HHS Public Access

Author manuscript

Acad Emerg Med. Author manuscript; available in PMC 2024 June 05.

Published in final edited form as:

Acad Emerg Med. 2021 December ; 28(12): 1452–1474. doi:10.1111/acem.14330.

TELEHEALTH IN EMERGENCY MEDICINE: A CONSENSUS CONFERENCE TO MAP THE INTERSECTION OF TELEHEALTH AND EMERGENCY MEDICINE

Emily M. Hayden, MD, MHPE[1], **Christopher Davis, MD**[2], **Sunday Clark, MPH, ScD**[3], **Aditi U. Joshi, MD, MSc**[4], **Elizabeth A. Krupinski, PhD**[5], **Neel Naik, MD**[3], **Michael J. Ward, MD, PhD, MBA**[6], **Kori S. Zachrison, MD, MSc**[1], **Erica Olsen, MD**[7], **Bernard P. Chang, MD, PhD**[7], **Elizabeth Burner, MD, MPH**[8], **Kabir Yadav, MDCM, MS, MSHS**[9], **Peter W. Greenwald, MD, MD**[3], **Shruti Chandra, MD, MEHP**[4] **On behalf of the Society for Academic Emergency Medicine 2020 Consensus Conference**

[1]Department of Emergency Medicine, Massachusetts General Hospital

[2]Department of Emergency Medicine, University of Colorado School of Medicine

[3]Department of Emergency Medicine, Weill Cornell Medicine

[4]Department of Emergency Medicine, Thomas Jefferson University

[5]Department of Radiology & Imaging Sciences, Emory University

[6]Department of Emergency Medicine, Vanderbilt University Medical Center

[7]Department of Emergency Medicine, Columbia University, College of Physicians and Surgeons

[8]Department of Emergency Medicine, Keck School of Medicine of University of Southern California

[9]Department of Emergency Medicine, Harbor-University of California-Los Angeles

Abstract

Introduction—Telehealth has the potential to significantly change the specialty of Emergency Medicine (EM) and has rapidly expanded in EM during the COVID pandemic; however, it is unclear how EM should intersect with telehealth. The field lacks a unified research agenda with priorities for scientific questions on telehealth in EM.

Methods—Through the 2020 Society for Academic Emergency Medicine's annual consensus conference, experts in EM and telehealth created a research agenda for the topic. The multi-year process used a modified Delphi technique to develop research questions related to telehealth in EM. Research questions were excluded from the final research agenda if they did not meet a threshold of at least 80% of votes indicating "important" or "very important".

Results—Round 1 of voting included 94 research questions, expanded to 103 questions in Round 2, and refined to 36 questions for the final vote. Consensus occurred with a final set of 24 important research questions spanning five breakout group topics. Each breakout group domain was represented in the final set of questions. Examples of the questions include: "Among underserved populations, what are mechanisms by which disparities in emergency care delivery may be exacerbated or ameliorated by TH" (Health Care Access) and "In what situations should

the quality and safety of TH be compared to in-person care and in what situations should it be compared to no care" (Quality and Safety).

Conclusion—The primary finding from the process was the breadth of gaps in the evidence for telehealth in EM, and telehealth in general. Our consensus process identified priority research questions for the use of and evaluation of telehealth in EM to fill the current knowledge gaps. Support should be provided to answer the research questions to guide the evidenced-based development of telehealth in EM.

Introduction

Telehealth—the use of various telecommunication technologies to provide a broad range of healthcare services (Figure 1)— was an emerging platform of Emergency Medicine (EM) care delivery prior to the COVID pandemic. Using video-based telehealth, experienced emergency nurses and board-certified EM physicians provide guidance to remote clinicians, in the continental United States (US) and to other medical providers or staff in remote locations outside of the US, such as in airline and maritime medicine. These provider-to-provider programs leverage EM expertise to fill gaps in care at sites external to the brick-and-mortar Emergency Departments (EDs). Emergency physicians staff several of the direct-to-patient or direct-to-consumer programs, either part of their group practice or as independent contractors. Tele-triage facilitates the triage process and can reduce the time from ED arrival to provider evaluation. In tele-triage, an EM physician provides clinical guidance or order entry following a live-streamed video conversation with the patient in ED triage. Tele-triage enables a physician to oversee triage at multiple sites, e.g., multiple EDs in the same health care system or multiple triage locations within a large ED. Most of the EM use of telehealth prior to COVID was limited to video-based visits with little use of asynchronous telehealth modalities such as store-and-forward technology or mHealth.

Even prior to the pandemic, the importance of telehealth in EM care delivery was increasing, with many in the field seeking to answer broad questions with regards to how telehealth fits into EM care and how EM will shape the future of telehealth. On September 22 and 24, we held the 2020 Society for Academic Emergency Medicine (SAEM) Consensus Conference, Telehealth in Emergency Medicine: A Consensus Conference to Map the Intersection of Emergency Medicine and Telehealth, the culmination of a multi-year process. During this conference, experts from EM and telehealth convened virtually to create consensus around the highest telehealth research priorities. While the consensus conference was planned prior to the discovery of the novel coronavirus, the COVID pandemic highlighted the importance of telehealth in EM. Adoption and use accelerated dramatically during the COVID pandemic; telehealth visits throughout the US medical system increased more than 175 times the pre-COVID baseline.[1] Specifically in emergency medicine (EM), telehealth rapidly expanded during COVID, with novel uses such as video-conference via electronic tablets in patient rooms to decrease personal protective equipment (PPE) usage[2,3] and widespread expansion of existing practices such as remote connection of specialists and EM patients.[4] Innovative uses of telehealth in EM also controlled the flow of patients into the ED further protecting ED staff and patients.[2–4] Some EDs even provided remote patient monitoring to COVID+ patients at ED discharge.[5]

Research to date has rendered mixed results for the efficacy and impact of telehealth services, which makes a robust research agenda essential to provide the scientific basis to guide the development of telehealth in EM. Given the pressures from patients, payors, and healthcare institutions to provide increased access to high quality care at decreased costs, along with the accelerated use of telehealth during the pandemic, further study is warranted as to whether telehealth can provide solutions. Emergency medicine serves as a microcosm of the healthcare system and can provide valuable insight to how telehealth could address current and future problems in healthcare. Emergency Medicine leaders must understand telehealth and advocate for telehealth-related legislation and policies that enable rather than obstruct the use of telehealth in EM.

In seeking to create a comprehensive telehealth research agenda in EM, the consensus process involved a diverse interdisciplinary group that discussed themes and priorities informed by national experts both within and outside of EM. By bringing together researchers, educators, and telehealth experts, we sought to examine the intersection of telehealth and EM to inform a future research agenda and guide messaging to policy makers regarding regulatory policy related to telehealth delivery.

Methods

We used a nine-step modified Delphi method[6] to identify and reach agreement amongst a group of relevant stakeholders in EM and telehealth on key research priorities in telehealth and EM. With this iterative process, we aimed to reach consensus on the key questions from the breakout topics, as well as eliminate areas that stakeholders identified as lower priority. Details of the steps can be found in Figure 2.

The *first step* began in 2016 and included a background literature search and consensus between content experts. This culminated in the five breakout group topics: (1) Educational Needs and Outcomes, (2) Healthcare Access, (3) Quality and Safety, (4) Research Facilitation, and (5) Workforce.

The *second step* began in the Fall of 2019 with the creation of breakout groups with an assigned content expert for each of the five groups. Emails to the SAEM Telehealth Interest Group recruited breakout group members. Breakout group leaders led discussions with their members and developed questions in their respective topics via electronic media and conference calls. The breakout group leaders and conference co-chairs determined an overarching conceptual framework did not exist for the large domain of telehealth. Instead, the breakout groups used conceptual frameworks that were specific to their domains. No limitations or requirements existed for the number of questions generated; however, the planning committee recommended a final 3–5 research questions for each breakout group. The breakout groups submitted to the co-chairs their initial summaries of the state of the science and potential research questions. Co-chairs reviewed the five summaries and ensured no overlap occurred.

The *third step* occurred three months preceding the original conference date. Relevant stakeholders within and outside of EM (Figure 3) provided feedback on the breakout

groups' summaries. Using SurveyMonkey (San Mateo, California) the following questions provided stakeholder feedback: (1) Are there any subject areas within this topic that are not represented here that you suggest we add, (2) Are there any subject areas within this topic that you suggest we remove, (3) Are there any important resources or seminal research articles that are not listed here, and (4) Any further comments?

Due to the cancellation of the original conference due to the COVID Public Health Emergency, we added a *fourth step* to incorporate any new research or insights from the explosion of telehealth during the COVID pandemic. The breakout group leaders revised their summaries using the initial stakeholder survey feedback and a virtual conference "Telehealth in Emergency Medicine during COVID: Lessons Learned".[4] A second stakeholder survey administered in July 2020, identical to the first stakeholder survey, provided targeted feedback to the breakout groups. The stakeholders who provided feedback in this round can be found in Figure 4.

The *fifth step* occurred the month preceding the rescheduled conference date. After the breakout groups revised their summaries with feedback from step four, each preregistered conference participant received all five of the breakout group summaries and a survey to rank the importance of the questions developed by the breakout groups. The ranking used a 5-point Likert scale with the following question stem, "As an area of research, the following question is:" with the following potential responses: "not important", "somewhat important", "neutral", "important", "very important". Participants could suggest new questions or gaps and provide comments in a free-text section. Breakout group leaders revised their summaries and research questions in light of the participant feedback from the preconference survey. Prior to the first voting (preconference survey), the Co-chairs determined *a priori* that questions receiving >80% responses with "important" or "very important" would remain on the research agenda and dropped the questions that did not meet this threshold.

The *sixth step* occurred on Day 1 of the virtual conference. The conference included three keynote speakers who provided different perspectives on EM telehealth. Former SAEM President and nationally recognized telehealth expert, Dr. Judd Hollander, discussed the myths surrounding the use of telehealth. Dr. Bisan Salhi, an EM physician researcher and expert on homelessness and high utilizers of ED care challenged the participants' assumptions on how to engage those who may be least included in telehealth programs. Aaron Martin, Executive Vice President and Chief Digital Officer of Providence St. Joseph Healthcare provided a snapshot of telehealth use in current progressive healthcare systems.

Along with the keynote presentations, two facilitated panel discussions included a diverse array of stakeholders including patients, providers, and representatives from the American Association of Medical Colleges, National Quality Foundation, Society for Education and Research in Connected Health Society, Telehealth Resources Centers and many others. The panelists provided a broad stakeholder perspective for the conference participants to consider when voting on the research agenda. Patients and patient advocates gave critical patient perspectives on the topic throughout the consensus planning process as well as during the conference breakout group discussions.

On Day 1 of the virtual conference, the breakout group leader led the breakout sessions. Due to resource constraints, the Healthcare Access and the Quality and Safety groups met concurrently as did the Educational Needs and Outcomes, Research Facilitation, and Workforce groups. Each attendee participated in two separate breakout group discussions on each of the conference days.

The breakout group leader began the sessions with a presentation of the topic and the research questions. Telehealth content experts further described the breakout group topic with short presentations followed by open dialog amongst the participants. During the pre-conference rehearsals with the breakout group leaders, the planning committee reviewed clear goals and objectives of the sessions and voting to mitigate inter-group variation. The following guidelines were established: each breakout group could not be subdivided into smaller discussion groups, discussions should be managed so that all participants were heard, and priority should be given to the patient and patient representatives.

Scribes documented discussions during the sessions (Scribe America, Fort Lauderdale, Florida). The scribes shared the notes with the respective breakout groups leaders at the end of the live virtual conference days.

At the end of the Day 1 breakout session, participants completed a survey of the breakout group's research questions using Poll Everywhere (Poll Everywhere, San Francisco, CA). Not all breakout groups were able to discuss each of the research questions; therefore, participants completed a separate survey on the evening of Day for Round 2 of voting on the importance of the current questions for the research agenda.

The *seventh step* occurred on Day 2 of the conference. The same five breakout groups met again, and the breakout group leader led a brief discussion of those items that had not reached >80% in Round 2 of voting. Participants could make a case to rescue the questions from being discarded. After that, the floor opened to discussion on the questions that met the 80% threshold. That evening, the breakout group participants completed a survey as a last round (Round 3) of voting.

The *eighth step* occurred after the conference. The post-conference evaluation included the following question, "Do you have any further feedback or concerns about the final research agenda presented on September 24th?" This question served to surface any disagreement that may not have been captured in the conference day.

The *ninth step* occurred after feedback from the post-conference evaluations were received. The breakout groups revised their summaries according to feedback from the conference day and the post-conference evaluation. The conference planning committee reviewed and incorporated these summaries into these conference proceedings.

Various methods obtained participants' agreement on the research questions. The preconference stakeholder surveys and Round 1 of voting (preconference survey) used Survey Monkey (Survey Monkey, San Mateo, CA). Initially we planned to use Poll Everywhere (Poll Everywhere, San Francisco, CA) for voting within the breakout groups; however, it was not effective in the virtual conference setting. Specifically, the breakout

sessions were too short for a detailed videocall-based discussion of all the research questions and the simultaneous use of Poll Everywhere to vote on each item took time away from the discussion. Instead, real-time discussions were prioritized. For any question posed on the wording of a potential research question, the breakout group leader would open the discussion and edit immediately. Ideally ample time would have been given for both discussion and voting. As most groups could not vote on priorities in the time allotted, the planning committee decided on the evening of Day 1 to use Survey Monkey for the voting for the remainder of the process, including for Rounds 2 and 3 of voting, as well as for the post-conference evaluation.

Results

The preconference survey included 94 candidate items for priority research questions developed by the five breakout groups. Of the 47 pre-registered participants, 38 (81%) responded to the preconference survey (step 5 from Methods) for Round 1 of voting (Pre-conference Survey, Appendix). Most of the preregistered participants came from teaching hospitals (89.5%) in urban settings (68.4%) (Table 1). Most preregistered participants practiced clinical EM (71%). Seventy-one per cent reported that they use or have used telehealth in their clinical practice where only 7.9% reported that they do not use telehealth, nor did they have any plans to create a program. Of the preregistered participants, less than a quarter reported having telehealth training programs for trainees. Participants rated the importance of all questions on the preconference survey and carried forward for the next round of voting.

At the live virtual conference, 93 unique attendees (excluding SAEM staff) participated; 88 attendees on Day 1 and 65 attendees on Day 2. Please see Table 2 for the attendance and Table 3 voting response rates for Breakout Group Day 1 and Day 2. Round 2 of voting included 103 research questions and Round 3 of voting included 36 research questions on the survey (Appendix).

For the post-conference survey, we had a 68.9% response rate (64/93). General feedback included the rushed feeling of the breakout group discussions. No participants objected to the final list of research questions. The final 24 questions for the Telehealth in Emergency Medicine Consensus Conference Research Agenda is listed in Figure 5.

Discussion

While telehealth provided solutions during the COVID pandemic in delivery of acute unscheduled care, it is an emerging care platform with strengths and weaknesses that must be better delineated. This consensus process highlighted several key research gaps; accordingly, these gaps will require focused effort to close. Telehealth innovations in EM are being widely implemented, often without convincing evidence in the literature. We did not intend to halt the infusion of telehealth into EM with this conference, but to underscore the need for parallel research processes while these innovations occur.

Below are the findings from each breakout group, including the current state of the science and the final research questions. As stated in the Methods, an overarching conceptual

framework did not exist for all five breakout group themes; however, each breakout group chose their own framework. We present the summaries in alphabetical order.

Educational Needs and Outcomes

The educational needs and outcomes for telehealth in EM are divided into these four domains: (1) core competencies and best practices, (2) best strategies to educate all EM providers, (3) assessment of clinical impact, and (4) use of telehealth *for* education.

Competencies—While a variety of societies and professions have published on general competencies in telehealth,[7–12] publications delineating telehealth competencies specific to EM are relatively few.[13,14] These publications in EM speak to the competencies for practicing physicians, medical students, and other clinicians using telehealth for providing patient care. Recognizing that EM telehealth is relatively new, there is a need for evaluation studies of EM health care professionals' perception to validate and gain acceptance as part of EM practice.[15–17]

In 2016 the American College of Emergency Physicians (ACEP) indicated that, with regard to telehealth, "an appropriate and adequate examination to establish a diagnosis or underlying condition" should be performed.[18] Further, the "technology used must be adequate to enable an examination similar to that possible in a face-to-face encounter". No other details outline the specifics of the remote exam to ensure similarity to an in-person patient encounter. The American Telemedicine Association (ATA) published practice guidelines noting that the remote provider's examination may include "an explicit physician-guided self-examination which may include peripheral devices."[19] There are many publications on use cases for telehealth in EM. However, there is little mention of best practices of a modified exam for telehealth.

Educational Strategies

Training Modalities and Curriculum Integration: The need for telehealth training for medical students and residents is recognized by the American Medical Association (AMA) and AAMC[11,12,20] as well as learners.[21] Training modalities in the literature are predominantly short didactics via online modules or face-to-face sessions. Blended methods that incorporate experiential learning in addition to didactics often involve either simulation with trainees role playing as a provider caring for a patient via telehealth using standardized patients.[22] Other experiential learning included shadowing in clinical telehealth shifts or conducting a telehealth visit under supervision.[23] Formal telehealth education should incorporate both didactics and experiential learning; however, further research is needed to determine the most effective training modalities for telehealth education, especially as it applies to different aspects of telehealth education (e.g., "webside" manner, choosing most appropriate telehealth modality, etc.). Furthermore, a paradigm shift is needed to true mastery and competency of telehealth skills and concepts, which can be achieved through longitudinal integration telehealth education to existing curricula.

