Advancing Telemedicine through Medical Simulation in Emergency Medicine

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ABSTRACT

Our institution's health system is a network of hospitals and clinics in the upper Midwest. The health system includes 21 Emergency Departments (EDs), of which 10 are designated Critical Access (CA) sites, serving approximately 320,000 patients each year. Ensuring timely access to high quality emergency care across this vast enterprise is challenging; medical simulation and telemedicine play an integral part in this endeavor.

The Emergency Medicine (EM) Community Simulation Program delivers on site and *in situ* multidisciplinary courses focusing on teamwork, communication, and high-risk clinical care and promotes practice standardization across the health system. In order to expand the expertise available in our health system sites, acute care telemedicine services are available in the health system EDs, including TeleStroke, TeleNeonatology, and TeleEmergency Medicine. To promote use of these services and allow simulated practice with the technology, we include the use of telemedicine consultation in our simulation courses.

Embedding telemedicine in these scenarios proves beneficial in several ways. Simulation scenarios provide opportunities for troubleshooting connectivity outside of active patient care. After simulation training, health system providers noted increased familiarity with the technology and workflows and improved understanding of available services and indications for consultation. Additionally, this collaboration sparked expansion of our TeleNeonatology service from sites with Family Birth Centers to all CA EDs across the health system.

Telemedicine capabilities and resources continue to evolve at our institution. Simulation has been an impactful way to improve standardization of emergency care and promote the growth of our telemedicine services as we continue to incorporate this technology into our enterprise-wide EM practice.

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INTRODUCTION

Our institution's health system includes 21 Emergency Departments (EDs) that serve approximately 320,000 patients each year (see Figure 1). There are 10 federally designated Critical Access (CA) hospitals, several moderate-sized community EDs, three level III trauma centers, one level II trauma center, and one academic tertiary care referral center. Consequently, available resources vary significantly across the health system sites. Integrating clinical practice to ensure timely access to standardized high quality emergency care across this vast enterprise is paramount, but not without challenges; medical simulation and telemedicine play and integral part in this endeavor.

Figure 1. Map of the Health System. The South West MN Region (red) has 6 EDs: Fairmont, St. James, Waseca, Springfield, New Prague, and Mankato (regional hub). The South East MN Region (yellow) has 7 EDs: Red Wing, Lake City, Cannon Falls, Owatonna, Albert Lea, Austin, and Rochester (regional hub). The North West WI Region (orange) has 5 EDs: Bloomer, Barron, Osseo, Menomnie, and Eau Claire (regional hub). The South West WI Region has 3 EDs: Sparta, Decorah, and La Crosse (regional hub). Image © Mayo Foundation for Medical Education and Research, 2017.

In broad terms, telemedicine is the use of electronic, visual, and audio information and communication technology to provide and support health care where distance separates the participants (Pande, Patel, Powers, D'ancona, & Karamanoukian, 2003). It is used to provide diagnostic and consultation support to practitioners at distant sites, assist in or directly deliver medical care to patients at distant sites, and enhance the skills and knowledge of distant

medical care providers. Telemedicine serves as a means of communication as well as a diagnostic or therapeutic modality (Lambrecht, 1997).

In 1997, a descriptive analysis of the first year of operation of The Dakota Telemedicine System was published (Lamabrecht, 1997). Their telemedicine network linked three rural hospitals and adjoining clinics (spoke sites) with a level II tertiary referral site (hub site) which was, on average, located 113 miles away. The spoke sites, staffed by primary care providers, initiated the consultations. Of the teleconsultations made, Emergency Medicine (EM) was the most requested service (24%). This was the first report examining the role of EM in telemedicine.

Since then, telemedicine and its applications have grown dramatically. In the field of EM, telemedicine consultations between EM physicians at referral sites and rural EDs has been shown to alter diagnosis, treatment, and/or decision to transfer a patient (Stamford, Bickford, Hsiao, & Mattern, 1999) and improve (decrease) door-to-provider time and length-of-stay for transferred patients (Mohr et al., 2018). Additionally, telemedicine has been used to connect EM physicians directly with a specialist which facilitates timely administration of therapy and has been shown to reduce patient transfers for several conditions (including stroke, trauma, ophthalmology, cardiology, and others) (Ward, Jaana, & Natafgi, 2015).

