be prepared. Potential sources for civilian exposure include terrorist attacks, military attacks, inadvertent discharge from domestic stockpiles, and industrial events. Terror incidents have increased dramatically over the last decade (Global Terror Database) with increasing numbers of mass shootings, recent emergence of targeted automobile ramming mass casualty (TARMAC) attacks, and with infamous events such as the Oklahoma City bombing and 9/11 attacks still so recent in history.

Historically, hospitals have been poorly equipped to deal with massive influxes of patients, particularly with regard to weapons of mass destruction (WMDs).[2,3] Adequate response to an MCI involves every aspect of hospital operations, from providers in the Emergency Department (ED) to housekeeping staff, security, and supply chains. Since these are high-acuity, low-frequency events, there are few opportunities for providers to practice. Simulation drills are thought to provide a way for providers to practice MCI response and increase competency in this skill set, though formal evaluation of its effectiveness should be explored futher.[4,5,6]

This exercise focused on the presentation and management of trauma patients exposed to sarin gas in a terrorist bombing. This scenario was chosen due to real, large scale, and tactical attacks using nerve agents such as the Aum Shinrikyo release of sarin in the Tokyo subway system, nerve agent attacks against the Kurds in Iraq and most recently with the sarin attacks of civilians by the Syrian government.[7,8] This unique, in-situ MCI simulation was simultaneously conducted at two academic hospitals during the normal hours of resident didactic conference. Goals of the exercise were to provide Emergency Medicine (EM) residents and other healthcare workers in the department the familiarity and hands-on exposure to the decontamination equipment and methods, to increase confidence and ability using an all-hazards approach to identify and treat victims exposed to a CBRNE incident, and to foster communication and teamwork among various healthcare workers when available resources are overwhelmed. The authors believe this mass casualty scenario could similarly be implemented both at similar institutions on site as well as within a simulation center to prepare healthcare workers for a mass casualty event.

METHODS

Development

We created this 2-hour session to be part of the EM Resident Simulation Curriculum. The MCI simulation was created, in part, to fulfill the ACGME requirement for EM residents to participate in such training for graduation. The simulation scenario consisted of 6 separate individual patient simulation scenarios as well as a mass casualty triage intake simulation. EM faculty, including expert simulation faculty, created these scenarios through an iterative collaborative process. They were reviewed by the simulation staff for revisions as well.

Equipment/Environment

We conducted the simulation training exercise at two urban EDs during resident simulation conference day. The format of the scenario was virtually identical at each site. Three simulated patients presented into a trauma bay normally designed to care for two critically ill patients with a unique trauma and symptoms consistent with organophosphate poisoning from a sarin gas exposure (**Table 1**). Each hospital site had one high-fidelity Laerdal Sim Man 3G simulator and two standardized patients. All standard equipment in the resuscitation bays was available to include simulator telemetry output on a connected laptop screen, the installed resuscitation bay telemetry monitors, crash carts, bag valve masks, ECG machine, intubation equipment, thoracostomy kits, and all other commonly used medical equipment stocked in the resuscitation bay. Participants were limited in their ability to order labs and diagnostic imaging to simulate the reality of a hospital whose resources were overwhelmed due to a mass casualty incident. Eventually a "Chem Pack" containing mock vials of 2-Pam and additional atropine was made available to use. A laptop computer was positioned within the resuscitation bays to provide updates about the mass casualty incident. We also erected a decontamination tent at the entrance of the ambulance bay at each hospital for the triage simulation scenario. Inflatable, low-fidelity manikens were used for triage and decontamination at this site.

Personnel

Two simulation technicians were on site to operate the high-fidelity simulators. An EM faculty member was present for each simulation in the resuscitation bays, as well as one at the triage tents to conduct the scenarios and document when critical actions were met by the residents. Supporting nursing staff and ED techs also participated in patient care during the simulation. Nursing placed IVs, administered fluids, and verbalized administration of medications and blood when requested by the team. A supervising EM faculty member and hospital environmental safety officer was present at each site to orchestrate the overarching movement of trainees, personnel, and equipment. The standardized patients consisted of simulation staff for the individual scenarios. Volunteer scribes and medical students were integrated with the inflatable manikins at the triage site.

Implementation

We assigned EM residents of all training levels (years 1–4) to either a triage team or one of three treatment teams that would be caring for a single patient encounter. We briefed them to the goals of the simulation day in a conference room prior to moving to the ED for the exercise. A pre-recorded dramatization of a news report was then played, outlining that an explosion had occurred in the downtown train depot, and residents were brought to the treatment areas to begin the simulation.

We escorted the residents assigned to the triage team to the decontamination tents to receive patients. A faculty moderator and hospital environmental safety officer instructed them as to how to don personal protection equipment (PPE) prior to beginning the scenario, in order to realistically

Table 1. Simulation Cases

	Presentation*	Diagnosis^	Critical Actions+
AEC Patient 1	33yo unresponsive patient with shortness of breath, nausea, vomiting and diarrhea	Hypoxic respiratory failure with tension pneumothorax	Recognize unprotected airway and intubate Needle decompress the chest followed by placing chest tube
AEC Patient 2	24yo pregnant patient with abdominal pain, vaginal bleeding, cough and shortness of breath	Hemorrhagic shock due to placental abruption	Recognize shock, transfuse patient Assess fetal heart tones and emergently consult OB/GYN
AEC Patient 3	55yo heart failure patient with shortness of breath, cough and penetrating trauma to the lower extremity	Hemorrhagic shock and pulseless limb	Recognize shock, apply tourniquet and transfuse patient
TMH Patient 1	8yo patient with decreased mental status, dyspnea, vomiting, diarrhea and has significant abdominal bruising	Hypoxic respiratory failure and possible intra-abdominal injury	Recognize unprotected airway and intubate Recognize and test for possible intra-abdominal injury
TMH Patient 2	24yo asthmatic presents after being knocked down by blast complaining of head pain and shortness of breath	Blast injury with ruptured tympanic membranes and possible intracranial injury	Recognize TM rupture Evaluate and test for brain injury Treat dyspnea with bronchodilators
TMH Patient 3	ED nurse caring for patient develops shortness of breath	Secondary exposure to sarin resulting in healthcare worker	Recognize secondary exposure Decontaminate patient before treatment