Training Content: Technical knowledge, such as how to use the telehealth video platforms, is cited as a key barrier to telehealth utilization in both the general telehealth and EM

literature.[24] One evaluation of a telehealth-enhanced emergency care program noted that inadequate telehealth technician training led to low confidence levels and performance difficulties.[25] Literature on EM-specific use of tele-stroke and tele-ultrasound similarly cite inconsistent or lack of technical training as barriers to adoption and utilization.[26,27] A formalized training program has the potential to address key factors previously cited as barriers to provider adoption and engagement in telehealth.[28,29] Furthermore, providers familiar with technology are more inclined to use telehealth. No targeted studies in EM literature exist focusing on training in technical knowledge of telehealth.[30]

Little empirical research is available on the critical soft-skills or unique telehealth etiquette skills necessary to conduct a successful telehealth visit. Currently there is no literature specific to EM practitioner training related to telehealth etiquette. While empathy and communication skills, including bedside manner, are part of healthcare training, these skills may not transfer intuitively to a telehealth encounter.[31] Poor telehealth etiquette is often the cause of unsuccessful telehealth encounters.[32] Emergency Medicine physicians should receive early training and assessment related to telehealth etiquette.[33]

EM physicians regularly engage in interprofessional practice. Despite this, little EM research has focused on how to further develop collaboration through telehealth technologies. Other non-EM literature describes how telehealth facilitates collaboration across professions[34] and details an interprofessional telehealth curriculum for third year medical students.[35,36]

Educational Outcomes—To ensure trainees are satisfying core competencies, we must assess the quality and impact of the telehealth training outside of satisfaction surveys. No EM literature has assessed if training in telehealth skills translate to improvements in clinical or financial outcomes. In the ACEP 2016 Policy paper on “Emergency Medicine Telemedicine”, guidelines describe provider orientation and training that include 1) understanding current local and state laws for the practice of telehealth, 2) “maintaining their technical and clinical competence”, 3) creating and following contingency plans for technology failures and 4) following telehealth protocols for escalating care as appropriate.[18] However, no described minimum standard training requirement exists in EM literature.

Telehealth for Education—Tele-education including tele-simulation and tele-mentoring have been used increasingly by EM physicians.[37,38] A number of applications have been described for tele-mentoring, for example, Project ECHO and ultrasound skill training.[39–42] The literature describes applications of tele-simulation for resuscitation training, acute trauma care, and primary care.[37,38] During the COVID-19 pandemic, tele-simulation and tele-mentoring played an integral role in rapid education of providers.[43,44] While descriptive studies have been published regarding use of telehealth for education, no EM studies have evaluated the effectiveness of tele-education beyond self-report. No best practices or guidelines of tele-education have been published.

During the virtual synchronous consensus conference, discussion focused on wording of each individual question, specifically the breadth of each question. Discussion focused on broadening the scope of questions to encompass a larger research agenda while still

providing definite guidance. Another consideration discussed was a desire to provide guidance without creating a framework that would become a checklist or "merit badge" for telehealth education/training.

It is notable that while all four domains had representative questions during the final vote (Figure 5), the seven questions that ultimately passed were focused on the first two domains, Core Competencies and Educational Strategies. Given the paucity of EM research to date in this field, this focus on core competencies and educational curricula likely represents a desire to focus the research agenda on establishing a solid base of research in these key areas before advancing to other aspects of telehealth education.

Competencies

- What are the core competencies in telehealth that are common to all providers, regardless of role, specialty, or level of training?
- What gaps, if any, in current EM training need to be addressed to adapt practice to telehealth?
- In patient-provider telehealth encounters, what are the components of the video-based physical exam?

Educational Strategies

- What types of educational experiences and instructional modalities are effective to teach telehealth to EM practitioners?
- How do we train emergency practitioners in virtual presence (webside manner) for patient-to-provider and provider-to-provider encounters?
- What are the best ways to integrate telehealth skills into both UME and GME EM curricula?
- How do we train interprofessional EM teams to provide collaborative care via telehealth?

Healthcare Access in Emergency Care Delivery

Telehealth can improve access and quality of healthcare for patients in remote and other settings. For this Consensus Conference, we focused our review of this expansive topic on literature examining telehealth for healthcare access *in emergency care delivery*. The review is organized in 4 distinct content areas: (1) Access to Specialists; (2) Access to Specialists in Out-of-Hospital and Resource-Limited Settings; (3) Optimizing ED Utilization and Disposition Coordination; and (4) Enhancing Access for Underserved Populations.

We used a framework developed by the Supporting Pediatric Research on Outcomes and Utilization of Telehealth (SPROUT) group to identify gaps to guide future investigative efforts.[45] Priority research questions are categorized into the SPROUT domains: (1) Impact of telehealth on patient-level and population-level health outcomes; (2) Impact of telehealth on the quality of healthcare delivered; (3) Outcomes of the telehealth encounter and program (related to people, process, and tools); and (4) Implementation process measurements. Discussions during the consensus conference events underscored the importance of a

patient-centered approach to the use and study of telehealth for healthcare access, and the need to ensure equity across populations.

Access to Specialists—Telehealth is frequently used to connect ED patients with specialists, most often for time-sensitive emergencies.[46–48] Telestroke has been a particularly successful model system with widespread implementation and has improved access to stroke specialists and reperfusion therapy.[49,50,59–67,51–58] In trauma and critical illness, evidence suggests telehealth can optimize triage, reduce transfers, and better stabilize transferred patients, with decreased mortality and ICU admission rates.[68,69,78–84,70–77] Among pediatric critical care patients, telehealth has been shown to decrease ICU admissions, transfers, medication errors, and improve provider satisfaction.[29,85,94–100,86–93] In behavioral health, telehealth has reduced length of stay, improved transfer processes, and enabled "psychiatry clearance" and discharge planning.[101–109] Telehealth has also been used to expand access to buprenorphine treatment.[110] Among nearly all these clinical applications, intermediate and process measures are often surrogates, but the evidence is otherwise fairly consistently lacking in studies evaluating the impact on patient- and population-level outcomes.

Access to Specialists & Specialist-guided Emergency Interventions in Out-of-Hospital & Resource-Limited Settings—Most prehospital telehealth research has focused on the impact on feasibility, reliability of prehospital technology, and its effect on time-sensitive illnesses, system resource utilization, and cost-effectiveness.[111,112,121–123,113–120] High quality efficacy trials are limited; most studies are observational, descriptive, or simulation studies and demonstrations. Simulation studies suggest a range of benefits from prehospital telehealth including improved guideline/protocol adherence, shorter time-to-treatment for procedures, improved quality of prehospital notification, and fewer errors in handoffs. Technology may be used for remote supervision of EMS personnel in routine care or tasks with which they are familiar. In addition, the idea of tele-mentoring -- remote mentoring of unfamiliar procedures to less experienced caregivers -- has also been demonstrated to be feasible in simulated settings.[124–128] However, data on real-world implementation are needed. Additionally, only a few prehospital studies assess patient or population-level outcomes. In meta-analyses, prehospital ECG transmission was associated with improved in-hospital mortality, and mobile stroke units were associated with reduced time-to-treatment and hospital length of stay.[129–131] Evidence related to trauma management and pediatric care in the prehospital setting is limited. Across conditions, evidence evaluating longer-term patient outcomes is lacking. Evidence is also limited in more resource-limited and disaster settings. Published literature describes operational models for disaster and humanitarian response,[132–137] barriers to implementation and use, current and potential uses of telehealth applications in acute and recovery phases, and feasibility of novel technologies (e.g., robots, drones).[138–140] Future studies should identify potential points of system failure, quantify reliability of system performance in order to optimize implementation of systems with infrequent but high-stakes use, and evaluate patient- and population-level health outcomes.

Optimizing ED Utilization and Disposition Coordination—Telehealth is commonly used to reduce or improve ED utilization, crowding, disposition coordination, and transfer processes.[141–145] The use of telehealth for acute illness in non-acute care settings (e.g., nursing homes, correctional facilities, and schools) tends to lead to fewer ED transfers without negatively impacting patient outcomes.[146,147] Telehealth in skilled nursing facilities (SNF) has been shown to reduce transfers, lower costs, and be favorably perceived by stakeholders. However, research on this topic is limited and merits further investigation. As with the broader literature on remote patient monitoring and home health care delivery, it is challenging to craft an overview of interventions directly involving emergency care by EMS and the ED. Telehealth is also used by prehospital providers to avert unnecessary ED visits and improve resource utilization with favorable cost, quality, provider and patient satisfaction. Direct-to-consumer (DTC) telehealth for low acuity conditions may contribute to a small reduction in ED utilization, but some studies also suggest an additive rather than substitutive effect of DTC; more data are needed.[148,149] With respect to ED crowding, telehealth provides a potential solution through reducing volume, utilizing remote providers, or improving ED processes of care.[150–155] Results are mixed but evidence suggests that telehealth applications lead to reduced ED length of stay, and improved patient satisfaction. Reducing transfers and improving pre-transfer management are primary outcomes for many telehealth interventions as discussed above.[156–161] Evidence suggests that telehealth is infrequently used for transfer coordination in connecting a remote patient with a *different* hospital than the telehealth 'hub'.[162] Finally, in the setting of the ongoing COVID-19 pandemic, there has been increasing use of telehealth for post-ED discharge monitoring. Literature on implementation and outcomes of this application is limited.

Enhancing Access for Underserved Populations—Telehealth has been associated with improved access to specialists for patients in rural or under-resourced settings and has been associated with improvements in metrics such as length of stay, reduced transfers, increased discharges, improved costs, and similar quality of care, as discussed above.[163–172] Barriers to telehealth in rural EDs have previously been described and cost is the most frequently cited.[173–178] In addition to patients in rural settings, telehealth may also play a role in improving access for other underserved populations.[179–182] It is important to note, however, that there are limited data devoted to populations with limited English proficiency, low health literacy, residence in WIFI deserts, or other health-related social determinants that may influence accessibility.[183] Disparities along racial or ethnic lines in relation to access to emergency telehealth have not been well studied. Differences in telehealth uptake, adoption and use may be present amongst different groups, and there may certain health disparities may even be exacerbated in certain clinical situations, necessitating additional research to explore the intersection of social determinants of health and technology.[184]

In summary, the evidence to date supports the feasibility of telehealth applications to improve emergency healthcare access in a variety of settings and conditions, as well as some measures of care efficiency (e.g., length of stay, transfer rates).[144,185] Despite the vast potential for telehealth to improve access to emergency care, there are limited objectively controlled data describing benefits to patient-level or population-level health outcomes. As a tool with potential to mitigate disparities in access, improved understanding of how

telehealth influences patient access and health outcomes in rural and otherwise underserved settings is central.[186] Future research is needed to ensure that a technology intended to narrow disparities does not, in fact, widen them. We also noted in our review that there are limited data on the optimal approaches to educate the public about the benefits and downsides of telehealth encounters, or strategies for interacting with a provider during a telehealth encounter. More patient-centered approaches to telehealth access research will be valuable.

As mentioned previously, we categorized the research questions using the SPROUT framework. The final research questions are the following:

Patient-, population-level health outcomes

- How does emergency telehealth access vary by patient or population characteristics?
- When considering the impact of telehealth for improving access, what are the appropriate patient-level outcomes to evaluate?
- When considering the impact of telehealth for improving access, what are the appropriate population-level outcomes to evaluate?
- What are costs and cost-effectiveness of telehealth from the perspective of the patient and the system, and relatedly, what is the appropriate approach to differentiate value of increased access vs excessive low-value utilization?

Quality of healthcare delivery

- Among underserved populations, what are mechanisms by which disparities in emergency care delivery may be exacerbated or ameliorated by telehealth?

Outcomes of the telehealth encounter and program

- What are the barriers and facilitators of implementation of telehealth in EDs (e.g., barriers such as payment models or healthcare delivery systems)?

Implementation process measurements

- What lessons can we learn from the expansion of telehealth during the COVID-19 pandemic?
- What are the barriers and facilitators to improving access via telehealth and quality of care for underserved populations?

Quality and Safety

We sought to evaluate potential research gaps in quality and safety of emergency telehealth. Given the potential for overlap in content areas and in the setting of the COVID-19 pandemic rapidly accelerated adoption of telehealth in emergency care, we defined the scope and definition of these areas using organizing framework(s) to evaluate quality and safety. We used the Agency for Healthcare Research and Quality's (AHRQ) simplified framework for quality which was adapted from the original Institute of Medicine's (IOM) definition

of quality.[187] AHRQ's framework reduces the number of domains from six to three – *effectiveness*, *patient- centeredness*, and *safety*.

Effectiveness is care that is proven to work and maps to the original IOM dimensions of effectiveness, timeliness, and, in some cases, to efficiency. *Patient-centeredness* is care that is responsive to a patient's needs and preferences and maps to the patient-centered and equity domains. Finally, *Safety* involves care that protects patients from medical errors and does not cause harm and maps to the safety dimension.

Effectiveness in Emergency Telehealth—We identified seven broad categories of models of emergency telehealth evaluating effectiveness: (1) Prehospital: Emergency Department (ED) to Outpatient Clinic, (2) Prehospital Emergency Medical Services (EMS): ED to ambulance staff, (3) ED-ED Consultations: Emergency Medicine (EM) Physician to rural emergency advanced practice provider for general ED care consultations, (4) Specialist Consultations to ED: Specialty Physician to EM Physician specialty consultation for specific conditions, (5) Direct to consumer; and (6) International telehealth. Effectiveness studies addressed the following categories of care most frequently: (1) cardiovascular (e.g., acute myocardial infarction); (2) trauma; (3) ophthalmological; (4) neurological (e.g., stroke); (5) mental health; (6) pediatric; and (7) critical care.

There are three types of effectiveness studies performed to date: (1) Randomized controlled trials (RCT); (2) Non-controlled comparative- effectiveness studies, including non-inferiority studies; and (3) Non-controlled, non-comparative, single intervention reported outcomes. Beyond several RCT evaluations of telestroke, effectiveness evaluations are primarily descriptive without controls lacking rigorous randomized evaluation. Finally, effectiveness outcomes studied to date have been primarily operational (e.g., time-to-events such as primary percutaneous coronary intervention), disposition (AMA, transfer rates), clinical decision-making (e.g., diagnostic accuracy), and ED return visits. A paucity of studies evaluated clinical outcomes of telehealth models.

Patient-Centeredness in Emergency Telehealth—Three broad categories of telehealth studies in which patient- centeredness was studied: (1) prehospital; (2) patient experience with direct-to-patient telehealth visits; and (3) studies evaluating the provision of ancillary care services through telehealth (e.g. social work).

Use of telehealth in prehospital settings allows EMS to transport patients to different levels of care, potentially to a non-ED healthcare facility. The studies related to prehospital and direct-to-patient telehealth measured absolute reduction in transport to the ED and triage to appropriate level of care needed as surrogates for patient-centeredness. While few measures of patient-centeredness exist (e.g., Consumer Assessment of Healthcare Providers and Systems [CAHPS®]), even fewer were validated despite the number of measurements under consideration: patient confidence, comprehension, and adherence to recommendations after telehealth encounters.

Studies of ancillary services (social work and case management [CM]) have examined the delivery of discharge instruction teaching and patient teaching. While several studies

included CM as the primary reason for the telehealth visit, no studies described the implementation of these ancillary services into an unscheduled telehealth visit for a primarily medical concern where ancillary services were subsequently needed. Outcomes for CM telehealth visits included rates of adherence to being present for the telehealth visit and adherence to the services provided (e.g., wound care).

Safety in Emergency Telehealth—Assessing quality includes evaluation of the protection from errors and harm. One framework of safety in EM proposes the following dimensions: (1) patient harm; (2) application of appropriate interventions; (3) error identification and correction; and (4) ED safety culture.[188] In 2019, AHRQ released a systematic review to identify and summarize the available evidence about telehealth consultation.[189] Consultation referred to the sharing of information or collaboration between providers regardless of the patient's involvement.[189] They asked, "Do telehealth consultations result in harms, adverse events, or negative unintended consequences?"[189] Results from this systematic review along with the proposed safety framework were used to organize our approach to safety of emergency telehealth, namely product safety studies and safety studies of emergency telehealth.

Product safety studies looked at products that patients or health care workers can use remotely to interface with health care providers and are relevant for acute events that may result in an ED visit. Smart phones with the addition of software can be used for physical exam, information communication (e.g., ECGs), performance feedback (e.g., CPR), and consultation (e.g., orthopedic injuries).[190–199] While promising, these studies lacked follow-up to demonstrate safety with wider implementation.[200–204] Several studies evaluated the quality of patient-reported data (e.g., blood pressure) and concluded that these were reliable means to collect such data.[205,206] Studies showed that tele-dermatology consultation directed by health care providers (e.g., a primary care provider requests a tele-dermatology consult for their patient) is safe, with errors toward conservative treatment.[94] Direct-to-patient tele-dermatology may not be safe as there is currently little oversight on direct-to-consumer telemedicine. One study reviewed five different dermatology apps and found a large variation in the quality in history taking, medication use, allergies. None of these dermatology telehealth apps gave feedback on picture quality.[195] These studies in tele-dermatology may inform how telehealth in EM is accessed and used, specifically, if it is safe for patients to choose tele-emergency care or if it is safer for primary care providers to refer patients to tele-emergency care. Also noted by these tele-dermatology studies is the variability of clinical oversight in the different programs, which also can inform best practices in emergency telehealth program oversight.