Our institution has an active telemedicine network. Currently available acute care telemedicine consultations to the health system EDs include TeleStroke (Stroke Neurologist), TeleNeonatology (Neonatologist), and TeleEM (Board Certified EM physician and EM trained pharmacist). TeleStroke consultations have been available since 2015, are available 24/7, and are most widely used among the available services. TeleNeonatology consultations have been available to all health system sites with Family Birth Centers to assist with neonatal resuscitation in the post-partum period since 2016. TeleEM is our fastest growing telemedicine service. This connects health system ED providers to EM physicians at the referral center for assistance with patient care or to facilitate patient transfer. Pilots began in 2017 and the service formally launched in October 2018. TeleEM consultation is available 12 hours/day, 7 days/week, with plans to expand to 24/7 availability.

The growth and development of our TeleEM service has been challenging in several respects. One of our most significant barriers currently is promoting use of the service throughout the health system. TeleEM consultations are initiated by the health system ED provider on an as-needed basis. As such, buy-in from the remote clinician is essential for continued use and a successful program (Stamford et al., 1999; Fang, Asiedu, Harris, Carroll, & Colby, 2018a). Some of this difficulty stems from lack of awareness of service availability, lack of education and training on use of the technology, and lack of perceived need for the service by health system ED providers. Fang et al. (2018a), when evaluating the implementation of our institution's TeleNeonatology service, noted similar barriers.

Recently, the department of EM at our institution established the EM Community Simulation Program (CSP). The EM CSP uses medical simulation to promote standardization of the Emergency Medical practice across the health system as well as to provide ongoing education and training for health system EM providers and care teams, and to facilitate quality and process improvement. Simulations are multidisciplinary and focus on teamwork, communication, and clinical care. They are held on-site and, when possible*, in situ* in the ED. *In situ* simulation is the most effective way for care teams and EM leadership to identify opportunities for quality improvement on a local level and to best understand what resources exist at each site and how best to standardize our practice across the health system. Recognizing telemedicine as a resource globally available in the health system EDs, and in an effort to help integrate telemedicine into the local EM practices, we recently began embedding the use of telemedicine into our *in situ* EM simulations.

Telesimulation, a newer development in medical simulation, is the process by which synchronous video and simulation resources are utilized to provide education, training, and/or assessment to learners at an off-site location (a distant site that would preclude the education, training, and/or assessment without the use of telecommunication resources) (McCoy, Sayegh, Alrabah, & Yarris, 2017). Although telesimulation utilizing high-fidelity human patient simulators (mannequins) via remote viewing and debriefing or remote control of the mannequin has been described (Beissel et al., 2017; Hayden, Khatri, Kelly, Yager, & Salazer, 2018; von Lubitz et al., 2003), the literature supporting its use is limited and little is understood about its limitations or the optimal economic and geographic factors favoring this approach over in-person simulation (Hayden et al., 2018). This is distinct from our use of on-site simulation to facilitate and practice the use of telemedicine. We are not aware of other similar programs.

Herein, we provide a descriptive analysis of our experience utilizing *in situ* simulation to advance telemedicine as a resource in our system-wide Emergency Medicine practice.

METHODS

To date, we have included telemedicine consultation in our Difficult Airway and Obstetrical Emergencies simulation sessions.

The Difficult Airway curriculum includes skills stations for procedural task training on adult and pediatric endotracheal intubation, the use of oral and nasopharyngeal airway adjuncts, supraglottic devices like the laryngeal mask airway device, and cricothyrotomy. There are also three multidisciplinary *in situ* simulation cases: a 63 year-old-male with a chronic obstructive pulmonary disease exacerbation requiring endotracheal intubation, an 18 month-old-female suffering from smoke inhalation after a house fire requiring endotracheal intubation, and a 29 year-old-male trauma victim with a neck injury who is unable to be endotracheally intubated or effectively bag-mask-ventilated and ultimately requires cricothyrotomy.

The Obstetrical Emergencies curriculum consists of a bank of six case topics: imminent delivery, shoulder dystocia, post-partum hemorrhage, eclampsia, traumatic arrest with perimortem caesarian section, and neonatal resuscitation. Some topics can be combined into a single simulation case. For example, a pregnant female presents in active labor and delivery is imminent, the delivery is complicated by a shoulder dystocia or post-partum hemorrhage, and the neonate may require resuscitation.