* Contact corresponding author for detailed simulation script.
^ All patients will have a diagnosis of organophosphate toxicity with varying degrees of severity.
+ All patients require administration of atropine and 2-PAM in treatment of organophosphate toxicity.

create a treatment scenario in which PPE of this nature is required. The standardized patients and inflatable manikens presented to the triage team with a brief script of their symptoms. Based on the presentation, the team applied SMART-TAG© TSG Associates LTD per triage guidelines to prioritize patient care. Twelve simulated patients comprised an equal number of green, yellow, red, and black tag designations were to be appropriately treated and those requiring further management were then sent through the decontamination process in the tent where ED nurses and techs were stationed to assist. EMS participated in the drill by bringing two patients by ambulance to the ambulance bay decontamination station.

We escorted each treatment team in rapid sequence as their assigned simulated patient arrived in the resuscitation bay. All three patients were treated simultaneously to augment the chaos of an overcrowded MCI. A pre-recorded dramatized newscast was played mid-scenario which revealed that the train bombing released sarin. We displayed this mid-scenario video directly to the residents if they had not yet identified the presenting toxidrome in their patient in a timely fashion.

Assessment

The reported results focus on the overall evaluation of the simulation program itself, rather than the individual participant. Evaluative data was gathered from all willing participants, regardless of their role in the simulation. The standard feedback form used by our department for all resident simulations was administered in a mobile phone compatible format using Qualtrics This feedback form has been used with over 800 learner encounters prior to this simulation.

Debriefing

At the end of the exercise, residents walked through the resuscitation bay as well as the disaster tent to view portions of the scenario that they did not experience. Each EM faculty preceptor spent about 15 minutes individually reviewing the critical actions with their assigned team. The participants at each hospital site gathered to debrief for 20 minutes on each scenario, specifically summarizing their scenario, the critical actions required, and any changes in how they would have managed the scenario to optimize care. We then gathered all participants from each hospital for a general event debriefing, during which the residents summarized their scenario to describe the injuries and critical actions they employed during the simulation.

RESULTS

A total of 40 participants completed the voluntary feedback form. Participants included EM residents, EM faculty, advanced practice providers, medical students, nursing staff, facilities management personnel, and prehospital providers (**Table 2**).

Table 2. Participant Responders to the Simulation Evaluation Tool

Role	%	Count
Emergency Medicine PGY 1	17.50%	7
Emergency Medicine PGY 2	10.00%	4
Emergency Medicine PGY 3	17.50%	7
Emergency Medicine PGY 4	10.00%	4
Advanced Practice Provider	2.50%	1
Medical Student	2.50%	1
Emergency Medicine Faculty	27.50%	11
Other (3 RNs, 2 prehospital providers)	12.50%	5
Total	**100%**	**40**

Table 3. Participant Ratings of Simulation Exercise on a 1–5 scale

Please Rate:	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Scenario Overall	3.00	5.00	4.45	0.67	0.45	40
Relevance to training/duties	3.00	5.00	4.63	0.58	0.33	40
Faculty effectiveness at facilitation/debriefing	2.00	5.00	4.45	0.74	0.55	40

The mean rating for the scenario overall, relevance to training/duties, and faculty effectiveness at facilitation and debriefing were all rated highly on a 1–5 scale (**Table 3**). Ninety percent of respondents felt the learning objectives were clearly defined. Representing the perceived value of this training, 98% of respondents recommended this simulation should become part of the standard EM residency curriculum.

The most valuable feedback came from the free text responses to the questions, "Please give AT LEAST ONE suggestion to improve this simulation" and "Other comments or suggestions?" (**Box 1.**) While a formal thematic analysis is beyond the scope of this project, the authors noted the following feedback to consider in future events: respondents note a lack of clarity in participant role in the triage and decontamination assignments, and some reported confusion about "deconned" patients who remained fully clothed during the simulation. Unlike a typical ED patient encounter, during the simulation scenario the standardized patients and student volunteers were not undressed by the residents providing the simulated patient care. These issues could be remedied in the future by specifically addressing them in the pre-brief or by the standardized patients wearing a nude-colored bodysuit under their clothing. As for "other comments or suggestions," many residents specifically noted the high value of the debriefing exercises.

Box 1. Simulation Survey

Q1. What best describes you?
PGY 1
PGY 2
PGY 3
PGY 4
Advanced Practice Provider
Medical Student
Emergency Medicine Faculty
Other
Q2. On a scale of 1 to 5, please rate the scenario overall.
Q3. On a scale of 1 to 5, please rate the scenario's relevance to your training/duties.
Q4. On a scale of 1 to 5, please rate the faculty effectiveness at facilitation and debriefing.
Q5. Please give AT LEAST ONE suggestion to improve this simulation.
Q6. Would you recommend this simulation become part of the standard curriculum?
Yes
No
Q7. Other comments or suggestions?

DISCUSSION

Most of the disaster preparedness education that EM residents receive is in the form of lectures and classroom didactics.[9,10] Programs have sought to implement disaster experiences into residency curriculum in other ways, including tabletop exercises, computer-based simulations, high-fidelity simulation sessions, and virtual reality,[11,12,13] with mixed success. Simulation-based disaster exercises have been shown to be useful and to increase resident confidence in managing disaster events.[11]

Other than tabletop exercises, a review of the literature is bereft of in-situ, hospital-based MCI simulations, especially with more than one hospital involved. This is likely because of the challenging logistics and time commitment to run such an event. This simulation exercise would not have been possible without many months of preparation. Most important was advance collaboration with key stakeholders at both hospitals, including administration, EMS leadership, environmental safety, senior nursing, and ancillary staff. All told, more than 10 stakeholders and committed faculty participated in the disaster simulation at each site.