Safety studies of emergency telehealth were categorized as: pharmacy, non-stroke EM consultation, and stroke care. Pharmacy tele-support by real time to ED providers and medication monitoring after discharge both show reduction in errors and harm.[207,208] Studies using EM providers for tele-triage in the ED and prehospital setting showed changes to length of stay and length of ambulance service, lacked significant reporting of patient-centered outcomes, but did not find evidence of harm.[207,209] The AHRQ review found 19 studies on ED specialty consultation, none reporting harms.[189] They found 22 EMS and urgent care studies, one of which reported data that could be interpreted as harm, but was not

defined as such by the authors.[189] Telestroke was the most common EM-related telehealth application both in the AHRQ and our review. The AHRQ review found 29 studies (two RCTs), one of which only had four patients. Compared with hub hospitals managing stroke patients, spoke hospitals that used telehealth found no difference in the emergency care of acute ischemic stroke patients with telehealth (compared with hub hospitals).[210] Eleven studies reviewed by AHRQ reported harm outcomes, specifically intracranial hemorrhage (ICH), which was not different between groups. At least one study stated specifically in its limitations that it was not powered to detect harm.[131,189]

The final three questions (Figure 5) represent a reduction of the much larger group of questions by representing the three quality and safety domains (effectiveness, patient-centeredness, and safety) by the more collective "quality and safety". Individual questions tended to focus on individual quality and safety domains thereby reducing potential redundancy. Further, these questions were refined to allow for generalizability depending on the situation or population. Other research question topics of interest not included on the final list involved the quality and safety of specific populations and conditions of interest, performance of virtual physical exams, necessary study designs, and the impact of emergency telehealth on patient and provider communications. The final three questions involve patient outcomes, comparison of in-person and virtual care, and care transitions and the role emergency telehealth plays in all three.

- How can telehealth be used to augment safe transitions of care?
- In what situations should the quality and safety of telehealth be compared to in-person care and in what situations should it be compared to "no care"?
- In which clinical conditions, populations, and settings does emergency telehealth improve patient and operational outcomes?

Use of Telehealth in Emergency Medicine Research

Telehealth and related digital health tools (e.g., mHealth, eHealth) are advancing patient care with respect to quality, access, cost and a wide variety of related metrics. It may also offer an opportunity to improve research, including clinical trials, conducted in the emergency medicine setting – potentially improving the quality of the research and increasing access to research participation for individuals or groups of individuals not reached by current methods. The consensus conference narrowed the scope of important research questions to two broad areas: the use of telehealth for EM research facilitation and special considerations for the use of telehealth in research.

Use of Telehealth for EM Research Facilitation—While the literature in this area is growing, there is still an opportunity for additional research to ensure efficacy in utilizing telehealth and technology to facilitate emergency medicine research. Potential research topics include but are not limited to: assessing the receptiveness of patients seen by telehealth only to participate in research studies; developing strategies to increase receptiveness; determining if the use of telehealth for recruitment or obtaining informed consent affects representativeness of participants; devising effective strategies to improve

representation; and determining if tele-recruiting and consent can protect and reduce attrition and support staff.

Studies in other medical disciplines, including those that likely collaborate with emergency medicine (e.g., neurology trials for stroke treatment) have found telehealth to be valuable in facilitating or enhancing recruitment, informed consent, and data collection. Lane and colleagues[211] conducted a literature review of studies examining online recruitment and retention for mHealth studies. Online recruitment was the most frequently used modality and studies focused primarily on smoking cessation and mental health interventions. Among the 12 studies included, none focused on emergency medicine.

While the online recruitment methods were considered promising, areas for additional research were identified, including participant retention and generalizability to other settings.[211] Mastellos et al. found that eHealth-supported recruitment was successful in the primary care research setting.[212] Telehealth networks have also been identified as being helpful for subject recruitment in areas such as stroke[213,214], multiple sclerosis[215], and sexually transmitted infections[216].

Abujarad et al. developed a mHealth tool to enhance informed consent for clinical procedures.[217] The toolbox they created allowed for informed consent process to include tablets (e.g., iPads) utilizing virtual coaching with text-to-speech automated translation and interactive multimedia elements (e.g., graphics, video clips, animations, presentations). They concluded that mHealth can be effective in delivering health communications including informed consent. Importantly, the authors noted that ensuring patient comprehension should be central to any informed consent approach.[217]

To our knowledge, only one study within EM has examined the use of telehealth to facilitate informed consent. Bobb et al tested whether telehealth-enabled research informed consent provided non-inferior comprehension compared with a standard informed consent process in the setting of an academic emergency department.[218] They found that comprehension of research informed consent via telehealth was not inferior to face-to-face informed consent with respect to subjective understanding of informed consent or parent trial study accrual rates.[218] More work is needed in this area to determine the usefulness of using telehealth informed consent for research across different types of institutions.

Varma et al. explored telehealth-enhanced monitoring (automatic remote monitoring) vs. in-person follow-up for patients receiving an implantable cardioverter defibrillator (ICD).[219] They found that the telehealth-enhanced monitoring improved retention and adherence to scheduled follow-up compared with in-person follow-up visits.

In an emergency medicine-specific study, Varner et al explored text message reminders for study follow-up as a way to reduce attrition.[220] They found that in their cohort of subjects consenting to participate in a randomized trial, text message reminders of upcoming telephone follow-up interviews were effective in reducing attrition.[220]

Taken together, these studies begin to suggest utility in using telehealth to enhance clinical research. Rigorous evaluation within emergency medicine, across types of centers

(e.g., urban, rural, academic, community, trauma centers) and across the breadth of chief complaints and diagnoses treated in the emergency department is needed.

Special Considerations for the Use of Telehealth in Research—Although technology, access, and financial considerations are common barriers to telemedicine services, in general, additional barriers to patients engaging in research may be more related to reaching and engaging special populations. For example, there is a need for developing strategies for remote consenting of surrogates for pediatric populations, integrating American Sign Language into video-consent, and determining whether perceptions of internet and technology access are accurate in developed and developing countries?

Practice guidelines for telehealth (e.g., those developed by the American Telemedicine Association) often note special populations and the need for awareness regarding inclusion and access with respect to clinical care. This is an area that might also benefit from systematic investigation with respect to telehealth and emergency medicine research. For example, Greenwald et al. found that older adults with low acuity emergency department visits were comfortable receiving and satisfied with receiving care via telehealth.[221] The Telemental Health Guidelines for Children and Adolescents provides a useful framework for evaluating and providing guidance for the use of telehealth in emergency medicine research that is inclusive.[222]

The final wording of the two research questions for this breakout group are:

- How can/should telehealth be used for research facilitation, including recruitment, informed consent, reducing attrition, and data collection, for EM research?
- Which individuals or populations require special considerations as the role of telehealth in EM research is expanded and what are the key barriers for engaging these patients in telehealth-facilitated research studies?

Workforce

The use of telehealth in emergency care may have a profound effect on the future practice and makeup of the workforce. Four main workforce-related topics were chosen for this breakout group: (1) provider psychological health; (2) costs; (3) future staffing; and (4) rural versus urban workforce.

Provider Psychological Health—Provider mental health and burnout are significant issues in EM and with complex causes. Some of the EM-specific suspected causes of burnout are work hours, mix of shifts, Electronic Health Record (EHR) use, litigation stress, negative interactions with colleagues and patients, staffing needs, and sleep loss.[223–225] Whether the addition of telehealth to clinical practice will improve or worsen these is unknown. Some studies predict telehealth will improve burnout, but there were no studies found specific to EM physicians.[132] A study by Romig et al. mentioned that a telehealth backup process improved burnout in critical care nurses in a self-reported survey.[226] Burnout studies in EM do not mention telehealth or demonstrate how telehealth could alleviate burnout by increasing the variety of shifts, increasing the access to specialists, and

improving the transfer process. Alternatively, there are no studies of burnout in EM about how telehealth can increase burnout by increasing the complexity of shifts, stretching the scope of the practitioner, e*t cetera*. How aspects of telehealth will impact burnout is yet unknown.

Costs—We evaluated how telehealth's costs to the individual, system and community will affect the future EM workforce. In general, telehealth is advertised as a cost saving measure, however barriers to reimbursement, implementation and staffing have significant investment costs and limit implementation.[94,95,227–233] It is yet to be seen how the changes in telehealth reimbursement and regulations[234,235] impact the use of telehealth within EM. A RAND study noted that in a particular patient population studied, direct to consumer (DTC) telehealth increased utilization resulting in likely future increased costs to the healthcare system.[236] Studies since have tried to determine whether longer outlook projections from established programs continue to demonstrate increased costs. Different EM staffing models, including the use of Advance Practice Providers (APPs), may require fewer physicians and affect costs (positively and negatively).[77,169,171] Using telehealth to streamline processes, by bringing patients to the appropriate level of care or improving throughput metrics could also impact costs.[95,150,163,169,207,233,237–239] While studies in remote consults show cost savings due to lack of transfer or earlier interventions, its use is not standardized.[163,240]

Future Staffing—Current staffing of telehealth covers a wide spectrum and includes physicians, APPs, nurses, emergency medical technicians (EMTs), and clinical telepresenters (i.e., those aiding with telehealth encounters).[241–245] Each group may have a different role (e.g., EMTs may call for prehospital telehealth, while telepresenters aid EM physicians with specialty consults). The pre-hospital use of Emergency Triage, Treat and Transport (ET3) intends to decrease ED volume by encouraging non-transport when appropriate; although, it is unclear if ED volumes will decrease.

Most of the literature on telehealth staffing models include descriptive studies of direct to consumer programs staffed by either physicians or APPs, or EMS oversight by EM physicians.[117,246–250] Staffing descriptions in the literature typically were specific to the program being described as there are many variations of telehealth in emergency medicine.[152,245,251,252] While most studies described how current emergency care processes were supported, the literature did not include future states of ED shifts with the addition of virtual care, ET3 models, and Emergency Medical Services (EMS).[253,254] A gap exists in understanding the future role that EM physicians will provide to support prehospital and hospital-to-hospital critical care transport, specifically using real-time videoconferencing for patient management decisions during transport, including decisions to direct paramedic care in the absence of protocols.[164,255–260]

Also missing in the literature is the role of EM physicians in telehealth in relation to other types of practitioners.[249,253,256,261] Depending on how telehealth will exist in EM practice and the staffing models chosen, the future EM workforce composition will likely change.

Rural versus Urban Workforce—Rural and urban EM practitioners have different needs and this likely translates to their telehealth use. For example, most studies in rural

areas noted telehealth use for remote consults for access to specialty evaluation and transfer.[255] Gaps exist in how rural and urban EM differ and it is important to further understand this topic, including the future of regional care access and effects of population migration.[161,262–268] As more rural centers are closed and centralized metropolitan areas stretch their healthcare resources, there may be a greater need for trained EM telehealth providers.[74 29,262,265,266,269]

During the consensus conference days, discussion included recommendations to broaden initial research questions to include a wider variety of health care providers in EM, including EMS, APPs, telepresenters, administrative teams, family members and care partners. While another breakout group focused on education, the use of family and care partners in telehealth may require new instruction and assessments telehealth and healthcare in the future.[270]

The final research questions for this breakout group are:

- How effective can TH be as a solution for hospitals, particularly rural and critical access, that are unable to staff with board-certified EM physicians at the bedside?
- What types of training will be required for current practicing providers?
- What kinds of staffing will be best suited for emergency TH in different settings (e.g., APP versus rural physician, rural versus urban, etc.)?
- What kinds of staffing and systems are required to ensure provider efficiency in emergency TH?

The gaps in evidence are broad, from defining appropriate educational outcomes to determining when to use a comparison of telehealth to in-person care versus no care. Many of these questions are focused on EM; however, they are applicable to telehealth in general. The research stimulated by the agenda we laid out will inform future policy and regulations. This agenda will also clarify a new value proposition for EM, that of providing acute, unscheduled care wherever a patient is located. As telehealth in EM expands in scope and volume, the answers to the research questions on this agenda are critical for effectively educating EM telehealth providers, maintaining or increasing access to healthcare through telehealth, ensuring safe and quality care for patients using telehealth, implementing telehealth thoughtfully into the research process, and appropriately managing the EM workforce with the integration of telehealth into EM practice.

Limitations

The results of this consensus conference have limitations. Initially, we planned for an in-person conference with opportunities for in-person discussion. Compared to a conference conducted in person, areas that may have been affected by the virtual format include the following: a less rich discussion, lack of familiarity of the virtual voting methods, and less opportunity for networking. Attendance at the conference potentially would have been higher at the in-person conference as it is traditionally scheduled as a pre-conference day to the SAEM Annual Meeting, which typically brings in additional EM providers who are already attending the annual meeting. With the need to reschedule due to the COVID

pandemic, the planning committee chose to host a virtual meeting spanning two afternoons in the same week. This may have benefited the consensus process as it allowed two separate voting sessions after breakout group discussions; however, it may have limited the number of attendees.

The iterative cycle of remote voting and discussion may have limited our findings. For our first round of voting, we intentionally scheduled the survey administration and deadlines so there was time for the breakout groups to assimilate the survey results. However, we only captured those pre-registered participants who had registered by the time the survey was sent. It is clear from the number of preregistered participants and final list of attendees that we were not capturing all the attendees in the pre-conference survey. We attempted to mitigate this by maintaining all research questions from the list until after Round 2 of voting (after the live breakout group discussions on conference Day 1). Ad hoc feedback from both the conference planning committee and the participants confirmed that more time was needed for discussion of the research questions. This critique was strongly stated by many and the planning committee recommends future consensus conferences build in adequate time for discussion. While the planning committee intentionally scheduled two discussion sessions per topic, each separated by a full day for reflection and further asynchronous feedback and discussion, it is possible that some of the results would have been different if more time was allotted for the discussion.

The topic of telehealth in EM is broad and it is possible that there are domains that may not have been captured. The demographics of the attendees may have biased the final research agenda as the attendees were largely from urban teaching hospitals who are already use telehealth. It is possible that certain research questions were missed or not retained through the voting process due to the skewed attendee demographics. We solicited expert feedback throughout the process to ensure completeness; however, given the wide range of possible topics, sections may have been inadvertently left out, such as implementation science. While the consensus process covered a wide-ranging domain and all topics pertaining to telehealth were open for discussion, there are also key characteristics of telehealth in EM that did not ascend to the final priority research questions. Examples of these missing topics are reimbursement and privacy, both critical to the provision and receipt of telehealth. Reimbursement plays a significant role in telehealth, as both a barrier and driver of telehealth use. While the topic of reimbursement did not make it into the final questions, the evidence and lessons learned from answering the proposed research questions inform the arguments for or against reimbursement models or reimbursement options.

Conclusions

The use of telehealth is increasing due to the COVID pandemic, and Emergency Medicine has adopted many new telehealth modalities. The 2020 SAEM Consensus Conference on Telehealth in Emergency Medicine convened experts in Emergency Medicine and telehealth to generate research priorities. The 24 research areas identified can inform future research funding opportunities as well as healthcare policy and regulations. Future studies are needed to better understand how Emergency Medicine will shape telehealth and how telehealth will impact Emergency Medicine.

Acknowledgements

The authors would like to thank Society for Academic Emergency Medicine's (SAEM) staff for their work on the consensus process, particularly Ms. Melissa McMillian. The authors thank to Dr. Judd Hollander for his guidance throughout the conference planning process. The authors appreciate the time and expertise the breakout group leaders and members gave to the consensus process. The authors are grateful for the patients and patient advocates who gave their time and perspectives throughout the consensus process.

Funding statement:

The consensus conference was supported by grant R13 HS027528-01 from the Agency for Healthcare Research and Quality. Additional funding was provided by several organizational and institutional donors.

COI:

Dr. Burner's time to study telehealth interventions in Emergency Care was supported by NIH grant K23DK106538.

Appendix.

Round 1 (Preconference) Survey

Round 1 (Preconference) Voting Results

Round 3 (Final) Voting Results

Round 1 (Preconference) Survey Questions

For the question stem: As an area of research, (question/statement) is: [Likert scale from "not important at all", "of little importance", "of average importance", "very important", "absolutely essential"]

TH=Telehealth

EM=Emergency Medicine

APP=Advanced Practice Provider

Educational Needs and Outcomes

1. What are the core competencies in TH that are common to all providers?
2. What are the core competencies in TH for EM practitioners?
3. In patient-provider TH encounters, what is a standard approach to the video-based physical exam?
4. How does the video-based physical exam vary with modality and setting?
5. What modalities of training are most effective in TH education for emergency practitioners?
6. How can current EM curricula integrate TH education to allow for mastery of TH skills?

7. At what training levels should TH education be integrated for emergency practitioners?
8. How do we create technical knowledge training programs for emergency practitioners?
9. How do we teach technical TH knowledge to enable emergency practitioners to navigate technical difficulties during live encounters?
10. How do we train emergency practitioners in TH etiquette to ensure successful patient-to-provider and provider-to-provider encounters?
11. How do we train EM teams to provide care via TH?
12. Does training for EM providers in TH skills impact clinical outcomes or quality of care?
13. Does training for EM providers in TH skills impact patient satisfaction?
14. Should there be a minimum standard training requirement for EM practitioners to allow for independent practice of TH?
15. What are the best practices for tele-education and real-time tele-mentoring in EM?
16. How can TH platforms allow for more effective supervision of bedside learners?

Healthcare Access

1. What are the appropriate outcomes to evaluate the impact on patient-level outcomes?
2. What are the appropriate outcomes to evaluate the impact on population-level outcomes?
3. What is the impact of TH access on patient-centered outcomes for critically ill patients (e.g., intubation, ICU length of stay, morbidity, and mortality)?
4. What is the cost-effectiveness of TH in emergency care?
5. What are barriers and facilitators to more widespread implementation of TH in EDs?
6. What are effective strategies for incorporating medical specialists within emergency TH to improve access for patients?
7. High quality efficacy data is needed for prehospital applications for heart attack, trauma, pediatric applications. Which patient- and population-level outcomes should be prioritized?
8. How does TH affect outcomes when used in austere settings such as disaster response?
9. Does out-of-hospital TH improve the timeliness of interventions for patients with traumatic injury?