The flow and progression of the case is facilitated by an embedded instructor. This instructor's role includes keeping participants on track, supplementing information or findings that cannot be simulated (such as being the voice of the patient or confirming physical exam findings), and prompting participants with regard to what tasks can and cannot be performed on the mannequin. With regard to telemedicine consultation, the embedded instructor, at his or her discretion, was able to prompt the care team to place the consultation. Prompts to consult telemedicine were given if the team seemed to be struggling with appropriate clinical management or if they had not independently placed a telemedicine consultation at the expected point in the case.

The TeleEM service was available for consultation for both the Difficult Airway and Obstetrical Emergencies sessions and TeleNeonatology was available for consultation for the neonatal resuscitation scenario within the Obstetrical Emergencies sessions. When we began in 2017, TeleEM consultation availability was limited as the program was in its pilot phase. Currently, it is available daily, but not until 11am. Consequently, TeleEM consultation was not available for use during all of the simulation scenarios. TeleNeonatology is readily available at all health system sites with Family Birth Centers, but no formal agreement currently exists for sites without Family Birth Centers, such as our CA sites. However, the TeleNeonatology physician group did agree to participate in the simulations and had a Neonatologist standing-by to perform the consultations.

Participants for the simulation cases were organized into care teams that reflected the actual composition of care teams in the ED at that site. Typically, this would include one or two providers (either physicians or Advanced Practice Providers {physician assistants or nurse practitioners}) and two to three nurses. Additional support staff, such as respiratory therapists, Certified Registered Nurse Anesthetists (CRNAs), or additional nurses may or may not be available to respond in an emergency situation depending on the site and time of day. During the simulations, resources were limited to what would be available at the site during an actual clinical encounter in the ED. Again, consistent with the local clinical practice, other specialty services were potentially available by phone or telemedicine consultation, but were not available for in-person assistance during the simulations.

Participation in the simulation sessions was encouraged by regional and local leadership, but was voluntary. In some cases, participants could claim continuing education credits or local initiatives provided compensation for their time. The multidisciplinary simulation center, located at the referral hospital, provided compensation for the instructors' time as well as physical equipment including the mannequins.

Participants were asked to complete a short survey evaluating their experience with telemedicine during the simulation scenarios. The nine-question survey was available online and completion of the survey was voluntary.

Participants were contacted via e-mail approximately three to fifteen months after completion of the simulation course. A reminder e-mail was sent approximately two weeks after the original survey request.

RESULTS

Telemedicine consultation was available during four simulation sessions (one Difficult Airway session and three Obstetrical Emergencies sessions). Eighty-eight individuals participated in one or more of these sessions. Eighty-two participants were reachable via email and asked to complete the survey: 26 APPs, 11 physicians, 41 nurses, and 4 other (e.g. paramedic/EMT, ED tech, etc.). Thirty-nine participants (47.6%) completed the survey. Participant demographic information is listed in Table 1.

Table 1. Participant Demographic Information.

	Total N (%)[a]	**Practice Type N (%)[b]**			**Clinical time in ED[c] N (%)[b]**	
Participant Type		**Academic Center**	**Community Hospital**	**Critical Access Hospital**	**> 75%**	**< 75%**
APP	15 (18.3)	1 (6.7)	6 (40.0)	8 (53.3)	11 (73.3)	4 (26.7)
Physician	5 (6.1)	1 (20.0)	4 (80.0)	0 (0.0)	5 (100.0)	0 (0.0)
Nurse	18 (22.0)	0 (0%)	9 (50.0)	9 (50.0)	11 (61.1)	7 (38.9)
Other	1 (1.2)	0 (0%)	0 (0.0)	1 (100.0)	0 (0.0)	1 (100.0)
Total	39 (100)	2 (5.1)	19 (48.7)	18 (46.2)	27 (69.2)	12 (30.8)

Note: [a] N = number of survey respondents of that participant type (percent of total survey respondents). [b] N = number of survey respondents of that participant type (percent of survey respondents of that participant type). [c] Clinical time in ED = percent of clinical time spent providing direct patient care to patients in the Emergency Department.