We were fortunate that on the actual date of the exercise, the weather was favorable, and the actual ED visits that morning – both hospitals combine for approximately 175,000 ED visits per year – were low enough to prevent the simulated disaster from interfering with normal ED function.

The rationale behind the in-situ design of this scenario was enhanced realism, as it was conducted in the actual workplace of the EM residents and ancillary staff. Utilizing standardized patients with injuries, along with hi-fidelity manikins that had received toxic doses of sarin gas, further served to make the entire scenario more realistic. The fact that 98% of respondents recommended this simulation become part of the standard curriculum strongly suggests that this is a preferred disaster education modality compared to classroom didactics and other methods. This response is presumed likely because of active learning and the realism of the scenario.

The secondary goal of this in-situ simulation was to stress the need for the residents to protect themselves from inadvertent exposures in an MCI, which could occur in a real biological or chemical disaster. The use of a nerve agent allowed the inclusion of worried, well-standardized patients, further simulating what would happen in an actual disaster.

Limitations

Although all participants were invited to provide feedback, most respondents who completed the evaluation form were EM residents and faculty. We suspect that this is due to their familiarity with this tool and its expectation to be completed after didactic sessions. We recognize the need to encourage all groups of participants to provide feedback at future simulated MCIs.

The risk of performing an in-situ simulation is that it can be derailed by the demand for real patient care, jeopardizing the execution of the entire scenario. We had limited time to perform the scenario for this reason. This limitation also prevents each learner from experiencing each patient scenario, which is particularly relevant when comparing the triage and simulation teams' experiences. This is partially offset by the shared experience with the group debriefing at the end of the exercise. The goal of enacting the realism of a true MCI merits the loss of specific scenario exposure. We also did not measure retention of medical knowledge learned during this exercise, so efficacy of this training program cannot be critiqued.

The larger goal is to provide trainees with a different scenario in subsequent years. We plan to include a post-simulation test to assess medical knowledge and have an objective measure of the value of in-situ, disaster-based education, rather than only a subjective one. Specifically, we could include knowledge-based, multiple-choice questions for the simulation teams on evaluation for, and treatment of, blast injuries and organophosphate poisoning, as well as proper decontamination practices. We could also include multiple-choice or free-text response questions as to what each level in the START tool represents. We do not plan to administer a pretest to gauge prior knowledge because it could potentially affect performance during the scenario.

It was acknowledged in the preparation of this drill that including additional ancillary staff (e.g., blood bank, radiology technicians, security) would provide further benefit in training for a mass casualty incident to test our facility's preparedness, but due to the complexities already required to orchestrate nursing, EMS, and residents for training, as well as to minimize further disruption of true patient care ongoing in the Emergency Department, we did not include these components in the simulation.

Although it is conceivable to compare medical knowledge across learners with a post-test, it would be difficult to power this analysis at a single institution. A post-test given 6 to 9 months after may alternatively have value in assessing the decay of knowledge.

In conclusion, this in-situ MCI simulation was perceived as such a success by faculty, administrators, and our EM residents that a different in-situ MCI was designed and scheduled for the next academic year. It is our belief that annual in-situ disaster simulations with rigorous, post-test analysis will foster teamwork, understanding of existing disaster protocols, increase knowledge retention, improve healthcare worker safety, and enable EDs and hospital systems to be better prepared for such a high-acuity and low-frequency event. This exercise demonstrated that we could successfully run scenarios with high-fidelity simulators, low-fidelity simulators, and standardized patients, just as we would in our simulation center, with significant preceptor oversight within the environment that trainees would encounter a real disaster scenario.

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Robotic Simulation in Urologic Surgery

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ABSTRACT

Robotic surgery continues to revolutionize the field of urologic surgery, and thus it is crucial that graduating urologic surgery residents demonstrate proficiency with this technology. The large learning curve of utilizing robotic technology limits resident immediate participation in real-life robotic surgery, and skill acquisition is further challenged by variable case volume. Robotic simulation offers an invaluable opportunity for urologic trainees to cultivate strong foundational skills in a non-clinical setting, ultimately leading to both competence and operative confidence. Several different simulation technologies and robotic assessment protocols have been developed and demonstrate validity in several domains. However, despite their demonstrable utility, there is no formal robotic curricula within US urologic surgery residencies. In this article, we will review the current state of robotic simulation training in urologic surgery and highlight the importance of its widespread utilization in urologic surgery residency training programs.

KEYWORDS: simulation, robotics, urologic surgery, education

INTRODUCTION

While many surgical specialties are only now adopting the use of the da Vinci robot, urologic surgeons have become increasingly facile with this system for complex pelvic surgeries since its introduction in 2000. Today, its use continues to expand across the various urologic subspecialties. Robotic surgery has paved the way for many great advances in patient care and outcomes, especially with regards to reduced morbidity and shortened hospital stays.[1] With this widespread transition to minimally invasive technique, the importance of graduating urology residents with robotic proficiency has only become more critical. Robotic simulation is of significant interest to surgical educators for preparing urologic surgery residents for their future careers, regardless of subspecialization. However, to date there is a lack of standardized robotics training curricula within United States (US) urology residency programs. Herein, we highlight the importance of robotic urological surgery simulation, describe the basics of simulation training, and review current available simulation assessments and technologies.

BENEFITS OF SURGICAL SIMULATION

There are many essential benefits robotic simulation offers to surgical trainees. However, of utmost importance is its impact on patient safety. It is well understood that the risk of adverse events is inversely related to years of robotic experience.[2] In 2015, the Emergency Care Research Institute (ECRI) cited insufficient training in robotic surgery as one of the top ten health hazards of the year.[3] To address this risk, the authors proposed a comprehensive program, which includes initial observership, bedside assistant experience, and simulation training prior to real-life robotic surgery under the supervision of a proctor. Prior studies have demonstrated significant improvements in technical performance after training with virtual reality simulators, highlighting the vital role simulation can play in improving patient outcomes and reducing overall morbidity.[4,5,6]

The importance of robotic simulation is further underscored by the impact of the COVID-19 pandemic. Reduced case load during COVID-19 caused a significant reduction in operative case numbers for residents, leading to increased anxiety about performance.[7] One study demonstrated a reduction in perceived robotic skills amongst trainees with an associated increase in time to completion of suturing techniques.[8] Formal simulation programs have been proposed as a solution to addressing this lack of surgical exposure.[9] An obvious barrier to such a program, however, is trainee engagement, which is challenged by long work hours and varying call schedules that limit free time. One proposed solution is gamification of simulation technology, which has been shown to encourage resident participation while also providing a means for practicing and learning. Unfortunately, confidence in skills was not greatly impacted, suggesting a need for additional engagement strategies.[10]

VALIDITY

The utility of any robotic simulator relies on external validation of the system. In robotic surgical simulation, validity is defined by several different parameters. **Table 1** summarizes some of the important validity tests for robotic simulation.