10. What is the best way to approach telementoring and communication? How can applications of educational and communication science be applied to TH encounters and interactions?
11. What role does Project ECHO play with respect to access and education in emergency care delivery?
12. What are the appropriate outcomes to study in research of TH use in austere settings?
13. What is the economic impact of programs in out-of-hospital settings?
14. What is the technical and operational effectiveness of TH programs for improving access to medical care in disaster response?
15. What implementation lessons learned are there from existing TH disaster response programs?
16. What are potential barriers to use of TH for disaster response?
17. What are the clinical outcome measures to capture for reduced patient transfers to EDs?
18. How should we measure appropriateness of TH utilization for diverting and triaging patients with urgent and emergent medical issues? Is there a parallel to the “ambulatory care sensitive ED visits” in this domain?
19. What is the appropriate way to differentiate between increased access to care (generally good) and excessive utilization (increased cost with little benefit)?
20. How does emergency TH access vary by patient/population characteristics?
21. Does TH improve access to care for vulnerable or remote populations by facilitating specialist follow-up post-ED discharge when travel times for in-person specialist evaluation would have otherwise been prohibitively long?
22. What are potentially unintended consequences of enhancing TH access for vulnerable patients, e.g., if access is more challenging related to interpreters, digital literacy, or technology ownership?
23. For people with inadequate broadband access, in what situations is audio-only TH a viable alternative (versus no care at all)?
24. Were there lessons learned from the COVID-19 pandemic to inform our understanding of situations in which audio-only may be a reasonable alternative for individuals with inadequate broadband access?
25. Among vulnerable populations, are disparities in emergency care delivery exacerbated by TH, and if so how? At the same time, are there ways in which TH ameliorates disparities in emergency care for vulnerable populations, and if so, how?
26. What is the impact of emergency TH access on disparities in care for outcomes related to stroke, heart attack, and trauma?

27. What is the appropriate strategy to educate the public, to ensure patients understand risks and benefits, and that patients have the tools required to ensure a valuable/high-quality encounter?

28. What are barriers/facilitators to improving access and quality of care for underserved populations? (i.e. funding for infrastructure vs billing/insurance issues vs patient education strategies)

Quality and Safety

1. How should effectiveness of emergency TH be defined? And should it differ by population (e.g., pediatrics, trauma, prehospital, disaster)?

2. How should the effectiveness of emergency TH be measured and what is their relationship with meaningful patient outcomes from a patient, hospital, and societal perspective?

3. What is the fidelity of a virtual physical exam and patient-reported vital signs with in-person exams?

4. What are the appropriate metrics to evaluate the quality of a TH exam?

5. In which clinical conditions and settings does emergency TH improve patient and operational outcomes?

6. Which study designs are necessary (and/or sufficient) to evaluate the effectiveness of emergency TH?

7. In what situations should the effectiveness of TH be compared to in-person care and in what situations should it be compared to “no care”? How can the COVID-19 pandemic experience help answer this question?

8. What are valid measures of patient (family and caregiver) experience in emergency TH and what is their association with patient outcomes?

9. Which measures are representative of patient-centeredness in emergency TH?

10. Are traditional patient-centered measures valid in emergency TH encounters?

11. Is it feasible to evaluate the patient (family and caregiver) experience in an emergency TH setting?

12. Should quality of TH care delivery be assessed differently based on the population being served (vulnerable or underserved, pediatric, geriatric, etc.)? And if so, how?

13. With the exponential increase in TH visits during the pandemic, what new data are available and relevant in terms of patient centeredness and emergency TH?

14. How do traditional clinical measures of safety translate to the emergency TH setting?

15. Are there unique safety measures that should be developed and used for emergency TH?

16. Is emergency TH safe compared with in-person emergency care? Are there times in which emergency TH is safer?
17. How should safety evaluation be implemented in the ongoing practice of emergency TH?
18. How should a safety culture around TH be fostered?
19. What are the best practice future applications of novel pandemic-related models of in-room to out-of-room emergency TH models designed to limit exposure and preserving PPE?
20. How can TH be used to augment safe transitions of care?

Research Facilitation

1. Can TH be used for research facilitation, including recruitment, informed consent, and data collection, for EM research?
2. Can TH be used as part of a study intervention in EM research?
3. Can TH be used to reduce attrition in EM research?
4. Are there individuals or populations that require special consideration if the role of TH in EM research is expanded: pediatrics, geriatrics, rural areas, low-income populations, populations with limited healthcare access (those with the potential to have access and technology gaps), limited English proficiency populations, individuals with disabilities?

Workforce

1. What factors in provider burnout (backup, additional shifts, time in career, urgent care component, etc.) can TH possibly alleviate?
2. How do we measure whether TH alleviates burnout symptoms?
3. What workforce provisions should be made for non-English speaking patients?
4. What does the use of TH on recipient hospitals (spoke) affect burnout on those physicians?
5. Is there an effect on physician burnout due to being at a distance in a TH encounter?
6. How will TH impact the clinician patient interaction/relationship, potentially affecting burnout? Can we design TH encounters to improve burnout?
7. What types of TH will be practiced in the future ED?
8. What types of TH will require EM physician oversight or direct involvement?
9. What types of oversight of TH will future EM physicians be required to know, and will it affect physician retention?
10. Is there data on APP v physician-staffed TH and patient perception?

11. What factors and information exist to inform recruitment and retention of TH providers in EM?
12. What types of factors will determine who will be practicing TH in EM in the future?
13. How will expanded role for APPs change the future workforce?
14. What relationship, if any, will there be between the “TH provider” and the patient’s physician? How do we ensure there is standardization in staffing, laws, and technology?
15. What types of training will be required for current practicing providers?
16. What effect does reimbursement have on utilizing EM TH?
17. Do current cost savings or studies inspire more or less investment? What future staffing costs will be needed to use TH in EM?
18. What is the anticipated near-term and long-term growth of the TH resource? How do remote consults, pre hospital consults, use of remote triage affect costs in EM?
19. Can TH triage patients to a lower level of care, decreased ED admissions or readmissions, therefore saving costs to the system?
20. What are the effects on costs of reduced transfers and hospitals without board certified physicians in rural areas?
21. What changes to the rural and urban healthcare will affect the future EM workforce? Where will most TH take place in rural vs. urban EDs?
22. What kind of staffing will be required for TH in rural vs. urban EDs?
23. What changes to rural vs. urban healthcare can be served best by EM TH? What noted differences are there between rural v urban EM TH?
24. How will the current use of TH affect the staffing of rural EDs and hospitals?
25. Will there be more reliance on patient’s family members and informal caregivers in rural TH?
26. To what degree can TH be a solution for hospitals, particularly rural and critical access, that are unable to staff with board-certified EM physicians at the bedside?

Demographics

1. Name: (free text)
2. Institution: (free text)
3. Primary clinical setting: (Rural, Suburban, Urban, N/A)
4. Teaching Hospital: (Y/N/n/a)
5. Do you practice clinical EM? (Y/N)

6. What is your experience in telehealth?
   a. I use/have used telehealth in my practice
   b. There is no telehealth in my practice but there are plans to create a program
   c. There is no telehealth practice and no plan to create a program
7. Do you have a telehealth training program? (Check all that apply):
   a. Student
   b. Resident
   c. Fellow
   d. Other

Round 1 Voting Results (see separate attachment)

Round 3 Voting Results (see separate attachment)

Consensus Conference Participants

David Amponsah	Emily Hayden, Chair	Jacob Ramseyer
Martina Anto-Ocrah	Daniel Herrmann	Junaid Razzak[A]
Carl Berdahl	Nancy Holland	Karen Rheuban
Tehnaz Boyle[A]	Judd Hollander	Natcha Rummaneethorn
Elizabeth Burner[R]	Peter Hou[R]	Margaret Sande
Hope Burnham	Darryl Jefferson	Michael Sardone
Kristie Busch	John Joseph	Dana Schinasi[E]
Christopher Carpenter	*Aditi Joshi*[W]	Elizabeth Schoenfeld
Shruti Chandra, Co-chair	David Kessler	Evan Schwarz
Wendy Chang	Ji Won Kim[Q]	Sam Shen[A]
Sherita Chapman[A]	Joshua Kim	Scott Shipman
Bradley Chappell	Andrew Kirkpatrick[A]	Neal Sikka[E]
Dickson Cheung	Andrea Kitts*	Aggie Sikora
Jaron Christianson	*Elizabeth Krupinski*[R]	David Sklar
Sunday Clark[R]	Seth Krupp	Nina Solenski[E]
Alexis Cole	Maria Lame[E]	Tommy Stewart*
Christopher Davis, Co-chair	Kathleen Li[A]	Mindy Stimell-Rauch
Persis Dhas	Ana Maria Lopez	Elizabeth Suminski
Linley Dunn	Jennifer MacCready	Richard Summers
Robert Eisenstein	James Marcin	Thomas Terndrup
David Ernst	Jacob Mathew	K Noelle Tune
Barney Eskin	Christopher McDowell	Phyllis Vallee
Morgan Eutermoser	Colleen McQuown[Q]	Renoj Varughese
John Evanko	Lawrence Melniker[W]	Marcia Ward

Pamela Flores-Sanchez	Nicholas Mohr	*Michael Ward*[Q]
Barbara Forney	Kevin Munjal	Tim Weir
Sagar Galwankar[R]	*Neel Naik*[E]	David Whitehead
Elizabeth Goldberg	Erica Olsen	Kathy Wibberly[W]
Jason Goldwater[Q]	Christina Olson[Q]	Bella Wong*
Peter Greenwald, Co-chair	Chris Palmer[A]	Thomas Yang
David Hao[A]	Dimitrios Papanagnou[E]	*Kori Zachrison*[A]
Stephen Hartsell	Divya Parikh	

*Patient representatives

[E]Educational Needs and Outcomes Breakout Group member

[A]Healthcare Access Breakout Group member

[Q]Quality and Safety Breakout Group member

[R]Research Facilitation Breakout Group member

[W]Workforce Breakout Group member

Italicized names denote breakout group leaders

Breakout group members who were unable to attend the conference: Tina Gustin, Kendall Ho, Milania Trounce (Educational Needs and Outcomes); Sofian Berrouiguet and Jessica McKee (Healthcare Access); Todd Crocco, Michelle Lin, Oren Mechanic, Shashank Ravi, and Kimberly Rockwell (Quality and Safety); Carlos Camargo, AnnaMarie Chang, Vivek Chauhan, Brock Daniels, Scott Dresden, Jason Lowe, and James Victor Quinn (Research Facilitation); and Alex Forenko, Gordon Ngai, Karen O'Mara, Ryan Ribeira, and Chris Russi (Workforce).

References

1. Bestsennyy O, Gilbert G, Harris A, Rost J. Telehealth: A Quarter-Trillion-Dollar Post-COVID 19 Reality?; 2020. https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/telehealth-a-quarter-trillion-dollar-post-covid-19-reality#
2. Turer RW, Jones I, Rosenbloom ST, Slovis C, Ward MJ. Electronic personal protective equipment: A strategy to protect emergency department providers in the age of COVID-19. J Am Med Informatics Assoc. 2020;27(6):967–971. doi:10.1093/jamia/ocaa048
3. Bain J, Greenwald P, Mulcare M, et al. Utilizing Telemedicine in a Novel Approach to COVID-19 Management and Patient Experience in the Emergency Department. Acad Emerg Med. 2020;76(45):S101.
4. Hayden E Telehealth in Emergency Medicine During COVID: Lessons Learned. Published online 2020. https://www.youtube.com/watch?v=3NknFi4swOQ&feature=emb_logo
5. Aalam AA, Hood C, Donelan C, Rutenberg A, Kane EM, Sikka N. Remote patient monitoring for ED discharges in the COVID-19 pandemic. Emerg Med J. Published online 2021:1–3. doi:10.1136/emermed-2020-210022
6. Hemler O Analysis of the Future: The Delphi Method.; 1967.

7. DeJong C, Lucey CR, Dudley RA. Incorporating a New Technology While Doing No Harm, Virtually. JAMA. 2015;314(22):2351–2352. doi:10.1001/jama.2015.13572 [PubMed: 26647252]
8. Wesson JB, Kupperschmidt B. Rural Trauma Telemedicine. J Trauma Nurs. 2013;20(4):199–202. doi:10.1097/JTN.0000000000000012 [PubMed: 24305081]
9. van Houwelingen CTM, Moerman AH, Ettema RGA, Kort HSM, ten Cate O. Competencies required for nursing telehealth activities: A Delphi-study. Nurse Educ Today. 2016;39:50–62. doi:10.1016/j.nedt.2015.12.025 [PubMed: 27006033]
10. Oliveira Hashiguchi TC. Bringing Health Care to the Patient: An Overview of the Use of Telemedicine in OECD Countries.; 2020.
11. AAMC Telehealth Competencies. Published 2020. Accessed January 2, 2021. https://www.aamc.org/media/47796/download
12. Galpin K, Sikka N, King S, Horvath K, Shipman S. Expert Consensus: Telehealth skills for health care professionals. Telemed J E Heal. 2020;Epub ahead.
13. Sharma R, Nachum S, Davidson KW, Nochomovitz M. It's not just FaceTime: core competencies for the Medical Virtualist. Int J Emerg Med. 2019;12. doi:10.1186/s12245-019-0226-y
14. Gattu R, Teshome G, Lichenstein R. Telemedicine Applications for the Pediatric Emergency Medicine. Pediatr Emerg Care. 2016;32(2):123–130. doi:10.1097/PEC.0000000000000712 [PubMed: 26835573]
15. Payette C, Desrochers J, Lavoie-Tremblay M, Richer M-C. Exploring Perceptions of Healthcare Professionals in the Implementation of a New Professional Role of Clinical Telehealth Coordinator Within a University Integrated Healthcare Network. Telemed e-Health. 2010;16(5):614–619. doi:10.1089/tmj.2009.0154
16. Marsh-Feiley G, Eadie L, Wilson P. Paramedic and physician perspectives on the potential use of remotely supported prehospital ultrasound. Rural Remote Health. 2018;18(3):4574-undefined. doi:10.22605/RRH4574 [PubMed: 30207737]
17. Fairchild R, Ferng Kuo SF, Laws S, O'Brien A, Rahmouni H. Perceptions of Rural Emergency Department Providers regarding Telehealth-Based Care: Perceived Competency, Satisfaction with Care and Tele-ED Patient Disposition. Open J Nurs. 2017;7(7):721–733. doi:10.4236/ojn.2017.77054
18. Policy Statement: Emergency Medicine Telemedicine. ACEP. Published online January 2016.
19. Gough F, Budhrani S, Cohn E, et al. ATA Practice Guidelines for Live, On-Demand Primary and Urgent Care. Telemed e-Health. 2015;21(3):233–241. doi:10.1089/tmj.2015.0008
20. Association AM. Telemedicine in Medical Education D-295.313; 2016.
21. Edirippulige S, Smith AC, Armfield NR, Bensink M, Wootton R. Student Perceptions of a Hands-on Practicum to Supplement an Online eHealth Course. J Med Internet Res. 2012;14(6):e182-undefined. doi:10.2196/jmir.2029 [PubMed: 23246840]
22. Wang JJ, Lavigueur O, Sheridan M, Stern E. Implementation of a simulation-based telemedicine curriculum. Med Educ. 2017;51(11):1178–1179. doi:10.1111/medu.13433 [PubMed: 28913892]
23. Papanagnou D, Stone D, Chandra S, Watts P, Chang AM, Hollander JE. Integrating Telehealth Emergency Department Follow-up Visits into Residency Training. Cureus. 2018;10(4):e2433-undefined. doi:10.7759/cureus.2433 [PubMed: 29876155]
24. Scott Kruse C, Karem P, Shifflett K, Vegi L, Ravi K, Brooks M. Evaluating barriers to adopting telemedicine worldwide: A systematic review. J Telemed Telecare. 2018;24(1):4–12. doi:10.1177/1357633X16674087 [PubMed: 29320966]
25. Shah MN, Morris D, Jones CMC, et al. A Qualitative Evaluation of a Telemedicine-Enhanced Emergency Care Program for Older Adults. J Am Geriatr Soc. 2013;61(4):571–576. doi:10.1111/jgs.12157 [PubMed: 23452094]
26. Medeiros de Bustos E, Moulin T, Audebert HJ. Barriers, Legal Issues, Limitations and Ongoing Questions in Telemedicine Applied to Stroke. Cerebrovasc Dis. 2009;27(4):36–39. doi:10.1159/000213057 [PubMed: 19546540]
27. Douglas TM, Levine AR, Olivieri PP, et al. Brief training increases nurses' comfort using tele-ultrasound: A feasibility study. Intensive Crit Care Nurs. 2019;51:45–49. doi:10.1016/j.iccn.2018.11.004 [PubMed: 30514602]