Ninety percent of participants who responded to the survey had used telemedicine in the years prior to participating in the simulation session. Of those, the most frequently utilized telemedicine service was TeleStroke. Twenty percent of participants who had used telemedicine previously reported having consulted TeleNeonatology; all of these participants reported working less than 75% of their clinical time in the ED or had worked in locations outside the ED during their tenure in the health system (see Figure 2). Fifty two percent of participants noted they have used telemedicine in the three to fifteen months since participating in the simulation session. Although TeleStroke remained the most frequently utilized service, utilization of the TeleEM service increased; 75% of participants who used telemedicine reported using TeleEM consultation after the simulation session compared to 42.9% prior to the simulation session (see Figure 2). While this increase may be in part attributable to an increase in the availability of the TeleEM consultation service (transition from pilot phase to full implementation), we did find that awareness of the TeleEM service also increased after participation in the simulation session (see Figure 3). Our TeleNeonatology colleagues report one TeleNeonatology consultation from the ED after our simulation sessions were conducted. Of those who reported they have not used telemedicine since participating in the simulation, the most frequent reason was that the participant felt telemedicine consultation was not needed (94.4%).

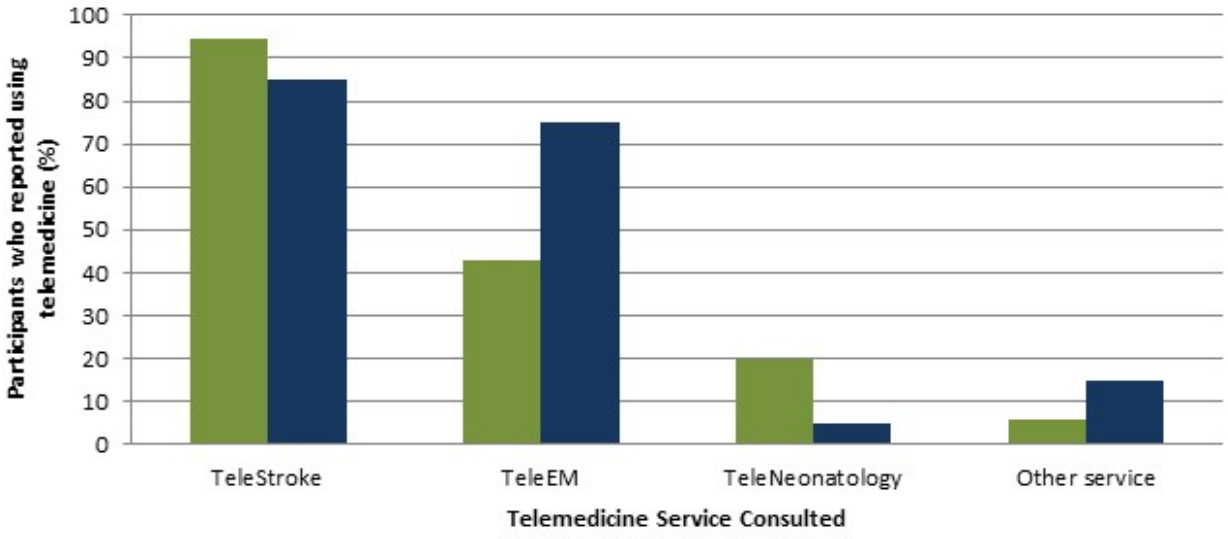

Figure 2. Acute Care Telemedicine Consultation Use Among Health System EDs. Participants were asked whether they have used acute care telemedicine prior to (green bars) and after (blue bars) participating in the simulation session. Those who answered yes were asked to report which acute care telemedicine service(s) they have used. Data are reported as the percent of participants who noted that they have used telemedicine consultation services.

The simulation sessions were designed to include the TeleEM and TeleNeonatology services. Participants were asked to rate how likely they would be to use or consider using one of these telemedicine services before and after participating in the simulations. On average, all participant groups noted they would be more likely to use or consider using the TeleEM or TeleNeonatology services after participating in the simulation (see Table 2). This increase was most notable among APPs and least among physicians.

Table 2. Participants' Likelihood of use of TeleEM or TeleNeonatology Services from the ED.

	Likelihood of use of TeleEM or TeleNeonatology[a]		
Participant Type	**Before Simulation**	**After Simulation**	**Delta**
APP	56.6	80.3	+ 23.7
Physician	41.6	47.2	+ 5.6
Nurse	63.1	79.1	+16.0
Total Respondents	*57.5*	*75.9*	*+18.4*

Note: Participants were asked how likely they would be to use/consider using TeleEM or TeleNeonatology services prior to and after participating in the simulation session. This was rated on a scale which generated a corresponding numeric value ranging from 0 (not likely) to 100 (very likely). [a] Data reported are averages.