Table 1. Definitions of validity terms related to virtual reality in robotic simulation

Validation Domain	Description
Face	Defines how well a simulator physically mimics real life
Content	Measures whether specific modules on a simulator represents the skills it intends to test
Construct	Measures if and how well a simulator can differentiate between an expert and novice performance
Predictive	Defines the simulator's ability to predict an individual's future performance

The first is construct validity, which assesses how well a particular task within a simulator actually represents an operative setting to the point that it can distinguish a novice from an expert surgeon. In other words, construct validity defines a system's ability to gauge competency. Similarly, content validity assesses whether a simulated task is actually representative of the skills it intends to test. Face validity is another measurement which defines how well the simulator technology physically mimics real-life surgery. Lastly, the predictive validity of the simulator defines the technology's ability to predict future performance. This domain of validity is of particular interest in simulated technology for surgical training as it may help identify a trainee's readiness to progress to higher levels of training. High-quality simulators should have demonstrable validity within several of these areas.

CURRENT SIMULATOR TECHNOLOGY

The use of simulators and virtual reality (VR) has increasingly been used in the acquisition of urologic robotic surgical skills on the da Vinci surgical system. VR training for robotic skills – rather than using the robotic system itself – may decrease cost, allow for more clinical utilization of the robotic system, and help promote validated curricula with objective performance metrics.[11] The most common VR simulators currently available on the market, including cost, developer, and release year, are summarized in **Table 2**. Other platforms include the Surgical Education Platform (SEP) and ProMIS Simulator; however, these are less frequently utilized in the US and are thus omitted from the discussion.

Table 2. VR robotic surgical simulators currently available on the market

VR Simulator	Cost	Developer	Release Year
dV-Trainer (dVT)	$110,000	Mimic Technologies, Inc.	2007
Robotic surgical simulator (RoSS)	$125,000	Simulated Surgical Systems LLC	2010
da Vinci Skills Simulator (dVSS)	$80,000	Intuitive Surgical Inc.	2011
RobotiX Mentor (RM)	$137,000	3D Systems	2014

Table 3. Validity attributes for VR simulators used in urologic surgery

VR Simulator	Validity
dVT	Face, construct, content
RoSS	Face, content
dVSS	Face, construct, content
RM	Face, construct, content

While the widespread adoption of VR simulation has been limited by the high cost of these machines, significant effort has been undertaken to evaluate and compare the efficacy of the various simulators available on the market.[12] The performance of each system is measured by its validity in various categories, which were previously described. The validity attributes of each technology are summarized in **Table 3**. The dVT simulator is a stand-alone trainer, which offers the trainee the opportunity to utilize the technology without requiring access to the da Vinci system. This technology has been shown to have face, content, and construct validity.[13] The RoSS simulator, another standalone system, was shown to predict intraoperative ability and to have face and content validity.[14,15] The dVSS simulator functions as a "backpack" to the da Vinci surgical system and cannot be used without access to the console system. However, it has been shown to result in improved surgical skills amongst novices and also to have face, content, and construct validity.[16,17] Finally, the RM simulator functions as a standalone system and also demonstrates face, construct, and content validity.[18]

Several comparative studies have been conducted for these systems. Hertz et al compared the content validity and cost-effectiveness of the dVT, dVSS, and RoSS systems.[19] Using a standardized questionnaire administered to surgical trainees, all simulators demonstrated evidence of face and content validity, with significantly higher scores for the dVSS (which is the least costly, but also frequently unavailable as it comes as an attachment to the operative robotic platform). Similarly, a meta-analysis by Schmidt et al demonstrated skill transfer and predictive validity of the dvSS and Mimic dvTrainer from three pooled studies with a total of 59 participants.[20] MacCraith et al also published a comprehensive review on robotic simulation training with a special focus on urologic surgery.[21] In their review, they determine that the simulators with the broadest range of exercises are the dvSS, RoSS and RM, which include exercises for needle handling, object manipulation, tissue handling/clipping, suturing and full surgical procedures. They also highlight the challenges of global application of this technology in training, including a current lack of standardization in delivery and implementation, and prohibitively high costs.

ROBOTIC SIMULATION IN SURGICAL ASSESSMENT

Robotic simulation provides an invaluable opportunity for objective assessment and tracking of trainee progress. To date, several different evaluation scales have been developed that can be utilized for objective review of resident and fellow robotics skills. In 2012, Global Evaluative Assessment of Robotic Skills (GEARS) was the first proposed global standardized assessment tool for robotic surgical skills.[22] Using a 5-point Likert scale to quantify performance, GEARS assesses surgeon skills in a task-independent manner pertaining to depth perception, bimanual dexterity, autonomy, efficiency, and force sensitivity, and has been demonstrated to be able to differentiate individuals across a spectrum of surgical expertise.[23] Liu et al further expanded on this with the development of the Assessment of Robotic Console Skills (ARCS) tool, which incorporates assessment in efficiency in utilization of multi-wristed instruments, energy sources, and a third arm.[24] In the initial study of ARCS, all domains except energy source usage demonstrated construct validity. Similar assessment tools include the Robotic Objective Structured Assessment of Technical Skills (R-OSATS) and the Crowd-Sourced Assessment of Technical Skills (C-SATS), and formal checklists with specific focus on suturing skills and robotic dissection techniques.[25–28] These specialized assessments are summarized in **Table 4**.