28. Hopp F, Whitten P, Subramanian U, Woodbridge P, Mackert M, Lowery J. Perspectives from the Veterans Health Administration about opportunities and barriers in telemedicine. J Telemed Telecare. 2006;12(8):404–409. doi:10.1258/135763306779378717 [PubMed: 17227606]
29. Ray KN, Felmet KA, Hamilton MF, et al. Clinician attitudes toward adoption of pediatric emergency telemedicine in rural hospitals. Pediatr Emerg Care. 2017;33(4):250–257. doi:10.1097/PEC.0000000000000583 [PubMed: 26785087]
30. Rogove HJ, McArthur D, Demaerschalk BM, Vespa PM. Barriers to Telemedicine: Survey of Current Users in Acute Care Units. Telemed e-Health. 2012;18(1):48–53. doi:10.1089/tmj.2011.0071
31. Wicklund E Do doctors have the right “bedside manner” for telehealth? Mobi Health News.
32. Miller EA. The technical and interpersonal aspects of telemedicine: effects on doctor–patient communication. J Telemed Telecare. 2003;9(1):1–7. doi:10.1258/135763303321159611 [PubMed: 12641885]
33. Gustin TS, Kott K, Rutledge C. Telehealth Etiquette Training: A Guideline for Preparing Interprofessional Teams for Successful Encounters. Nurse Educ. 2020;45(2):88–92. doi:10.1097/NNE.0000000000000680 [PubMed: 31022072]
34. Bond WF, Barker LT, Cooley KL, et al. A Simple Low-Cost Method to Integrate Telehealth Interprofessional Team Members During In Situ Simulation. Simul Healthc J Soc Simul Healthc. 2019;14(2):129–136. doi:10.1097/SIH.0000000000000357
35. Sweeney Haney T, Kott K, Rutledge CM, Britton B, Fowler CN, Poston RD. How to Prepare Interprofessional Teams in Two Weeks: An Innovative Education Program Nested in Telehealth. Int J Nurs Educ Scholarsh. 2018;15(1):undefined. doi:10.1515/ijnes-2017-0040
36. Jonas CE, Durning SJ, Zebrowski C, Cimino F. An Interdisciplinary, Multi-Institution Telehealth Course for Third-Year Medical Students. Acad Med. 2019;94(6):833–837. doi:10.1097/ACM.0000000000002701 [PubMed: 30870152]
37. McCoy E, Alrabah R, Weichmann W, et al. Feasibility of Telesimulation and Google Glass for Mass Casualty Triage Education and Training. West J Emerg Med. 2019;20(3):512–519. doi:10.5811/westjem.2019.3.40805 [PubMed: 31123554]
38. Hayden EM, Khatri A, Kelly HR, Yager PH, Salazar GM. Mannequin-based Telesimulation: Increasing Access to Simulation-based Education. Acad Emerg Med. 2018;25(2):144–147. doi:10.1111/acem.13299 [PubMed: 28846175]
39. Smith A, Addison R, Rogers P, et al. Remote Mentoring of Point-of-Care Ultrasound Skills to Inexperienced Operators Using Multiple Telemedicine Platforms: Is a Cell Phone Good Enough? J Ultrasound Med. 2018;37(11):2517–2525. doi:10.1002/jum.14609 [PubMed: 29577381]
40. Arora S, Kalishman SG, Thornton KA, et al. Project ECHO: A Telementoring Network Model for Continuing Professional Development. J Contin Educ Health Prof. 2017;37(4):239–244. doi:10.1097/CEH.0000000000000172 [PubMed: 29189491]
41. Poland S, Frey JA, Khobrani A, et al. Telepresent Focused Assessment With Sonography for Trauma Examination Training Versus Traditional Training for Medical Students: A Simulation-Based Pilot Study. J Ultrasound Med. 2018;37(8):1985–1992. doi:10.1002/jum.14551 [PubMed: 29388234]
42. Kim C, Kang BS, Choi HJ, Lim TH, Oh J, Chee Y. Clinical application of real-time tele-ultrasonography in diagnosing pediatric acute appendicitis in the ED. Am J Emerg Med. 2015;33(10):1354–1359. doi:10.1016/j.ajem.2015.07.048 [PubMed: 26306436]
43. Naik N, Finkelstein RA, Howell J, Rajwani K, Ching K. Telesimulation for COVID-19 Ventilator Management Training With Social-Distancing Restrictions During the Coronavirus Pandemic. Simul Gaming. 2020;51(4):571–577. doi:10.1177/1046878120926561
44. Howe G Mobilizing Project ECHO to Build Provider Capacity in Response to COVID-19. Center for Health Care Strategies, Inc.
45. Supporting Pediatric Research on Outcomes and Utilization of Telehealth (SPROUT). American Academy of Pediatrics.
46. Akhtar M, Van Heukelom PG, Ahmed A, et al. Telemedicine physical examination utilizing a consumer device demonstrates poor concordance with in-person physical examination in

emergency department patients with sore throat: A prospective blinded study. Telemed e-Health. 2018;24(10):790–796. doi:10.1089/tmj.2017.0240

47. Stahl I, Dreyfuss D, Ofir D, et al. Reliability of smartphone-based teleradiology for evaluating thoracolumbar spine fractures. Spine J. 2017;17(2):161–167. doi:10.1016/j.spinee.2016.08.021 [PubMed: 27542623]
48. Wedekind L, Sainani K, Pershing S. Supply and Perceived Demand for Teleophthalmology in Triage and Consultations in California Emergency Departments. JAMA Ophthalmol. 2016;134(5):537–543. doi:10.1001/jamaophthalmol.2016.0316 [PubMed: 27010537]
49. Shea CM, Alishahi Tabriz A, Turner K, North S, Reiter KL. Telestroke Adoption Among Community Hospitals in North Carolina: A Cross-Sectional Study. J Stroke Cerebrovasc Dis. 2018;27(9):2411–2417. doi:10.1016/j.jstrokecerebrovasdis.2018.04.032 [PubMed: 29784607]
50. Silva GS, Farrell S, Shandra E, Viswanathan A, Schwamm LH. The Status of Telestroke in the United States. Stroke. 2012;43(8):2078–2085. doi:10.1161/STROKEAHA.111.645861 [PubMed: 22700532]
51. Barlinn J, Gerber J, Barlinn K, et al. Acute endovascular treatment delivery to ischemic stroke patients transferred within a telestroke network: a retrospective observational study. Int J Stroke. 2017;12(5):502–509. doi:10.1177/1747493016681018 [PubMed: 27899742]
52. Harper K, McLeod M, Brown S, et al. Teleneurology service provided via tablet technology: 3-year outcomes and physician satisfaction. Rural Remote Health. 2019;19(1):4743-undefined. doi:10.22605/RRH4743 [PubMed: 30825873]
53. Mohr NM, Young T, Harland KK, et al. Telemedicine Is Associated with Faster Diagnostic Imaging in Stroke Patients: A Cohort Study. Telemed e-Health. 2019;25(2):93–100. doi:10.1089/tmj.2018.0013
54. Medeiros de Bustos E, Berthier E, Chavot D, Bouamra B, Moulin T. Evaluation of a French Regional Telemedicine Network Dedicated to Neurological Emergencies: A 14-Year Study. Telemed e-Health. 2018;24(2):155–160. doi:10.1089/tmj.2017.0035
55. Moloczij N, Mosley I, Moss KM, Bagot KL, Bladin CF, Cadilhac DA. Is telemedicine helping or hindering the delivery of stroke thrombolysis in rural areas? A qualitative analysis. Intern Med J. 2015;45(9):957–964. doi:10.1111/imj.12793 [PubMed: 25904209]
56. Mort A, Eadie L, Regan L, et al. Combining transcranial ultrasound with intelligent communication methods to enhance the remote assessment and management of stroke patients: Framework for a technology demonstrator. Health Informatics J. 2016;22(3):691–701. doi:10.1177/1460458215580353 [PubMed: 25975807]
57. Kageji T, Obata F, Oka H, et al. Drip-and-ship thrombolytic therapy supported by the telestroke system for acute ischemic stroke patients living in medically under-served areas. Neurol Med Chir (Tokyo). 2016;56(12):753–758. doi:10.2176/nmc.oa.2016-0100 [PubMed: 27333939]
58. Singh R, Mathiassen L, Switzer JA, Adams RJ. Assimilation of Web-Based Urgent Stroke Evaluation: A Qualitative Study of Two Networks. JMIR Med Informatics. 2014;2(1):e6-undefined. doi:10.2196/medinform.3028
59. Shuaib A, Khan K, Whittaker T, Amlani S, Crumley P. Introduction of Portable Computed Tomography Scanners, in the Treatment of Acute Stroke Patients via Telemedicine in Remote Communities. Int J Stroke. 2010;5(2):62–66. doi:10.1111/j.1747-4949.2010.00408.x [PubMed: 20446937]
60. Sairanen T, Soinila S, Nikkanen M, et al. Two years of Finnish Telestroke: thrombolysis at spokes equal to that at the hub. Neurology. 2011;76(13):1145–1152. doi:10.1212/WNL.0b013e318212a8d4 [PubMed: 21368283]
61. Switzer JA, Hall C, Gross H, et al. A Web-based Telestroke System Facilitates Rapid Treatment of Acute Ischemic Stroke Patients in Rural Emergency Departments. J Emerg Med. 2009;36(1):12–18. doi:10.1016/j.jemermed.2007.06.041 [PubMed: 18242925]
62. Demaerschalk BM, Raman R, Ernstrom K, Meyer BC. Efficacy of Telemedicine for Stroke: Pooled Analysis of the Stroke Team Remote Evaluation Using a Digital Observation Camera (STRokE DOC) and STRokE DOC Arizona Telestroke Trials. Telemed e-Health. 2012;18(3):230–237. doi:10.1089/tmj.2011.0116

63. Moreno A, Schwamm LH, Siddiqui KA, et al. Frequent Hub-Spoke Contact Is Associated with Improved Spoke Hospital Performance: Results from the Massachusetts General Hospital Telestroke Network. Telemed J E Health. 2017;24(9):678–683. [PubMed: 29271703]
64. Sauser-Zachrison K, Shen E, Sangha N, et al. Safe and Effective Implementation of Telestroke in a US Community Hospital Setting. Perm J. 2016;20(4):15–217. doi:10.7812/TPP/15-217
65. Miley ML, Demaerschalk BM, Olmstead NL, et al. The State of Emergency Stroke Resources and Care in Rural Arizona: A Platform for Telemedicine. Telemed e-Health. 2009;15(7):691–699. doi:10.1089/tmj.2009.0018
66. Adcock AK, Choi J, Alvi M, et al. Expanding Acute Stroke Care in Rural America: A Model for Statewide Success. Telemed e-Health. 2020;26(7):865–871. doi:10.1089/tmj.2019.0087
67. Jewett L, Mirian A, Connolly B, Silver FL, Sahlas DJ. Use of Geospatial Modeling to Evaluate the Impact of Telestroke on Access to Stroke Thrombolysis in Ontario. J Stroke Cerebrovasc Dis. 2017;26(7):1400–1406. doi:10.1016/j.jstrokecerebrovasdis.2017.03.023 [PubMed: 28478980]
68. Mohr NM, Vakkalanka JP, Harland KK, et al. Telemedicine Use Decreases Rural Emergency Department Length of Stay for Transferred North Dakota Trauma Patients. Telemed e-Health. 2018;24(3):194–202. doi:10.1089/tmj.2017.0083
69. Ashkenazi I, Zeina AR, Kessel B, et al. Effect of teleradiology upon pattern of transfer of head injured patients from a rural general hospital to a neurosurgical referral centre: follow-up study. Emerg Med J. 2015;32(12):946–950. doi:10.1136/emermed-2014-203930 [PubMed: 26446312]
70. Wibbenmeyer L, Kluesner K, Wu H, et al. Video-Enhanced Telemedicine Improves the Care of Acutely Injured Burn Patients in a Rural State. J Burn Care Res. 2016;37(6):e531–e538. doi:10.1097/BCR.0000000000000268 [PubMed: 26132049]
71. Rogers FB, Ricci M, Caputo M, et al. The Use of Telemedicine for Real-Time Video Consultation between Trauma Center and Community Hospital in a Rural Setting Improves Early Trauma Care: Preliminary Results. J Trauma Acute Care Surg. 2001;51(6):1037–1041. doi:10.1097/00005373-200112000-00002
72. Brownrigg P, Lowry JC, Edmondson MJ, Langton SG. Telemedicine in Oral Surgery and Maxillofacial Trauma: A Descriptive Account. Telemed J e-Health. 2004;10(1):27–31. doi:10.1089/153056204773644544 [PubMed: 15104912]
73. Ilko SA, Vakkalanka JP, Ahmed A, Harland KK, Mohr NM. Central Venous Access Capability and Critical Care Telemedicine Decreases Inter-Hospital Transfer Among Severe Sepsis Patients. Crit Care Med. 2019;47(5):659–667. doi:10.1097/CCM.0000000000003686 [PubMed: 30730442]
74. Zapka J, Simpson K, Hiott L, Langston L, Fakhry S, Ford D. A mixed methods descriptive investigation of readiness to change in rural hospitals participating in a tele-critical care intervention. BMC Health Serv Res. 2013;13:33-undefined. doi:10.1186/1472-6963-13-33 [PubMed: 23360332]
75. Ward MM, Ullrich F, Potter AJ, MacKinney AC, Kappel S, Mueller KJ. Factors Affecting Staff Perceptions of Tele-ICU Service in Rural Hospitals. Telemed e-Health. 2015;21(6):459–466. doi:10.1089/tmj.2014.0137
76. Essay P, Shahin TB, Balkan B, Mosier J, Subbian V. The Connected Intensive Care Unit Patient: Exploratory Analyses and Cohort Discovery From a Critical Care Telemedicine Database. JMIR Med Informatics. 2019;7(1):e13006-. doi:10.2196/13006
77. Lapointe L, Lavallee-Bourget M-H, Pichard-Jolicoeur A, Turgeon-Pelchat C, Fleet R. Impact of telemedicine on diagnosis, clinical management and outcomes in rural trauma patients: A rapid review. Can J Rural Med. 2020;25(1):31–40. doi:10.4103/CJRM.CJRM_8_19 [PubMed: 31854340]
78. Ricci MA, Caputo M, Amour J, et al. Telemedicine Reduces Discrepancies in Rural Trauma Care. Telemed J e-Health. 2003;9(1):3–11. doi:10.1089/153056203763317602 [PubMed: 12699603]
79. Mohr NM, Harland KK, Chrischilles EA, Bell A, Shane DM, Ward MM. Emergency Department Telemedicine Is Used for More Severely Injured Rural Trauma Patients, but Does Not Decrease Transfer: A Cohort Study. Acad Emerg Med. 2017;24(2):177–185. doi:10.1111/acem.13120 [PubMed: 28187248]
80. Duchesne JC, Kyle A, Simmons J, et al. Impact of Telemedicine Upon Rural Trauma Care. J Trauma Inj Infect Crit Care. 2008;64(1):92–98. doi:10.1097/TA.0b013e31815dd4c4

81. Lewis ER, Thomas CA, Wilson ML, Mbarika VWA. Telemedicine in Acute-Phase Injury Management: A Review of Practice and Advancements. Telemed e-Health. 2012;18(6):434–445. doi:10.1089/tmj.2011.0199
82. Latifi R, Weinstein RS, Porter JM, et al. Telemedicine and telepresence for trauma and emergency care management. Scand J Surg. 2007;96(4):281–289. doi:10.1177/145749690709600404 [PubMed: 18265854]
83. Latifi R, Hadeed GJ, Rhee P, et al. Initial experiences and outcomes of telepresence in the management of trauma and emergency surgical patients. Am J Surg. 2009;198(6):905–910. doi:10.1016/j.amjsurg.2009.08.011 [PubMed: 19969150]
84. Saffle JR, Edelman L, Theurer L, Morris SE, Cochran A. Telemedicine evaluation of acute burns is accurate and cost-effective. J Trauma - Inj Infect Crit Care. 2009;67(2):358–365. doi:10.1097/TA.0b013e3181ae9b02
85. Heath B, Salerno R, Hopkins A, Hertzig J, Caputo M. Pediatric critical care telemedicine in rural underserved emergency departments. Pediatr Crit Care Med. 2009;10(5):588–591. doi:10.1097/PCC.0b013e3181a63eac [PubMed: 19451850]
86. Uscher-Pines L, Kahn JM. Barriers and Facilitators to Pediatric Emergency Telemedicine in the United States. Telemed e-Health. 2014;20(11):990–996. doi:10.1089/tmj.2014.0015
87. Makkar A, McCoy M, Hallford G, Escobedo M, Szyld E. A Hybrid Form of Telemedicine: A Unique Way to Extend Intensive Care Service to Neonates in Medically Underserved Areas. Telemed e-Health. 2018;24(9):717–721. doi:10.1089/tmj.2017.0155
88. Okoroh EM, Kroelinger CD, Smith AM, Goodman DA, Barfield WD. US and territory telemedicine policies: identifying gaps in perinatal care. Am J Obstet Gynecol. 2016;215(6):772.e1–772.e6. doi:10.1016/j.ajog.2016.08.020
89. Harvey JB, Yeager BE, Cramer C, Wheeler D, McSwain SD. The Impact of Telemedicine on Pediatric Critical Care Triage. Pediatr Crit Care Med. 2017;18(11):e555–e560. doi:10.1097/PCC.0000000000001330 [PubMed: 28922271]
90. Hernandez M, Hojman N, Sadorra C, et al. Pediatric Critical Care Telemedicine Program: A Single Institution Review. Telemed e-Health. 2016;22(1):51–55. doi:10.1089/tmj.2015.0043
91. Dayal P, Chang CH, Benko WS, et al. Hospital Utilization Among Rural Children Served by Pediatric Neurology Telemedicine Clinics. JAMA Netw open. 2019;2(8):e199364. doi:10.1001/jamanetworkopen.2019.9364 [PubMed: 31418803]
92. Marcin JP, Ellis J, Mawis R, Nagrampa E, Nesbitt TS, Dimand RJ. Using Telemedicine to Provide Pediatric Subspecialty Care to Children with Special Health Care Needs in an Underserved Rural Community. Pediatrics. 2004;113(1 I):1–6. doi:10.1542/peds.113.1.1 [PubMed: 14702439]
93. Ronis SD, McConnochie KM, Wang H, Wood NE. Urban Telemedicine Enables Equity in Access to Acute Illness Care. Telemed e-Health. 2017;23(2):105–112. doi:10.1089/tmj.2016.0098
94. Dharmar M, Kuppermann N, Romano PS, et al. Telemedicine consultations and medication errors in rural emergency departments. Pediatrics. 2013;132(6):1090–1097. doi:10.1542/peds.2013-1374 [PubMed: 24276844]
95. Dharmar M, Romano PS, Kuppermann N, et al. Impact of Critical Care Telemedicine Consultations on Children in Rural Emergency Departments. Crit Care Med. 2013;41(10):2388–2395. doi:10.1097/CCM.0b013e31828e9824 [PubMed: 23921273]
96. Marcin JP, Nesbitt TS, Kallas HJ, Struve SN, Traugott CA, Dimand RJ. Use of telemedicine to provide pediatric critical care inpatient consultations to underserved rural Northern California. J Pediatr. 2004;144(3):375–380. doi:10.1016/j.jpeds.2003.12.017 [PubMed: 15001947]
97. Kaufman T, Geraghty EM, Dullet N, King J, Kissee J, Marcin JP. Geospatial Information System Analysis of Healthcare Need and Telemedicine Delivery in California. Telemed e-Health. 2017;23(5):430–434. doi:10.1089/tmj.2016.0144
98. Mohr NM, Harland KK, Shane DM, Miller SL, Torner JC. Potentially Avoidable Pediatric Interfacility Transfer Is a Costly Burden for Rural Families: A Cohort Study. Acad Emerg Med. 2016;23(8):885–894. [PubMed: 27018337]
99. Yang NH, Dharmar M, Kuppermann N, et al. Appropriateness of Disposition Following Telemedicine Consultations in Rural Emergency Departments. Pediatr Crit Care Med. 2015;16(3):e59–e64. doi:10.1097/PCC.0000000000000337 [PubMed: 25607743]