Many of the APPs staff CA EDs as the sole provider on-duty and do not have EM trained physician back-up immediately available. Conversely, health system physicians are presumably more comfortable caring for critical patients without TeleEM support because they have all completed EM residency training. This was observed anecdotally during the simulations. During our Obstetrical Emergencies courses, we noted that when available, TeleEM consultation was initiated infrequently; those care teams were led by EM trained physicians or APPs with EM physician back-up immediately available. TeleNeonatology, however, was universally consulted for assistance with neonatal resuscitation regardless of the level of training of the EM provider. Some teams required prompting by or assistance from the embedded instructor to initiate the TeleNeonatology consultation. This was also reflected in some providers' feedback; one EM trained physician commented, "I am unlikely to use telemedicine for EM, but would like it for Neonatology."

Participants were also asked what they gained from using telemedicine during the simulation scenarios. Most commonly, participants noted they were more comfortable interacting with the consultant while providing patient

care (46.2%) and that they were now aware of the TeleNeonatology (46.3%) or TeleEM service availability (35.9%). Many also noted increased familiarity with use of the technology (see Figure 3).

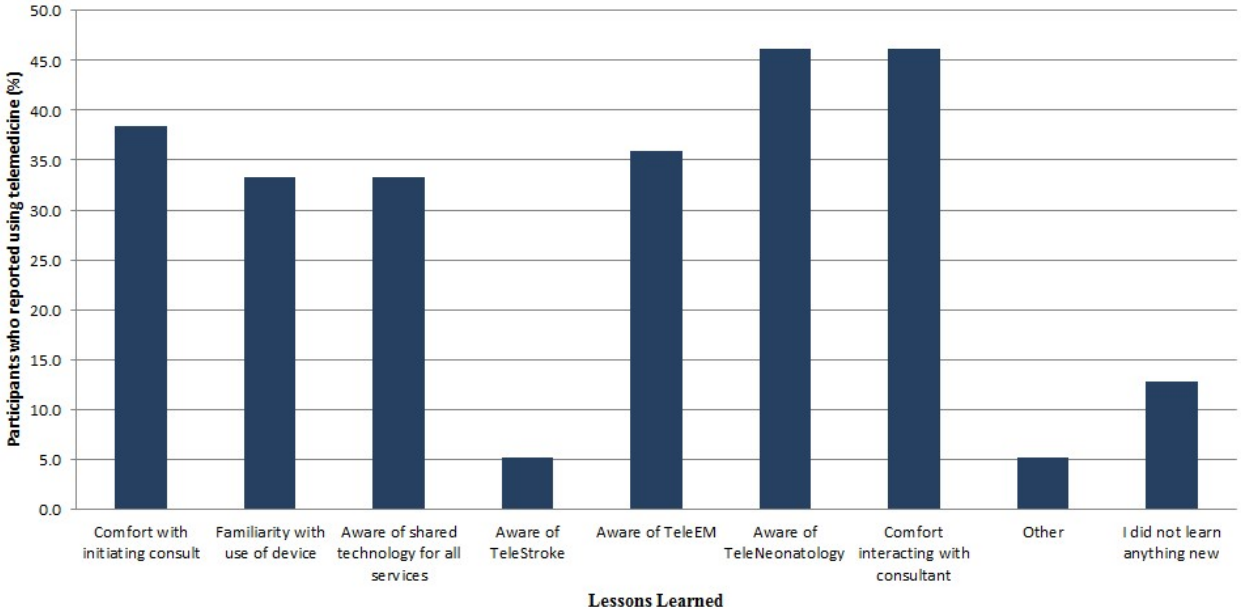

Figure 3. Lessons Learned Incorporating Telemedicine Consultation into *in situ* Emergency Medicine Simulations. Participants were asked what they learned about acute care telemedicine from their experience using telemedicine during the simulation sessions. Participants could choose one or more items from a list, or provide their own in an open-ended "Other" category. Data are reported as the percent of participants who reported that they have used telemedicine consultation services.