Table 4. Summary of common robotic skills assessment tools

Assessment Tool	Author	Summary
Global Evaluative Assessment of Robotic Skills (GEARS)	Sanchez et al (2016)	Global rating scale of surgeon robotic skills in depth perception, bimanual dexterity, autonomy, efficiency, and force sensitivity on 5-point Likert scale
Assessment of Robotic Console Skills (ARCS)	Liu et al (2018)	Global rating scale of surgeon skills in use of multi-wristed instruments, field of view optimization, instrument visualization, workspace efficiency, force sensitivity, and basic energy source utilization on 5-point Likert scale
Robotic Objective Structured Assessment of Technical Skills (R-OSATS)	Siddiqui et al (2014)	Assessment of robotic skills in terms of depth perception, accuracy, force and tissue handling, dexterity, and efficiency on inanimate objects in dry-lab setting.
Crowd-Sourced Assessment of Technical Skills (C-SATS)	Chen et al (2013)	Adapted from GEARS; utilizes crowd-sourcing of surgery performance ratings
Technical checklist for suturing in robotic surgery	Guni et al (2018)	Detailed checklist assessing suturing skills in terms of needle driving, knot tying, and general principles of suturing
Dissection Assessment for Robotic Technique (DART)	Vanstrum et al (2021)	Assessment of 6 domains of dissection including gesture selection and efficacy, instrument visualization and awareness, respect of tissue planes, tissue handling, tissue retraction, and efficiency on a 3-point rating scale

While these tools exist and are used to a varying degree nationally, none have been formally incorporated into the American Urological Association (AUA) urological surgery training curricula. The most widely implemented training protocol is the Morristown Protocol, which requires trainees to complete 10 different skills on the dVSS platform at specific benchmarks. The protocol demonstrates predictive validity, and thus, is an appealing tool for both resident assessment prior to live robotic surgery, and institutional robotic credentialing.[29] The current training pathway recommended by Intuitive for the da Vinci system includes a three-hour online course, a dry laboratory session, VR simulation (if available), and then two pig procedures followed by two proctored live surgeries.[30] In 2014 the EAU Robotic Curriculum was introduced as a 12-week program, including eLearning, procedure observation, didactic teaching, dry lab/VR simulation, nontechnical skills training, wet lab simulation, and modular operative training to train for robot-assisted laparoscopic prostatectomy (RALP). This was shown to be a valid and effective method to train for RALP.[31]

ROBOTIC SURGICAL GESTURES

Recently, there has been a growing interest in identifying correlations between specific surgeon psychomotor skills and patient clinical outcomes. Deconstruction of the surgical procedure into the smallest meaningful interactions between surgical instrument and tissue, or gestures, may further quantify surgeon skills and identify optimal procedural protocols. Dr. Andrew J. Hung and his colleagues have pioneered this work in robotic surgery. Initially, they identified 9 dissection and 4 supporting gestures as the fundamental instrument movements necessary for robotic surgery. They validated their findings through cross-referencing 40 videos of robotic hilar dissections during robotic-assisted partial nephrectomy.[32] More recently, these gestures have been utilized to predict patient-related outcomes and to classify specific movements based on quality and efficacy. This exciting work provides a novel perspective on surgical assessment and may pave the way for identifying best surgical practices to help guide future surgical robotic training.[33,34]

SYNTHETIC SURGICAL MODELS

Finally, other emerging technologies, including synthetic organs and models, are increasingly being utilized for robotic surgical training. As the technology of these synthetic models increases, they are slowly replacing the typical animal and cadaveric models that have been used for advanced robotic surgical simulation since its inception. These synthetic models present not only a more reliable, cost-effective option compared to cadavers, they also negate ethical concerns related to use of animals in surgery. The clinical applications of 3D-printed models for robotic simulation in urology have been previously reviewed and their development continues to expand.[35,36] Most notably, the Simulation Innovation Laboratory at the University of Rochester led by Dr. Ahmed Ghazi has developed and validated realistic simulation models for robot-assisted kidney transplant, robot-assisted partial nephrectomy, and RALP.[37–39] Other models have been developed for percutaneous nephrolithotomy (PCNL), partial nephrectomy, transurethral prostate resection (TURP), RALP, pyeloplasty, and kidney transplant. An attractive aspect of these models is their consistency and reliability in the educational setting. Thus, as the technology continues to become more sophisticated, increased utilization of these simulation models in surgical training is likely to become more apparent.

CONCLUSION

Robotic surgery has become a hallmark of urologic surgery and now plays a significant role in many subspecialties including pediatrics, intraabdominal reconstruction, female and pelvic floor reconstruction, and urologic oncology. Robotic surgery has optimized patient postoperative outcomes for many common urologic surgeries, and its utilization is likely to continue to expand. Therefore, it is imperative that urologic surgery residents are well-trained in the utilization of this technology. While many virtual reality technologies and high-fidelity anatomic models have been developed to train urologic surgery residents in robotics, the lack of a formalized curriculum results in variable exposure in each training program. Nonetheless, it is clear that the available robotic simulation technology offers a unique opportunity for skill acquisition while preserving patient outcomes, and its formal incorporation into residency training is essential. These technologies are likely to continue to develop in the coming years, and their validity and applicability must be redemonstrated with each iteration. The utilization of synthetic models provides further standardization of surgical simulation and represents an exciting new field for growth. Therefore, as robotics continues to redefine urologic surgical technique and patient outcomes, the evolution of our field has never been more exciting.

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Arthroscopic Simulation in Orthopaedic Surgery Training

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ABSTRACT

Surgical simulation has become a commonly utilized and well-researched training adjunct in nearly all surgical specialties. Balancing high-quality orthopaedic surgical training in the face of work hour restrictions and efficiency pressures has become a challenge to educators and trainees alike. Surgical simulation is an opportunity to enhance such training and potentially permit trainees to be better equipped for the operating room. In orthopaedics, various low-fidelity, high-fidelity, and virtual reality simulation platforms are readily available to almost all trainees and permit simulation of a wide array of arthroscopic surgeries. In this review, we seek to highlight the potential utility of simulation-based training in orthopaedic surgery, the various types of available simulators, and review the evidence for simulator use.