100. Yang NH, Dharmar M, Yoo BK, et al. Economic Evaluation of Pediatric Telemedicine Consultations to Rural Emergency Departments. Med Decis Mak. 2015;35(6):773–783. doi:10.1177/0272989X15584916

101. Meyer JD, McKean AJS, Blegen RN, Demaerschalk BM. Emergency Department Telepsychiatry Service Model for a Rural Regional Health System: The First Steps. Telemed e-Health. 2019;25(1):18–24. doi:10.1089/tmj.2017.0293

102. Vakkalanka JP, Harland KK, Wittrock A, et al. Telemedicine is associated with rapid transfer and fewer involuntary holds among patients presenting with suicidal ideation in rural hospitals: a propensity matched cohort study. J Epidemiol Community Health. 2019;73(11):1033–1039. doi:10.1136/jech-2019-212623 [PubMed: 31492762]

103. Saurman E, Perkins D, Roberts R, Roberts A, Patfield M, Lyle D. Responding to Mental Health Emergencies: Implementation of an Innovative Telehealth Service in Rural and Remote New South Wales, Australia. J Emerg Nurs. 2011;37(5):453–459. doi:10.1016/j.jen.2010.11.005 [PubMed: 21889653]

104. Saurman E, Lyle D, Kirby S, Roberts R. Assessing program efficiency: A time and motion study of the mental health emergency care - Rural access program in NSW Australia. Int J Environ Res Public Health. 2014;11(8):7678–7689. doi:10.3390/ijerph110807678 [PubMed: 25089774]

105. Southard EP, Neufeld JD, Laws S. Telemental Health Evaluations Enhance Access and Efficiency in a Critical Access Hospital Emergency Department. Telemed e-Health. 2014;20(7):664–668. doi:10.1089/tmj.2013.0257

106. Shore JH, Hilty DM, Yellowlees P. Emergency management guidelines for telepsychiatry. Gen Hosp Psychiatry. 2007;29(3):199–206. doi:10.1016/j.genhosppsych.2007.01.013 [PubMed: 17484936]

107. Roberts N, Hu T, Axas N, Repetti L. Child and Adolescent Emergency and Urgent Mental Health Delivery Through Telepsychiatry: 12-Month Prospective Study. Telemed e-Health. 2017;23(10):842–846. doi:10.1089/tmj.2016.0269

108. Fairchild RM, Ferng-Kuo S-F, Laws S, Rahmouni H, Hardesty D. Telehealth Decreases Rural Emergency Department Wait Times for Behavioral Health Patients in a Group of Critical Access Hospitals. Telemed e-Health. 2019;25(12):1154–1164. doi:10.1089/tmj.2018.0227

109. Jacobs JC, Blonigen DM, Kimerling R, et al. Increasing Mental Health Care Access, Continuity, and Efficiency for Veterans Through Telehealth With Video Tablets. Psychiatr Serv. 2019;70(11):976–982. doi:10.1176/appi.ps.201900104 [PubMed: 31378193]

110. Weintraub E, Greenblatt AD, Chang J, Himelhoch S, Welsh C. Expanding access to buprenorphine treatment in rural areas with the use of telemedicine. Am J Addict. 2018;27(8):612–617. doi:10.1111/ajad.12805 [PubMed: 30265425]

111. Alverson DC, Edison K, Flournoy L, Korte B, Magruder C, Miller C. Telehealth Tools for Public Health, Emergency, or Disaster Preparedness and Response: A Summary Report. Telemed e-Health. 2010;16(1):112–114. doi:10.1089/tmj.2009.0149

112. Balch D, Taylor C, Rosenthal D, Bausch C, Warner D, Morris R. Shadow bowl 2003: A collaborative exercise in community readiness, agency cooperation, and medical response. Telemed J e-Health. 2004;10(3):330–342. doi:10.1089/tmj.2004.10.330 [PubMed: 15650528]

113. Der-Martirosian C, Griffin AR, Chu K, Dobalian A. Telehealth at the US Department of Veterans Affairs after Hurricane Sandy. J Telemed Telecare. 2019;25(5):310–317. doi:10.1177/1357633X17751005 [PubMed: 29384428]

114. Kim TJ, Arrieta MI, Eastburn SL, et al. Post-disaster Gulf Coast Recovery Using Telehealth. Telemed e-Health. 2013;19(3):200–210. doi:10.1089/tmj.2012.0100

115. Vo AH, Brooks GB, Bourdeau M, Farr R, Raimer BG. University of Texas Medical Branch Telemedicine Disaster Response and Recovery: Lessons Learned from Hurricane Ike. Telemed e-Health. 2010;16(5):627–633. doi:10.1089/tmj.2009.0162

116. Uscher-Pines L, Fischer S, Tong I, Mehrotra A, Malsberger R, Ray K. Virtual First Responders: the Role of Direct-to-Consumer Telemedicine in Caring for People Impacted by Natural Disasters. J Gen Intern Med. 2018;33(8):1242–1244. doi:10.1007/s11606-018-4440-8 [PubMed: 29691713]

117. Xiong W, Bair A, Sandrock C, Wang S, Siddiqui J, Hupert N. Implementing telemedicine in medical emergency response: Concept of operation for a regional telemedicine hub. J Med Syst. 2012;36(3):1651–1660. doi:10.1007/s10916-010-9626-5 [PubMed: 21161569]
118. Doarn CR, Latifi R, Poropatich RK, et al. Development and Validation of Telemedicine for Disaster Response: The North Atlantic Treaty Organization Multinational System. Telemed e-Health. 2018;24(9):657–668. doi:10.1089/tmj.2017.0237
119. Burke RV, Berg BM, Vee P, et al. Using robotic telecommunications to triage pediatric disaster victims. J Pediatr Surg. 2012;47(1):221–224. doi:10.1016/j.jpedsurg.2011.10.046 [PubMed: 22244422]
120. Hu M, Sugimoto M, Rebeiro Hargrave A, et al. Mobile Healthcare System for Health Checkups and Telemedicine in Post-Disaster Situations. Stud Health Technol Inform. 2015;216:79–83. [PubMed: 26262014]
121. Meade K, Lam DM. A Deployable Telemedicine Capability in Support of Humanitarian Operations. Telemed e-Health. 2007;13(3):331–340. doi:10.1089/tmj.2006.0040
122. Saadi A, Mateen FJ. International Issues: Teleneurology in humanitarian crises. Neurology. 2017;89(3):e16–e19. doi:10.1212/WNL.0000000000004114 [PubMed: 28716879]
123. Piza F, Steinman M, Baldisserotto S, Morbeck RA, Silva E. Is there a role for telemedicine in disaster medicine? Crit Care. 2014;18(6):646-undefined. doi:10.1186/s13054-014-0646-2 [PubMed: 25672492]
124. Evaluation of Contingency Telemedical Support to Improve Casualty Care at a Simulated Military Intermediate Resuscitation Facility: The EM-ANGEL Study - PubMed.
125. Netzer I, Kirkpatrick AW, Nissan M, et al. Rubrum Coelis: The Contribution of Real-Time Telementoring in Acute Trauma Scenarios—A Randomized Controlled Trial. Telemed e-Health. 2019;25(11):1108–1114. doi:10.1089/tmj.2018.0173
126. Kirkpatrick AW, Mckee JL, Netzer I, et al. A Randomized Trial of Mentored vs Nonmentored Military Medics Compared in the Application of a Wound Clamp Without Prior Training: When to Shut Up and Just Watch! Mil Med. 2020;185(1):67–72. doi:10.1093/milmed/usz251 [PubMed: 32074324]
127. Kirkpatrick AW, McKee JL, Netzer I, et al. Transoceanic telementoring of tube thoracostomy insertion: A randomized controlled trial of telementored versus unmentored insertion of tube thoracostomy by military medical technicians. Telemed e-Health. 2019;25(8):730–739. doi:10.1089/tmj.2018.0138
128. Eder P, Reime B, Wurmb T, Kippnich U, Shammas L, Rashid A. Prehospital Telemedical Emergency Management of Severely Injured Trauma Patients. Methods Inf Med. 2018;57(5–06):231–242. doi:10.3414/ME18-05-0001 [PubMed: 30875702]
129. Wu T-C, Parker SA, Jagolino A, et al. Telemedicine Can Replace the Neurologist on a Mobile Stroke Unit. Stroke. 2017;48(2):493–496. doi:10.1161/STROKEAHA.116.015363 [PubMed: 28082671]
130. Taqui A, Cerejo R, Itrat A, et al. Reduction in time to treatment in prehospital telemedicine evaluation and thrombolysis. Neurology. 2017;88(14):1305–1312. doi:10.1212/WNL.0000000000003786 [PubMed: 28275084]
131. Itrat A, Taqui A, Cerejo R, et al. Telemedicine in Prehospital Stroke Evaluation and Thrombolysis. JAMA Neurol. 2016;73(2):162–168. doi:10.1001/jamaneurol.2015.3849 [PubMed: 26641366]
132. Rolston DM, Meltzer JS. Telemedicine in the Intensive Care Unit: Its Role in Emergencies and Disaster Management. Crit Care Clin. 2015;31(2):239–255. doi:10.1016/j.ccc.2014.12.004 [PubMed: 25814452]
133. Simmons S, Alverson D, Poropatich R, D'Iorio J, DeVany M, Doarn CR. Applying Telehealth in Natural and Anthropogenic Disasters. Telemed e-Health. 2008;14(9):968–971. doi:10.1089/tmj.2008.0117
134. Reynolds HN, Sheinfeld G, Chang J, Tabatabai A, Simmons D. The Tele-Intensive Care Unit During a Disaster: Seamless Transition from Routine Operations to Disaster Mode. Telemed e-Health. 2011;17(9):746–749. doi:10.1089/tmj.2011.0046

135. Delaigue S, Bonnardot L, Steichen O, et al. Seven years of telemedicine in Medecins Sans Frontieres demonstrate that offering direct specialist expertise in the frontline brings clinical and educational value. J Glob Health. 2018;8(2). doi:10.7189/jogh.08.020414

136. Murren-Boezem J, Solo-Josephson P, Zettler-Greeley CM. A Pediatric Telemedicine Response to a Natural Disaster. Telemed e-Health. 2020;26(6):720–724. doi:10.1089/tmj.2019.0100

137. Hershey TB, Van Nostrand E, Sood RK, Potter M. Legal Considerations for Health Care Practitioners After Superstorm Sandy. Disaster Med Public Health Prep. 2016;10(3). doi:10.1017/dmp.2016.33

138. Rosser JB, Parker BC, Vignesh V. Medical Applications of Drones for Disaster Relief: A Review of the Literature. Surg Technol Int. 2018;33:17–22. [PubMed: 30384393]

139. Carenzo L, Barra FL, Ingrassia PL, Colombo D, Costa A, Della Corte F. Disaster medicine through Google Glass. Eur J Emerg Med. 2015;22(3):222–225. doi:10.1097/MEJ.0000000000000229 [PubMed: 25460812]

140. Cicero MX, Walsh B, Solad Y, et al. Do You See What I See? Insights from Using Google Glass for Disaster Telemedicine Triage. Prehosp Disaster Med. 2015;30(1):4–8. doi:10.1017/S1049023X1400140X [PubMed: 25571779]

141. Davis C, Bender M, Smith T, Broad J. Feasibility and Acute Care Utilization Outcomes of a Post-Acute Transitional Telemonitoring Program for Underserved Chronic Disease Patients. Telemed e-Health. 2015;21(9):705–713. doi:10.1089/tmj.2014.0181

142. Cherry JC, Moffatt TP, Rodriguez C, Dryden K. Diabetes disease management program for an indigent population empowered by Telemedicine technology. Diabetes Technol Ther. 2002;4(6):783–791. doi:10.1089/152091502321118801 [PubMed: 12685802]

143. Pekmezaris R, Nouryan CN, Schwartz R, et al. A Randomized Controlled Trial Comparing Telehealth Self-Management to Standard Outpatient Management in Underserved Black and Hispanic Patients Living with Heart Failure. Telemed e-Health. 2019;25(10):917–925. doi:10.1089/tmj.2018.0219

144. Ward M, Jaana M, Natafgi N. Systematic review of telemedicine applications in emergency rooms. Int J Med Informations. 2015;84:601–616.

145. McLendon SF, Wood FG, Stanley N. Enhancing diabetes care through care coordination, telemedicine, and education: Evaluation of a rural pilot program. Public Health Nurs. 2019;36(3):310–320. doi:10.1111/phn.12601 [PubMed: 30868661]

146. Hofmeyer J, Leider JP, Satorius J, Tanenbaum E, Basel D, Knudson A. Implementation of Telemedicine Consultation to Assess Unplanned Transfers in Rural Long-Term Care Facilities, 2012–2015: A Pilot Study. J Am Med Dir Assoc. 2016;17(11):1006–1010. doi:10.1016/j.jamda.2016.06.014 [PubMed: 27477614]

147. Brainard JS, Ford JA, Steel N, Jones AP. A systematic review of health service interventions to reduce use of unplanned health care in rural areas. J Eval Clin Pract. 2016;22(2):145–155. doi:10.1111/jep.12470 [PubMed: 26507368]

148. Steventon A, Ariti C, Fisher E, Bardsley M. Effect of telehealth on hospital utilisation and mortality in routine clinical practice: a matched control cohort study in an early adopter site. BMJ Open. 2016;6(2). doi:10.1136/bmjopen-2015-009221

149. Uscher-Pines L, Mulcahy A, Cowling D, Hunter G, Burns R, Mehrotra A. Access and Quality of Care in Direct-to-Consumer Telemedicine. Telemed e-Health. 2016;22(4):282–287. doi:10.1089/tmj.2015.0079

150. Guss B, Mishkin D, Sharma R. Using Telemedicine to Address Crowding in the ED. ED Manag. 2016;28(11):127–131. [PubMed: 29211411]

151. San Diego ED leverages telemedicine in a bid to ease crowding, long wait times. ED Manag. 2013;25(8):93–95. [PubMed: 23923522]

152. McHugh C, Krinsky R, Sharma R. Innovations in Emergency Nursing: Transforming Emergency Care Through a Novel Nurse-Driven ED Telehealth Express Care Service. J Emerg Nurs. 2018;44(5):472–477. doi:10.1016/j.jen.2018.03.001 [PubMed: 29631785]

153. Telepsychiatry program eases patient crowding in the ED, expedites mental health services to patients and providers. ED Manag. 2013;25(11):121–124. [PubMed: 24195141]

154. States leverage telepsychiatry solutions to ease ED crowding, accelerate care. ED Manag. 2015;27(2):13–17. [PubMed: 25688413]

155. Will new e-facility help fight ED overcrowding? ED Manag. 2006;18(10):117–118. [PubMed: 17040025]

156. Penninga L, Lorentzen AK, Davis C. A Telemedicine Case Series for Acute Medical Emergencies in Greenland: A Model for Austere Environments. Telemed J E Health. 2020;26(8):1066–1070. doi:10.1089/tmj.2019.0123 [PubMed: 31804895]

157. Kumar S, Yogesan K, Hudson B, Tay-Kearney ML, Constable IJ. Emergency eye care in rural Australia: Role of internet. Eye. 2006;20(12):1342–1344. doi:10.1038/sj.eye.6702104 [PubMed: 16179932]

158. Nagayoshi Y, Oshima S, Ogawa H. Clinical Impact of Telemedicine Network System at Rural Hospitals Without On-Site Cardiac Surgery Backup. Telemed e-Health. 2016;22(11):960–964. doi:10.1089/tmj.2015.0225

159. Lyon M, Sturgis L, Lendermon D, et al. Rural ED transfers due to lack of radiology services. Am J Emerg Med. 2015;33(11):1630–1634. doi:10.1016/j.ajem.2015.07.050 [PubMed: 26349778]

160. Hicks LL, Boles KE, Hudson ST, et al. Using telemedicine to avoid transfer of rural emergency department patients. J Rural Health. 2001;17(3):220–228. [PubMed: 11765886]

161. Kuperman E, Linson E, Klefstad K, Perry E, Glenn K. The Virtual Hospitalist: A Single-Site Implementation Bringing Hospitalist Coverage to Critical Access Hospitals. J Hosp Med. 2018;13(11):759–763. doi:10.12788/jhm.3061 [PubMed: 30255859]

162. Hayden EM, Boggs KM, Espinola JA, Camargo CA, Zachrison KS. Telemedicine Facilitation of Transfer Coordination From Emergency Departments. Ann Emerg Med. 2020;76(5):602–608. doi:10.1016/j.annemergmed.2020.04.027 [PubMed: 32534835]

163. Mohr NM, Young T, Harland KK, et al. Emergency Department Telemedicine Shortens Rural Time-to-Provider and Emergency Department Transfer Times. Telemed e-Health. 2018;24(8):582–593.