DISCUSSION

The field of telemedicine has been evolving for decades (Pande, Patel, Powers, D'ancona, & Karamanoukian, 2003). Its use in Emergency Medicine was first described in 1997 (Lamabrecht, 1997) and has been growing rapidly since. Applications include consultation between EM providers and specialists (Ward, Jaana, & Natafgi, 2015) as well as consultation between EM providers in rural EDs and EM providers at tertiary referral centers who can aid in patient care and facilitate patient transfer (Stamford, Bickford, Hsiao, & Mattern, 1999; Mohr et al., 2018). In our health care system, both of these telemedicine consultation service types are available to our rural and community EM providers. However, use of telemedicine consultation services varies across health system sites. Barriers to its use include lack of awareness of service availability, lack of education and training on use of the technology, lack of perceived need for the service by health system ED providers, and variability in telemedicine service availability. Recently, our EM Community Simulation Program began embedding the use of telemedicine consultation into our *in situ* EM simulation courses. To our knowledge, this is the first description of utilizing *in situ* simulation to facilitate the use of telemedicine in rural and community EDs.

Including telemedicine in our simulation scenarios proved beneficial in several ways. Simulation scenarios provide opportunities for troubleshooting connectivity outside of active patient care. In situations where multiple specialists may be requested for consultation, our technology does allow for a "multipresence" feature (see Figure 4). We did attempt to utilize this feature in one of our scenarios and noted some difficulties with ensuring both consulting physicians were able to see and hear the case and that the care team in the ED could hear both consultants. We also encountered a scenario where one care team was using the device for a TeleEM consultation when a second care team needed the device for a TeleNeonatology consultation. This provided an opportunity to troubleshoot handoff of the video consultation between specialty services without losing connection. Additionally, the option for our TeleEM physicians to work from home is being discussed and explored. In one session, the TeleEM physician was able to successfully connect from his home to assist in management of a difficult airway. Anectodally, we observed

that when telemedicine was used, local and consulting providers felt the quality of the connection and video was good and that the consultation was helpful for management of the patient.