KEYWORDS: surgical simulation, orthopaedic education, arthroscopic simulation, virtual reality

INTRODUCTION

Surgical simulation has become an important tool for graduate surgical education in recent decades, in response to paradigm shifts in the training landscape. Mastery following the traditional Halstedian approach of "see one–do one–teach one" is no longer feasible in modern surgical education, despite a growing need for competent, efficient surgeons.[1] It is increasingly difficult for trainees to strike a balance between prioritization of patient safety and satisfaction, and the volume constraints of resident duty hour restrictions and operating room efficiency.[1–3] To improve high-quality, efficient, and patient-centered care, interest in evidence-based, formal curricula to address core competencies of surgical training using models and simulators has grown.[4,5] Orthopaedic surgical simulation offers a promising adjunct to the apprenticeship model, providing an accessible, controlled environment without the risk of patient harm.[5] Simulation to improve surgical skills hinges on the concepts of pedagogic consistency and deliberate practice, the latter defined as focused, effortful skill repetition in progressive exercises that provide informative, immediate feedback.[5] Surgical simulation allows residents to advance through appropriately challenging skills at their own pace, with progress tracked based on clearly defined outcome measures.

There is a growing body of evidence demonstrating the considerable benefits of simulation in orthopaedic training, especially arthroscopy, though the incorporation of these methods into orthopaedics has lagged somewhat behind other disciplines.[6–8] Frank et al conducted a meta-analysis of 57 studies published between 1999–2016 concerning validated arthroscopic simulation models; the authors reported improvement in simulator task performance (24 of 25 studies that analyzed this metric; 96%) and improvement in operative performance after simulator training (4 of 4 studies; 100%), although they cautioned that the evidence for improved *in vivo* performance was limited.[8] A more recent 2021 systematic review from Lakhani et al added to this base with 44 studies regarding use of physical or augmented/virtual reality (AR/VR) arthroscopic models for ankle, knee, shoulder, and hip environments.[6] Similarly, they concluded that simulation is beneficial for orthopaedic trainees, with the majority of included studies demonstrating construct and transfer validity – important measures of the capability of the simulator to differentiate between levels of expertise, and the ability of the simulator to achieve learning and improvement outside of the simulation, respectively.[6,9] Although small scale studies have demonstrated improvement of technical performance and patient safety measures following a simulator training regimen for procedures such as diagnostic shoulder arthroscopy, there remains a question of how well simulator skills can transfer to operative performance and ultimately improve patient outcomes.[10]

Within orthopaedics, several simulator models are available, existing on a spectrum from low-fidelity self-made workstations to augmented and virtual reality environments. Despite evidence regarding the validity and success of these simulators, there is no consensus on a gold standard option for orthopaedic surgical simulation. We aim to provide evidence on the accessibility, validity, and success of various simulators, to inform residency training programs on how to best incorporate simulation into orthopaedic training.

PROFIDENCY-BASED TRAINING

As minimally invasive surgery became more prevalent in the late 20th century, surgical training programs were faced with the challenge of training surgeons in procedures that required distinctly unique skillsets from those utilized in open surgeries.[11] Historically, competency in surgical skills was assessed through either successful completion of a predetermined number of cases (i.e., a case minimum) or observation and evaluation by a more senior surgeon.[12] Unfortunately, these methods are inherently flawed due to subjectivity and variability in trainee skill level (i.e., some residents may need more than minimum case numbers to become proficient in a given procedure), as well as variability in the feedback provided to trainees. Thus, proficiency-based progression (PBP), or proficiency-based training (PBT), was born. This training strategy focuses solely on performance, using goal-directed and deliberate practice in the form of simulation to achieve competency, with the goal of developing a uniform skill set for all trainees to improve safety and efficiency in the operating room.[13]

PBT utilizes simulation-based training to allow learners to acquire specific skills, then uses objective measures to evaluate progress, and correct errors through direct feedback.[14] In orthopaedic surgery, PBT has been studied primarily within the realm of shoulder arthroscopy.[15–17] Arthroscopy is a minimally invasive skill that requires unique technical proficiencies compared to open surgeries, such as instrument triangulation, bimanual dexterity, and the ability to manipulate three dimensional images on a two-dimensional screen. Therefore, to maintain operative efficiency and patient safety, mastering these skills prior to the operating room is certainly ideal. In his pivotal work, Angelo et al broke down the steps of an arthroscopic shoulder labral repair into the core "phases" and "steps."[15] Arthroscopic portal placement, mobilization of the capsule and labrum, and glenoid preparation for anchor placement were denoted as "phases" of the repair, while each arthroscopic view or instrument manipulation was a "step." This training technique thus permits a metric-based system to provide a grading system for a trainee's performance, creating the opportunity to denote a trainee as competent at a given procedure if they can achieve certain metrics. Angelo et al demonstrated that PBT led to significant decreases in surgical error rate, as well as greater likelihood of achieving proficiency, when compared to traditional training techniques in arthroscopic Bankart repairs.[16] When coupling the metrics of arthroscopic Bankart repair performance with cadaveric shoulder training, Angelo et al found the ability to accurately measure surgeon skill.[17] These findings, which are in accordance with those of other authors,[10,18] can potentially provide useful metrics for surgeons to possess to ensure they are proficient in the necessary skills to safely perform arthroscopic surgery. Continued research into PBT and other arthroscopic and open orthopaedic surgeries would be a useful next step in advancing orthopaedic surgery simulation-based training.