164. Galli R, Keith JC, McKenzie K, Hall GS, Henderson K. TelEmergency: A Novel System for Delivering Emergency Care to Rural Hospitals. Ann Emerg Med. 2008;51(3):275–284. doi:10.1016/j.annemergmed.2007.04.025 [PubMed: 17764784]

165. Kyriacou E, Pavlopoulos S, Berler A, et al. Multi-purpose HealthCare Telemedicine Systems with mobile communication link support. Biomed Eng Online. 2003;2(1):7-undefined. doi:10.1186/1475-925X-2-7 [PubMed: 12694629]

166. Oest SER, Swanson MB, Ahmed A, Mohr NM. Perceptions and Perceived Utility of Rural Emergency Department Telemedicine Services: A Needs Assessment. Telemed e-Health. 2020;26(7):855–864. doi:10.1089/tmj.2019.0168

167. Natafgi N, Mohr NM, Wittrock A, Bell A, Ward MM. The Association Between Telemedicine and Emergency Department (ED) Disposition: A Stepped Wedge Design of an ED-Based Telemedicine Program in Critical Access Hospitals. J Rural Heal. 2020;36(3):360–370. doi:10.1111/jrh.12370

168. Potter AJ, Ward MM, Natafgi N, et al. Perceptions of the Benefits of Telemedicine in Rural Communities. Perspectives in Health Information Management.

169. Mueller KJ, Potter AJ, Clinton MacKinney A, Ward MM. Lessons from tele-emergency: Improving care quality and health outcomes by expanding support for rural care systems. Health Aff. 2014;33(2):228–234. doi:10.1377/hlthaff.2013.1016

170. Stamford P, Bickford T, Hsiao H, Mattern W. The significance of telemedicine in a rural emergency department. IEEE Eng Med Biol Mag. 1999;18(4):45–52. doi:10.1109/51.775488 [PubMed: 10429901]

171. Mackinney AC, Ward MM, Ullrich F, Ayyagari P, Bell AL, Mueller KJ. The Business Case for Tele-emergency. 2015;21(12):1005–1011. doi:10.1089/tmj.2014.0241

172. Nesbitt TS, Derlet RW, Ritter V, Pellegrino L, Kuenneth CA. Flexible bedside monitoring and assisted consultation in rural emergency departments. Calif J Emerg Med. 2002;3(3):40–45.

173. Zachrison KS, Boggs KM, Hayden EM, Espinola JA, Camargo CA. Understanding Barriers to Telemedicine Implementation in Rural Emergency Departments. Ann Emerg Med. 2020;75(3):392–399. doi:10.1016/j.annemergmed.2019.06.026 [PubMed: 31474481]

174. Zachrison K, Hayden E, Schwamm L, et al. Characterizing New England Emergency Departments by Telemedicine Use. West J Emerg Med. 2017;18(6):1055–1060. [PubMed: 29085537]
175. Jang-Jaccard J, Nepal S, Alem L, Li J. Barriers for Delivering Telehealth in Rural Australia: A Review Based on Australian Trials and Studies. Telemed e-Health. 2014;20(5):496–504. doi:10.1089/tmj.2013.0189
176. Edwards MA, Patel AC. Telemedicine in the state of Maine: A model for growth driven by rural needs. Telemed J e-Health. 2003;9(1):25–39. doi:10.1089/153056203763317620 [PubMed: 12699605]
177. Renouf T, Alani S, Whalen D, et al. City mouse, country mouse: A mixed-methods evaluation of perceived communication barriers between rural family physicians and urban consultants in Newfoundland and Labrador, Canada. BMJ Open. 2016;6(5). doi:10.1136/bmjopen-2015-010153
178. De Souza CHA, Morbeck RA, Steinman M, et al. Barriers and Benefits in Telemedicine Arising between a High-Technology Hospital Service Provider and Remote Public Healthcare Units: A Qualitative Study in Brazil. Telemed e-Health. 2017;23(6):527–532. doi:10.1089/tmj.2016.0158
179. Martin AB, Nelson JD, Bhavsar GP, McElligott J, Garr D, Leite RS. Feasibility assessment for using telehealth technology to improve access to dental care for rural and underserved populations. J Evid Based Dent Pract. 2016;16(4):228–235. doi:10.1016/j.jebdp.2016.08.002 [PubMed: 27938695]
180. Vega S, Marciscano I, Holcomb M, et al. Testing a Top-Down Strategy for Establishing a Sustainable Telemedicine Program in a Developing Country: The Arizona Telemedicine Program–U.S. Army–Republic of Panama Initiative. Telemed e-Health. 2013;19(10):746–753. doi:10.1089/tmj.2013.0025
181. Ly BA, Bourgeault IL, Labonté R, Niang MN. Physicians' perceptions on the impact of telemedicine on recruitment and retention in underserved areas: A descriptive study in Senegal. Hum Resour Health. 2017;15(1). doi:10.1186/s12960-017-0242-z
182. Casey M, Hayes PS, Heaney D, et al. Implementing transnational telemedicine solutions: A connected health project in rural and remote areas of six Northern Periphery countries. Eur J Gen Pract. 2013;19(1):52–58. doi:10.3109/13814788.2012.761440 [PubMed: 23432039]
183. Saliba V, Legido-Quigley H, Hallik R, Aaviksoo A, Car J, McKee M. Telemedicine across borders: A systematic review of factors that hinder or support implementation. Int J Med Inform. 2012;81(12):793–809. doi:10.1016/j.ijmedinf.2012.08.003 [PubMed: 22975018]
184. Samuels-Kalow M, Jaffe T, Zachrison K 2021; IP. Beyond just reporting disparities: designing telemedicine systems to improve health equity. Emerg Med J. 2021;In press.
185. Marsh-Feiley G, Eadie L, Wilson P. Telesonography in emergency medicine: A systematic review. PLoS One. 2018;13(5):e0194840-undefined. doi:10.1371/journal.pone.0194840 [PubMed: 29723198]
186. Harris Y, Gilman B, Ward MM, et al. Building the Evidence Base for Tele-Emergency Care: Efforts to Identify a Standardized Set of Outcome Measures. Telemed e-Health. 2017;23(7):561–566. doi:10.1089/tmj.2016.0190
187. Provide a Framework for Understanding Health Care Quality. Agency for Healthcare Research and Quality.
188. Pham JC, Alblaihed L, Cheung DS, et al. Measuring Patient Safety in the Emergency Department. Am J Med Qual. 2014;29(2):99–104. doi:10.1177/1062860613489846 [PubMed: 23728473]
189. Totten AM, Hansen RN, Wagner J, et al. Telehealth for Acute and Chronic Care Consultations; 2019. doi:10.23970/AHRQEPCCER216
190. Adusumilli G, Joseph SE, Samaan MA, et al. iPhone Sensors in Tracking Outcome Variables of the 30-Second Chair Stand Test and Stair Climb Test to Evaluate Disability: Cross-Sectional Pilot Study. JMIR mHealth uHealth. 2017;5(10):e166-undefined. doi:10.2196/mhealth.8656 [PubMed: 29079549]
191. Bilgi M, Gülalp B, Erol T, et al. Interpretation of Electrocardiogram Images Sent Through the Mobile Phone Multimedia Messaging Service. Telemed e-Health. 2012;18(2):126–131. doi:10.1089/tmj.2011.0108

192. Boccara D, Bekara F, Soussi S, et al. Ongoing Development and Evaluation of a Method of Telemedicine: Burn Care Management With a Smartphone. J Burn Care Res. 2018;39(4):580–584. doi:10.1093/jbcr/irx022 [PubMed: 29789857]

193. Coppetti T, Brauchlin A, Müggler S, et al. Accuracy of smartphone apps for heart rate measurement. Eur J Prev Cardiol. 2017;24(12):1287–1293. doi:10.1177/2047487317702044 [PubMed: 28464700]

194. Hoseini F, Ayatollahi H, Salehi SH. systematized review of telemedicine applications in treating burn patients. Med J Islam Repub Iran. 2016;30(1):459-undefined. [PubMed: 28491834]

195. Kochmann M, Locatis C. Direct to Consumer Mobile Teledermatology Apps: An Exploratory Study. Telemed e-Health. 2016;22(8):689–693. doi:10.1089/tmj.2015.0189

196. Meinich-Bache Ø, Engan K, Birkenes TS, Myklebust H. Real-Time Chest Compression Quality Measurements by Smartphone Camera. J Healthc Eng. 2018;2018:6241856-undefined. doi:10.1155/2018/6241856 [PubMed: 30581549]

197. Myers DR, Weiss A, Rollins MR, Lam WA. Towards remote assessment and screening of acute abdominal pain using only a smartphone with native accelerometers. Sci Rep. 2017;7(1):12750-undefined. doi:10.1038/s41598-017-13076-x [PubMed: 28986551]

198. Pundlik S, Tomasi M, Liu R, Houston K, Luo G. Development and Preliminary Evaluation of a Smartphone App for Measuring Eye Alignment. Transl Vis Sci Technol. 2019;8(1):19-undefined. doi:10.1167/tvst.8.1.19

199. Zhao JZ, Blazar PE, Mora AN, Earp BE. Range of Motion Measurements of the Fingers Via Smartphone Photography. HAND. 2020;15(5):679–685. doi:10.1177/1558944718820955 [PubMed: 30688093]

200. Bowman RJC, Kennedy C, Kirwan JF, Sze P, Murdoch IE. Reliability of telemedicine for diagnosing and managing eye problems in accident and emergency departments. Eye. 2003;17(6):743–746. doi:10.1038/sj.eye.6700489 [PubMed: 12928688]

201. Killeen AL, Brock KM, Dancho JF, Walters JL. Remote Temperature Monitoring in Patients With Visual Impairment Due to Diabetes Mellitus: A Proposed Improvement to Current Standard of Care for Prevention of Diabetic Foot Ulcers. J Diabetes Sci Technol. 2020;14(1):37–45. doi:10.1177/1932296819848769 [PubMed: 31122064]

202. Parker RA, Paterson M, Padfield P, et al. Are self-reported telemonitored blood pressure readings affected by end-digit preference: a prospective cohort study in Scotland. BMJ Open. 2018;8(1):e019431-undefined. doi:10.1136/bmjopen-2017-019431

203. Vargas BB, Shepard M, Hentz JG, Kutyreff C, Hershey LG, Starling AJ. Feasibility and accuracy of teleconcussion for acute evaluation of suspected concussion. Neurology. 2017;88(16):1580–1583. doi:10.1212/WNL.0000000000003841 [PubMed: 28341642]

204. Venail F, Akkari M, Merklen F, et al. Evaluation of otoscopy simulation as a training tool for real-time remote otoscopy. Int J Audiol. 2018;57(3):194–200. doi:10.1080/14992027.2017.1416190 [PubMed: 29256826]

205. Romero G, de Argila D, Ferrandiz L, et al. Modelos de práctica de la teledermatología en España. Estudio longitudinal 2009–2014. Actas Dermosifiliogr. 2018;109(7):624–630. doi:10.1016/j.ad.2018.03.015 [PubMed: 29807618]

206. Steventon A, Chaudhry SI, Lin Z, Mattera JA, Krumholz HM. Assessing the reliability of self-reported weight for the management of heart failure: application of fraud detection methods to a randomised trial of telemonitoring. BMC Med Inform Decis Mak. 2017;17(1):43-undefined. doi:10.1186/s12911-017-0426-4 [PubMed: 28420352]

207. Langabeer J, Gonzalez M, Alqusairi D, et al. Telehealth-Enabled Emergency Medical Services Program Reduces Ambulance Transport to Urban Emergency Departments. West J Emerg Med. 2016;17(6):713–720. doi:10.5811/westjem.2016.8.30660 [PubMed: 27833678]

208. Rebello KE, Gosian J, Salow M, Sweeney P, Rudolph JL, Driver JA. The Rural PILL Program: A Postdischarge Telepharmacy Intervention for Rural Veterans. J Rural Heal. 2017;33(3):332–339. doi:10.1111/jrh.12212

209. Tolia V, Castillo E, Guss D. EDTITRATE (Emergency Department Telemedicine Initiative to Rapidly Accommodate in Times of Emergency). J Telemed Telecare. 2017;23(4):484–488. doi:10.1177/1357633X16648535 [PubMed: 27279469]

210. Demaerschalk BM, Boyd EL, Barrett KM, et al. Comparison of Stroke Outcomes of Hub and Spoke Hospital Treated Patients in Mayo Clinic Telestroke Program. J Stroke Cerebrovasc Dis. 2018;27(11):2940–2942. doi:10.1016/j.jstrokecerebrovasdis.2018.06.024 [PubMed: 30146388]

211. Lane TS, Armin J, Gordon JS. Online Recruitment Methods for Web-Based and Mobile Health Studies: A Review of the Literature. J Med Internet Res. 2015;17(7):e183-undefined. doi:10.2196/jmir.4359 [PubMed: 26202991]

212. Mastellos N, Andreasson A, Huckvale K, et al. A cluster randomised controlled trial evaluating the effectiveness of eHealth-supported patient recruitment in primary care research: the TRANSFoRm study protocol. Implement Sci. 2015;10(1):15-undefined. doi:10.1186/s13012-015-0207-3 [PubMed: 25648301]

213. Switzer JA, Hall CE, Close B, et al. A Telestroke Network Enhances Recruitment into Acute Stroke Clinical Trials. Stroke. 2010;41(3):566–569. doi:10.1161/STROKEAHA.109.566844 [PubMed: 20056929]

214. Shoirah H, Wechsler LR, Jovin TG, Jadhav AP. Acute Stroke Trial Enrollment through a Telemedicine Network: A 12-Year Experience. J Stroke Cerebrovasc Dis. 2019;28(7):1926–1929. doi:10.1016/j.jstrokecerebrovasdis.2019.03.046 [PubMed: 31010762]

215. Miller DM, Fox R, Atreja A, et al. Using an Automated Recruitment Process to Generate an Unbiased Study Sample of Multiple Sclerosis Patients. Telemed e-Health. 2010;16(1):63–68. doi:10.1089/tmj.2009.0078

216. Stratton SL, Spencer HJ, Greenfield WW, et al. A novel use of a statewide telecolposcopy network for recruitment of participants in a Phase I clinical trial of a human papillomavirus therapeutic vaccine. Clin Trials J Soc Clin Trials. 2015;12(3):199–204. doi:10.1177/1740774514566333

217. Abujarad F, Alfano S, Bright TJ, et al. Building an Informed Consent Tool Starting with the Patient: The Patient-Centered Virtual Multimedia Interactive Informed Consent (VIC). AMIA Annu Symp Proc. 2018;2017:374–383. [PubMed: 29854101]

218. Bobb MR, Van Heukelom PG, Faine BA, et al. Telemedicine Provides Noninferior Research Informed Consent for Remote Study Enrollment: A Randomized Controlled Trial. Acad Emerg Med. 2016;23(7):759–765. doi:10.1111/acem.12966 [PubMed: 26990899]

219. Varma N, Michalski J, Stambler B, Pavri BB. Superiority of automatic remote monitoring compared with in-person evaluation for scheduled ICD follow-up in the TRUST trial - testing execution of the recommendations. Eur Heart J. 2014;35(20):1345–1352. doi:10.1093/eurheartj/ehu066 [PubMed: 24595864]

220. Varner C, McLeod S, Nahiddi N, Borgundvaag B. Text messaging research participants as a follow-up strategy to decrease emergency department study attrition. CJEM. 2018;20(1):148–153. doi:10.1017/cem.2016.408 [PubMed: 28065207]

221. Greenwald PW, Stern M, Clark S, et al. A Novel Emergency Department-Based Telemedicine Program: How Do Older Patients Fare? Telemed e-Health. 2019;25(10):966–972. doi:10.1089/tmj.2018.0162

222. Myers K, Nelson E-L, Rabinowitz T, et al. American Telemedicine Association Practice Guidelines for Telemental Health with Children and Adolescents. Telemed e-Health. 2017;23(10):779–804. doi:10.1089/tmj.2017.0177

223. Berger E Physician Burnout. Ann Emerg Med. 2013;61(3):A17–A19. doi:10.1016/j.annemergmed.2013.01.001

224. Narváez S, Tobar ÁM, López DM, Blobel B. Human-Centered Design of an mHealth App for the Prevention of Burnout Syndrome. Stud Health Technol Inform. 2016;228:215–219. [PubMed: 27577374]

225. Reliford A, Adebanjo B. Use of Telepsychiatry in Pediatric Emergency Room to Decrease Length of Stay for Psychiatric Patients, Improve Resident On-Call Burden, and Reduce Factors Related to Physician Burnout. Telemed e-Health. 2019;25(9):828–832. doi:10.1089/tmj.2018.0124

226. Romig MC, Latif A, Gill RS, Pronovost PJ, Sapirstein A. Perceived benefit of a telemedicine consultative service in a highly staffed intensive care unit. J Crit Care. 2012;27(4):e9–e16. doi:10.1016/j.jcrc.2011.12.007

227. Bynum AB, Irwin CA, Cranford CO, Denny GS. The Impact of Telemedicine on Patients' Cost Savings: Some Preliminary Findings. Telemed J e-Health. 2003;9(4):361–367. doi:10.1089/153056203772744680 [PubMed: 14980093]

228. Telemedicine for the Treatment of Urgent Conditions: A Review of Clinical Effectiveness, Cost-Effectiveness, and Guidelines.; 2015.

229. Emergency Telehealth for Urgent Conditions in Long-Term Care Facilities: Clinical Effectiveness, Cost-Effectiveness, and Guidelines.; 2015.