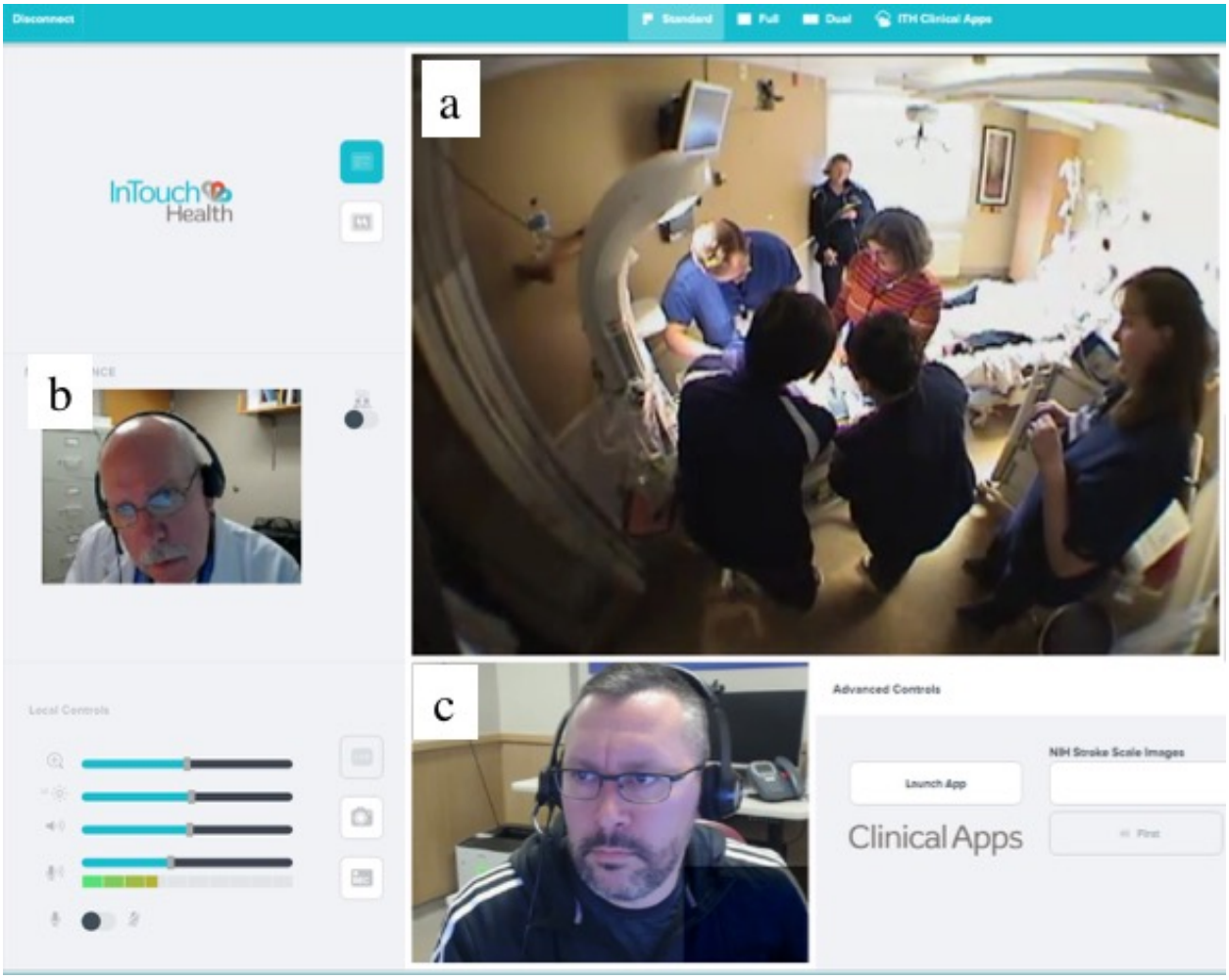

Figure 4. Use of the Multipresence Feature for Telemedicine Consultation During a High-Fidelity Patient Simulation Scenario. The image is a screen shot of the consulting TeleEM physician's workstation. a: Telemedicine consultant view of the health system ED care team and patient. b: Consulting TeleNeonatologist. c: Consulting TeleEM physician.

After simulation training, participants noted increased familiarity with the technology and workflows and improved understanding of available services and indications for consultation. Participants in all groups noted, on average, they are more likely to consider using TeleEM or TeleNeonatology after participating in the simulations. Many participants noted they felt more comfortable with interacting with the telemedicine consultant during active patient care and, anecdotally, noted that the consultation itself was valuable for care of the patient. Additionally, this collaboration sparked expansion of our TeleNeonatology service from sites with Family Birth Centers to all EDs across the health system. Dr. J. Fang and colleagues previously demonstrated that TeleNeonatology consultation improves the quality of resuscitation and adherence to national resuscitation guidelines during neonatal resuscitation in simulated (Fang, Carey, Lang, Lohse, & Colby, 2014) and clinical environments (Fang et al., 2018b). Delivery of an infant in the ED is infrequent, but does occasionally occur. Undoubtedly the expansion of our TeleNeonatology service availability to all health system EDs will enable standardization and improved quality of the care we provide these patients in our EDs.

LIMITATIONS

There are several limitations in this descriptive analysis. First, telemedicine service availability varied between simulation sessions. Initial sessions were held when TeleEM was in its pilot phase. Availability of this service increased from intermittent to daily over the course of this analysis. Consequently, some of the increase noted in TeleEM service use after participation in the simulation sessions may the result of increased availability of the service rather than experience utilizing the service during simulation. Additionally, although system-wide expansion is underway, the TeleNeonatology service is not currently available at all health system sites. Consequently, participants practicing at sites without formal TeleNeonatology service agreements who may have wished to consult TeleNeonatology since participating in the simulation are unable to do so; this may have had an impact on our survey results. Finally, there is variability in the length of time between participating in the simulation and completion of the survey. This is in part because of the limited frequency with which our EM CSP is able to deliver on-site *in situ* simulation sessions and in part because the authors wished to include all those who had participated in simulation with telemedicine to date at the time of our analysis. As such, there may be other factors that influence whether participants have used telemedicine since participating in the simulation sessions, including increases in service availability or the number of patients they have seen who are appropriate for telemedicine consultation.

CONCLUSIONS

Telemedicine capabilities and resources continue to evolve. At our institution, *in situ* simulation has been an impactful way to improve standardization of emergency care and promote the growth of our acute care telemedicine services as we continue to incorporate this technology into our enterprise-wide EM practice.

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