VALIDATION OF ARTHROSCOPIC SIMULATOR

Necessary to any discussion of surgical simulators is the principle of validity. For a surgical simulator to be truly useful, it must strive to replicate the surgical experience as closely as possible to reality. Therefore, any orthopaedic surgery simulation platform should ideally be validated in several different ways, including construct, content, transfer, and face validity (**Table 1**).[7] Construct validity is defined as the extent to which a simulator can differentiate the performance between users of various skill levels.[19] For example, an arthroscopic surgical simulator would have high construct validity if it can discern an expert arthroscopist with years of experience from a medical student, who is a novice. Content validity instead refers to an estimate of a surgical simulator's skill testing ability based upon a thorough assessment of the contents of the test items. Generally speaking, content validity is determined by opinions of those deemed experienced or expert in the field.[15] Transfer validity instead is an assessment of the ability to translate technical performance on a simulator to the operating room for a specific procedure.[8] Finally, face validity measures how real a simulator feels, evaluating how its performance looks and feels relative to reality. While these are relatively subjective measures, they remain important tools to critically assess surgical simulators prior to application within a training program.

Table 1. Types of Validity Related to Orthopaedic Surgery Simulation

Terms	Definition
Construct Validity	The extent to which a simulator can differentiate the performance between users of various skill levels
Content Validity	Measurement of a surgical simulator's skill testing ability based upon a thorough assessment of the contents of the test items
Transfer Validity	The ability to translate technical performance on a simulator to the operating room for a specific procedure
Face Validity	How true a simulator feels to the surgical experience

LOW-FIDELITY SIMULATORS

The term fidelity describes the ability of a certain simulator to adequately mimic the real surgical environment or skill set being tested, similar to the aforementioned concept of face validity.[20,21] Low-fidelity simulators therefore are physical models that may be associated with simulation modules that replicate aspects of surgical procedures, but with limited functionality and realism. According to a recent systematic review, these simulators are notably less expensive than their high-fidelity counterparts, and simpler to set-up, operate, and transport.[21] Therefore, low-fidelity simulators are often a good option for novices and basic skills training. Low-fidelity models may be self-made or can be purchased commercially. Ling et al compared the effectiveness of a self-made arthroscopic training camera versus a commercial camera, devices that cost roughly $30 and $50,000 USD, respectively.[20] The self-made construct was composed of an endoscopic camera fixed at 30 degrees of inclination to two parallel Kirschner wires, in addition to a small training box constructed using splint material; other "homemade" models are similarly composed of small USB cameras with built-in lights. Significant technical improvement was seen with both models, with no significant difference between the groups for any tests, suggesting equivalent learning effectiveness using the low-cost model.[20] As first described by Ferras-Tarrago et al, 3-dimentional (3D) printing of an arthroscopic simulator device offers a low cost, accessible alternative; the simulator model pattern can be downloaded for free and printed easily on any domestic 3D printer, and combined with an inexpensive ($14 USD) endoscopic camera.[22] The physical model is combined with an open-source, validated, practical training program, through which seasoned surgeons can virtually provide instruction and feedback to novices. This construct currently lacks evidence of transfer validity.

The Fundamentals of Arthroscopic Surgery Training, or the FAST workstation (Pacific Research Laboratories, Inc., WA, USA) is a relatively low-cost, low-fidelity commercial option, consisting of a computer-controlled arthroscopic box construct, various surgical instruments, and a computer interface to record movement and provide real-time feedback on performance.[23] This device is designed to develop the cornerstone skills of arthroscopy such as bimanual dexterity, grasping, triangulating, and knot tying; trainees can progress through the 6-module paired program consisting of various exercises, including visualization and probing, ring transfer, maze navigation, tissue biting, suture passing, and knot tying. Several studies have demonstrated the effectiveness of the FAST workstation and associated models in improving novice task performance. Goyal et al reported reliable construct validity, as well as improvement in performance with sequential tasks in a group of 20 orthopaedic surgeons of various skill levels.[24] Similarly, Meeks et al demonstrated significantly decreased time to completion of task modules after 6 weeks of FAST training in medical students.[25] Notably, the mean time to completion and number of errors did not change following 12- or 24-week intervals of inactivity, suggesting promising psychomotor retention of tested skills. Additionally, this study among others posits the feasibility and success of formal teaching for true novices, which would allow for earlier access to competency training.[25,26] However, there is some opposing evidence that several of the FAST modules have low construct validity – a multicenter study from Vaghela et al reported no demonstratable correlation between true arthroscopic experience and ambidextrous performance, as well as an inability of the modules to discriminate between participants' experience levels; this suggests the inadequacy of the construct for assessing advanced arthroscopic proficiency.[27] A similar study reported that the FAST simulator could discriminate between activities and training year, but not case experience as measured by score, path length, and time.[28] The authors still maintain the importance of the FAST workstation in building crucial but novice-level arthroscopic skills, despite conflicting evidence regarding its construct validity.

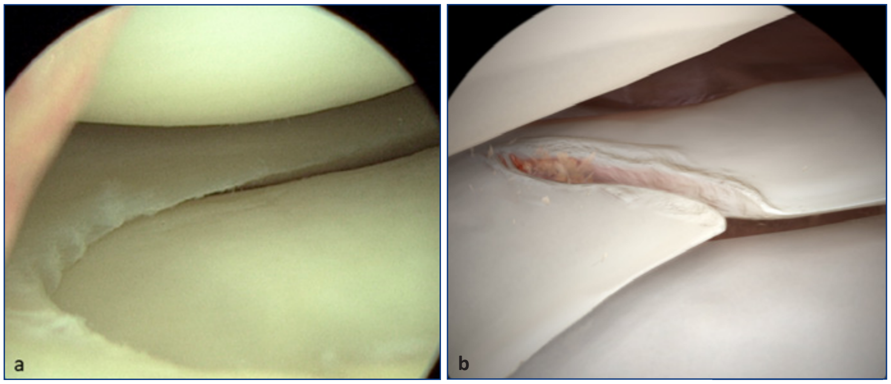
ArthroBox™ (Arthrex, Inc., Naples, FL, USA) is another example of a low-fidelity commercial training system for triangulation skills, comprised of a collapsible arthroscopy box with combined LED camera and light source that plugs directly into a personal computer.[29] Bouaicha et al demonstrated significant improvement in task performance following novice use of an ArthroBox trainer, and also found it to have construct validity.[30,31] Not only did they demonstrate improvement between baseline to follow-up on the low-fidelity model, subjects also showed subsequent improvement on high-fidelity, validated virtual knee simulators, suggesting that training on a more accessible device is beneficial for future performance on a higher fidelity construct and potentially in the operating room itself. A recent systematic review found that low-fidelity workstations improve novice trainee performance in arthroscopic tasks, and are likely more cost effective and simple to implement than higher fidelity simulators.[32] Ultimately, the cost effectiveness and potential training benefits of low-fidelity workstations make them a viable consideration for a training program's armamentarium.

HIGH-FIDELITY SIMULATORS

In comparison with low-fidelity simulators, high-fidelity simulators are more expensive but have improved realism and feel to the real world and operating room (**Figures 1A, 1B**). A common improvement in these simulators is the use of augmented reality (AR). Proprietary examples of high-fidelity simulators include ArthroS® (VirtaMed),[33] ARTHRO Mentor™ (Symbionix),[34] and InsightARTHRO VR® (3D Systems).[35] These products have the components of a mannequin, an arthroscopic video monitor, and simulated arthroscopic equipment. The arthroscopic equipment is nearly identical to operating room instruments and the majority of simulators provide tactile and haptic feedback for the instruments to simulate resistance and vibrations associated with their real use.

Several studies have sought to validate high-fidelity simulators for use in orthopaedic surgery resident training given the advantages of ease of use and demands for patient safety and quality control. These studies have examined both the validity of these simulators as well as their impact on surgical training. Various arthroscopic simulators have been validated both with face and construct validity and the general construct of the various proprietary simulators is overall similar amongst systems.[36] To examine the impact of these

Figures 1A, 1B.
[**A**] An intraoperative arthroscopic image of a right knee demonstrating a lateral meniscal tear after debridement.
[**B**] An image of a right knee with a large radial tear of the lateral meniscus from a high-fidelity arthroscopic simulator. Note the high-quality graphical comparison to a true arthroscopic image.



[Images from ArthroS® (VirtaMed) simulator video. Reproduced with permission of VirtaMed AG Switzerland]

simulators on surgical training, Rebolledo and colleagues compared high-fidelity arthroscopic simulation using the InsightARTHRO VR to didactic lectures, finding that the residents assigned to the surgical simulator group had significant improvement over those in the didactic session group in performing cadaveric diagnostic knee and shoulder arthroscopy.[18] Wang and colleagues designed a randomized controlled trial to assess the impact of simulation training on performance of cadaveric arthroscopy using a high-fidelity workstation. These researchers randomized novice participants to simulation training or no simulation training (control group) prior to assessing arthroscopic skills on a cadaver. After the use of the simulator 1 time per week for 3 weeks, the simulation group had significantly improved task-time completion scores for all tasks. However, when these groups practiced on a cadaveric models, these skills did not have significant transferable benefit as they found no difference between the groups in performing standard diagnostic arthroscopy of a knee and a shoulder.[37] Interestingly, they discuss a ceiling affect for task improvement that occurs after 3 trials for most of the tasks analyzed, concluding that there is some measurable improvement in coordination and efficiency for AR training models and that this improvement is rapidly obtained.

The validity of high-fidelity simulators has been assessed through various studies. Lakhani et al performed a thorough systematic review of arthroscopic simulators synthesizing the body of available literature related to arthroscopy simulation.[6] These authors found many studies which determined that several commercially available high-fidelity arthroscopic simulators demonstrate construct, transfer, and face validity, while only 3 studies assessed these simulators for content validity.[6] These have been validated for use in several joints, including the knee, shoulder, and hip. It remains essential that all commercially available arthroscopic simulators undergo evaluation of validity to ensure that the simulators can truly provide a realistic benefit to orthopaedic trainees. Furthermore, residency program directors should scrutinize the literature regarding specific simulators when considering the purchase of an expensive high-fidelity simulator to train their residents.

A meta-analysis of arthroscopic simulator training by the same group reviewed 57 studies with 1698 participants.[8] Twenty-five studies compared pre-simulator training to post-simulator tasks and 24, or 96%, of these studies showed significant improvement after simulator use. Four studies examined results on live-patient arthroscopy of which all 4 showed improvements after simulator use. High-fidelity simulators likely will continue to have a growing role in resident education. However, they may be cost prohibitive in many situations as they can cost tens to hundreds of thousands of dollars; therefore, training programs should carefully consider their options to determine if high-fidelity simulators are a cost-effective means to improve resident education.

While the aforementioned arthroscopy simulators utilize a form of virtual reality (VR), in which a mannequin and computer are utilized to experience an arthroscopic environment, commercially available VR headsets are emerging as another form of workstation. These headsets offer a wireless, computer-based simulation in which the user wears a VR headset and utilizes two controllers to manipulate a virtual environment, such as the operating room, without the need for a computer. For example, PrecisionOS® has created a complete hip arthroscopy VR experience in which trainees can immerse themselves in the operating room to simulate the steps of this technically demanding procedure.[38] While this platform has demonstrated good face and content validity, it has incomplete construct validity; further research on this type of VR arthroscopy simulation is necessary, but it remains an important emerging training tool to consider.

CONCLUSIONS

Surgical simulation platforms, which have been well-studied in techniques such as arthroscopy, remain a viable and proficient tool for improving an orthopaedic surgery trainee's skillset prior to entering the operating room. Low-fidelity simulators are a relatively low-cost, accessible option for training certain basic skills, while high-fidelity simulators afford an experience with higher face validity, but also substantially greater cost. Arthroscopic surgical simulators should be thoroughly evaluated for validity. While various studies have evaluated construct, face, and transfer validity in specific arthroscopic simulators, content validity is infrequently reported. The future of orthopaedic surgical simulation includes continued work on these aforementioned simulators, and expansion of true VR experiences that encompass all realms of orthopaedics from arthroplasty to trauma surgery. Future work in validating various VR modules and platforms will be useful to help elucidate this expansile technology's role in orthopaedic surgical training.

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