230. du Toit M, Malau-Aduli B, Vangaveti V, Sabesan S, Ray RA. Use of telehealth in the management of non-critical emergencies in rural or remote emergency departments: A systematic review. J Telemed Telecare. 2019;25(1):3–16. doi:10.1177/1357633X17734239 [PubMed: 28980853]

231. Nadar M, Jouvet P, Tucci M, Toledano B, Sicotte C. Impact of Synchronous Telemedicine Models on Clinical Outcomes in Pediatric Acute Care Settings. Pediatr Crit Care Med. 2018;19(12):e662–e671. doi:10.1097/PCC.0000000000001733 [PubMed: 30234678]

232. Dharmar M, Sadorra CK, Leigh P, Yang NH, Nesbitt TS, Marcin JP. The Financial Impact of a Pediatric Telemedicine Program: A Children's Hospital's Perspective. Telemed e-Health. 2013;19(7):502–508. doi:10.1089/tmj.2012.0266

233. Grabowski DC, O'Malley AJ. Use Of Telemedicine Can Reduce Hospitalizations Of Nursing Home Residents And Generate Savings For Medicare. Health Aff. 2014;33(2):244–250. doi:10.1377/hlthaff.2013.0922

234. CARES Act.

235. Additional Background: Sweeping Regulatory Changes to Help U.S. Healthcare System Address COVID-19 Patient Surge; 2020.

236. Ashwood JS, Mehrotra A, Cowling D, Uscher-Pines L. Direct-to-consumer telehealth may increase access to care but does not decrease spending. Health Aff. 2017;36(3):485–491. doi:10.1377/hlthaff.2016.1130

237. Persse DE, Gonzalez M, Langabeer J, Champagne-Langabeer T, Gleisberg GR. Tele-EMS Improves Productivity and Reduces Overall Costs. J Emerg Med Serv. Published online April 9, 2019.

238. Langabeer JR, Champagne-Langabeer T, Alqusairi D, et al. Cost–benefit analysis of telehealth in pre-hospital care. J Telemed Telecare. 2017;23(8). doi:10.1177/1357633X16680541

239. Dayal P, Hojman NM, Kissee JL, et al. Impact of Telemedicine on Severity of Illness and Outcomes Among Children Transferred From Referring Emergency Departments to a Children's Hospital PICU*. Pediatr Crit Care Med. 2016;17(6):516–521. doi:10.1097/PCC.0000000000000761 [PubMed: 27099972]

240. Lilly CM, Motzkus C, Rincon T, Cody SE, Landry K, Irwin RS. ICU Telemedicine Program Financial Outcomes. Chest. 2017;151(2):286–297. doi:10.1016/j.chest.2016.11.029 [PubMed: 27932050]

241. Brokmann JC, Conrad C, Rossaint R, et al. Treatment of Acute Coronary Syndrome by Telemedically Supported Paramedics Compared With Physician-Based Treatment: A Prospective, Interventional, Multicenter Trial. J Med Internet Res. 2016;18(12):e314-undefined. doi:10.2196/jmir.6358 [PubMed: 27908843]

242. EMS Agenda 2050 Technical Expert Panel. EMS Agenda 2050: A People-Centered Vision for the Future of Emergency Medical Services.; 2019.

243. French DM, Hall GA, McGeorge T, Haschker M, Brazeal JG, Dubose-Morris R. Hurricane Impact on Emergency Services and Use of Telehealth to Support Prehospital Care. Disaster Med Public Health Prep. 2020;14(1):39–43. doi:10.1017/dmp.2019.101 [PubMed: 31642420]

244. Jones RW, Despotou G, Arvanitis TN. Telehealth and the Re-Design of Emergency Medical Services. Stud Health Technol Inform. 2017;238:60–63. [PubMed: 28679887]

245. Joshi AU, Randolph FT, Chang AM, et al. Impact of Emergency Department Tele-intake on Left Without Being Seen and Throughput Metrics. Acad Emerg Med. 2020;27(2):139–147. doi:10.1111/acem.13890 [PubMed: 31733003]

246. Lilly CM, Mullen M. Critical Care Surge Management: A Role for ICU Telemedicine and Emergency Department Collaboration. Crit Care Med. 2019;47(9):1271–1273. doi:10.1097/CCM.0000000000003881 [PubMed: 31415312]

247. Adeoye O, Nyström KV., Yavagal DR, et al. Recommendations for the Establishment of Stroke Systems of Care: A 2019 Update. Stroke. 2019;50:e187–e210. doi:10.1161/STR.0000000000000173 [PubMed: 31104615]

248. Abrashkin KA, Washko J, Zhang J, Poku A, Kim H, Smith KL. Providing Acute Care at Home: Community Paramedics Enhance an Advanced Illness Management Program-Preliminary Data. J Am Geriatr Soc. 2016;64(12):2572–2576. doi:10.1111/jgs.14484 [PubMed: 27575363]

249. Acker JJ, Johnston TM, Lazarsfeld-Jensen A. Industrial paramedics, out on site but not out of mind. Rural Remote Health. 2014;14(4):2856-undefined. [PubMed: 25480308]

250. Afessa B Tele-intensive care unit: The horse out of the barn. Crit Care Med. 2010;38(1):292–293. doi:10.1097/CCM.0b013e3181b9d4dc [PubMed: 20023465]

251. Nguyen Y-L, Kahn JM, Angus DC. Reorganizing Adult Critical Care Delivery: the role of regionalization, telemedicine, and community outreach. Am J Respir Crit Care Med. 2010;181(11):1164–1169. doi:10.1164/rccm.200909-1441CP [PubMed: 20224067]

252. Rörtgen D, Bergrath S, Rossaint R, et al. Comparison of physician staffed emergency teams with paramedic teams assisted by telemedicine – a randomized, controlled simulation study. Resuscitation. 2013;84(1):85–92. doi:10.1016/j.resuscitation.2012.06.012 [PubMed: 22750663]

253. Bagot KL, Cadilhac DA, Vu M, Moss K, Bladin CF. Telemedicine in the acute health setting: A disruptive innovation for specialists (an example from stroke). J Telemed Telecare. 2015;21(8):443–448. doi:10.1177/1357633X15610722 [PubMed: 26556058]

254. Bagot KL, Moloczij N, Barclay-Moss K, Vu M, Bladin CF, Cadilhac DA. Sustainable implementation of innovative, technology-based health care practices: A qualitative case study from stroke telemedicine. J Telemed Telecare. 2020;26(1–2):79–91. doi:10.1177/1357633X18792380 [PubMed: 30193566]

255. Ellis DG, Mayrose J, Phelan M. Consultation times in emergency telemedicine using realtime videoconferencing. J Telemed Telecare. 2006;12(6):303–305. doi:10.1258/135763306778558187 [PubMed: 17022838]

256. Fong W-C, Ismail M, Lo JW-T, et al. Telephone and Teleradiology-Guided Thrombolysis Can Achieve Similar Outcome as Thrombolysis by Neurologist On-site. J Stroke Cerebrovasc Dis. 2015;24(6):1223–1228. doi:10.1016/j.jstrokecerebrovasdis.2015.01.022 [PubMed: 25906936]

257. Levine AC, Barry MA, Agrawal P, et al. Global Health and Emergency Care: Overcoming Clinical Research Barriers. Acad Emerg Med. 2017;24(4):484–493. doi:10.1111/acem.13142 [PubMed: 27976457]

258. Marx G, Beckers R, Brokmann JC, Deisz R, Pape H-C. Telekooperation für die innovative Versorgung am Beispiel des Universitätsklinikums Aachen. Bundesgesundheitsblatt - Gesundheitsforsch - Gesundheitsschutz. 2015;58(10). doi:10.1007/s00103-015-2224-4

259. McConnell KJ, Charlesworth CJ, Zhu JM, et al. Access to Primary, Mental Health, and Specialty Care: a Comparison of Medicaid and Commercially Insured Populations in Oregon. J Gen Intern Med. 2020;35(1):247–254. doi:10.1007/s11606-019-05439-z [PubMed: 31659659]

260. Morton MJ, DeAugustinis ML, Velasquez CA, Singh S, Kelen GD. Developments in Surge Research Priorities: A Systematic Review of the Literature Following the Academic Emergency Medicine Consensus Conference, 2007–2015. Acad Emerg Med. 2015;22(11):1235–1252. doi:10.1111/acem.12815 [PubMed: 26531863]

261. Ucinski T, Dolata G, Hełminiak R, et al. Integrating cross-border emergency medicine systems: Securing future preclinical medical workforce for remote medical services. Best Pract Res Clin Anaesthesiol. 2018;32(1):39–46. doi:10.1016/j.bpa.2018.04.004 [PubMed: 30049337]

262. Martiniano R, Rodat C, Baker B, et al. Case Studies of Telehealth Programs in New York.; 2018.

263. Gagnon M-P, Duplantie J, Fortin J-P, Landry R. Implementing telehealth to support medical practice in rural/remote regions: what are the conditions for success? Implement Sci. 2006;1:18-undefined. doi:10.1186/1748-5908-1-18 [PubMed: 16930484]

264. LaBarbera JM, Ellenby MS, Bouressa P, Burrell J, Flori HR, Marcin JP. The Impact of Telemedicine Intensivist Support and a Pediatric Hospitalist Program on a Community Hospital. Telemed e-Health. 2013;19(10):760-undefined. doi:10.1089/tmj.2012.0303

265. Molfenter T, Knudsen HK, Brown R, et al. Test of a workforce development intervention to expand opioid use disorder treatment pharmacotherapy prescribers: protocol for a cluster

randomized trial. Implement Sci. 2017;12(1):135-undefined. doi:10.1186/s13012-017-0665-x [PubMed: 29141653]

266. Rutledge CM, Haney T, Bordelon M, Renaud M, Fowler C. Telehealth: Preparing Advanced Practice Nurses to Address Healthcare Needs in Rural and Underserved Populations. Int J Nurs Educ Scholarsh. 2014;11(1). doi:10.1515/ijnes-2013-0061

267. Committee on Pediatric Workforce, Marcin JP, Rimsza ME, Moskowitz WB. The Use of Telemedicine to Address Access and Physician Workforce Shortages. Pediatrics. 2015;136(1):202–209. doi:10.1542/peds.2015-1253 [PubMed: 26122802]

268. Ward IM, Schmidt TW, Lappan C, Battafarano DF. How Critical is Tele-Medicine to the Rheumatology Workforce? Arthritis Care Res (Hoboken). 2016;68(10):1387–1389. doi:10.1002/acr.22853 [PubMed: 26866514]

269. Moore B, Sapien R, Committee on Pediatric Emergency Medicine. The Role of the Pediatrician in Rural Emergency Medical Services for Children. Pediatrics. 2012;130(5):978–982. doi:10.1542/peds.2012-2547 [PubMed: 23109681]

270. Hayden E, Erler K, Fleming D. Telehealth Ethics: The Role of Care Partners. Telemed e-Health. 2020;26(8):976–977.

Modality	Definition	Example
Live video	Live, streaming video for care encounters	A tele-mental health visit with a psychiatrist and a remotely-located patient
Asynchronous store-and-forward	Videos or images are uploaded for a provider to dispense an opinion	A patient uploads a photo of their rash for a dermatologist to provide a course of management
Remote patient monitoring	Monitoring of symptoms or vitals of a remote patient	An insulin pump sends real-time glucose results to the endocrinologist
mHealth (mobile health)	Using text-based systems to provide medication reminders	A liver transplant patient is texted with a reminder when a medication is due

Figure 1.
Description and examples of types of telehealth.

Step	Timeframe	Who	What was done	Outcomes
1	2016-2019	Conference Co-chairs	• Discussion with experts	• Breakout Group Themes
2	October 2019-January 2020	Breakout Group Leaders and Members	• Literature Review • Development of research questions	• Description of current state of science • List of initial research questions
3	February 2020	Stakeholders	• Survey completed	• Feedback on state of science • Feedback on initial research questions
4	May-July 2020	Conference Co-chairs, Breakout Group Leaders, Emergency Medicine Physicians, and Stakeholders	• Hosted virtual conference "Telehealth in Emergency Medicine in COVID: Lessons Learned" • Revised summaries • Surveyed stakeholders a second time	• Presentation of innovations and lessons learned for telehealth in EM during COVID • Feedback from stakeholders • Revisions of state of science and research questions
5	August-September 2020	Experts in EM and telehealth	• Breakout group summaries sent to pre-registered participants • Preconference survey as Round 1 of voting	• Feedback on state of science and research questions • Revised research questions
6	September 22, 2020	Breakout Group Leaders and Members, EM physicians, experts in telehealth	• Keynote and panel presentations • Breakout Group discussions • Round 2 of voting	• Revised research questions
7	September 24, 2020	Breakout Group Leaders and Members, EM physicians, experts in telehealth	• Keynote and panel presentations • Round 3 of voting	• Revised research questions
8	Late September 2020	Conference participants	• Post-conference evaluation	• Concerns voiced on final research questions
9	October 2020	Breakout Group Leaders and Members	• Revisions of summaries and research questions	• Final revisions to state of science • Final revisions to research questions

EM=Emergency Medicine

Figure 2.
Timeline and description of the 9-step modified Delphi consensus process.

Voting/Survey	Who	When
Feedback survey 1	Stakeholders	February 2020
Feedback survey 2	Stakeholders	July 2020
Feedback and Voting 1	Pre-registered participants	September 2020
Voting 2	Breakout Group participants	September 22, 2020
Voting 3	Breakout Group participants	September 24, 2020

Figure 3.
List and timeline of stakeholders who reviewed and/or voted on the research questions.

February 2020	July 2020
• American Association of Medical Colleges (AAMC) • American Telemedicine Association (ATA) • Emergency Medicine physicians • Emergency Telehealth Section, American College of Emergency Physicians (ACEP) • Patients/patient advocates • Research Committee, Society for Academic Emergency Medicine (SAEM) • Society for Education and Research in Connected Health (SEARCH) • Supporting Pediatric Research Outcomes and Utilization of Telehealth (SPROUT) • Telehealth Resource Centers (TRC)	• American Telemedicine Association (ATA) • Controlled Risk Insurance Company (CRICO) • Emergency Medicine physicians • Emergency Telehealth Section, American College of Emergency Physicians (ACEP) • Research Committee, Society for Academic Emergency Medicine (SAEM) • Telehealth Resource Centers (TRC)

Figure 4.
List of stakeholder representatives providing feedback to the Breakout Group summaries.

Educational Needs and Outcomes

Competencies

1. What are the core competencies in TH that are common to all providers, regardless of role, specialty, or level of training? (4.36)
2. What gaps, if any, in current EM training need to be addressed to adapt practice to telehealth? (4.45)
3. In patient-provider TH encounters, what are the components of the video-based physical exam? (4.18)

Educational Strategies

4. What types of educational experiences and instructional modalities are effective to teach TH to EM practitioners? (3.91)
5. How do we train emergency practitioners in virtual presence (webside manner) for patient-to-provider and provider-to-provider encounters? (4.27)
6. What are the best ways to integrate TH skills into both UME and GME EM curricula? (4.27)
7. How do we train interprofessional EM teams to provide collaborative care via TH? (4.27)

Healthcare Access

Patient-, population-level health outcomes

8. How does emergency TH access vary by patient or population characteristics? (3.86)
9. When considering the impact of TH for improving access, what are the appropriate patient-level outcomes to evaluate? (4.57)

10. When considering the impact of TH for improving access, what are the appropriate population-level outcomes to evaluate? (4.38)
11. What are costs and cost-effectiveness of TH from the perspective of the patient and the system, and relatedly, what is the appropriate approach to differentiate value of increased access vs excessive low-value utilization? (4.19)

Quality of healthcare delivery

12. Among underserved populations, what are mechanisms by which disparities in emergency care delivery may be exacerbated or ameliorated by TH? (4.14)

Outcomes of the telehealth encounter and program

13. What are the barriers and facilitators of implementation of TH in EDs (e.g., barriers such as payment models or healthcare delivery systems)? (4.05)

Implementation process measurements

14. What lessons can we learn from the expansion of TH during the COVID-19 pandemic? (3.95)
15. What are the barriers and facilitators to improving access via TH and quality of care for underserved populations? (4.43)

Quality and Safety

16. How can TH be used to augment safe transitions of care? (4.08)
17. In what situations should the quality and safety of TH be compared to in-person care and in what situations should it be compared to “no care”? (4.38)
18. In which clinical conditions, populations, and settings does emergency TH improve patient and operational outcomes? (4.77)

Research Facilitation

19. How can/should TH be used for research facilitation, including recruitment, informed consent, reducing attrition, and data collection, for EM research? (4.25)
20. Which individuals or populations require special considerations as the role of TH in EM research is expanded and what are the key barriers for engaging these patients in TH-facilitated research studies? (4.30)

Workforce

21. How effective can TH be as a solution for hospitals, particularly rural and critical access, that are unable to staff with board-certified EM physicians at the bedside? (4.43)
22. What types of training will be required for current practicing providers? (4.14)
23. What kinds of staffing will be best suited for emergency TH in different settings (e.g., APP versus rural physician, rural versus urban, etc.)? (4.14)
24. What kinds of staffing and systems are required to ensure provider efficiency in emergency TH? (4.14)

Figure 5.

List of final research questions for research agenda

Table 1.

Demographics of pre-registered participants. n=47

Characteristic	n (%)
Primary clinical setting	
Rural	1 (2.6)
Suburban	5 (13.1)
Urban	26 (68.4)
N/A	6 (15.8)
Teaching Hospital	
Yes	34 (89.5)
No	0 (0)
N/A	4 (10.5)
Practice Clinical EM	
Yes	27 (71)
No	11 (28.9)
Experience in TH	
I use/have used TH in my practice	27 (71)
There is no TH in my practice but there are plans to create a program	5 (13.1)
There is no TH practice and no plan to create a program	3 (7.9)
TH Training Program	
Student	7 (18.4)
Resident	9 (23.7)
Fellow	9 (23.7)
Other	8 (21.1)

N/A: Not applicable

EM: Emergency Medicine

TH: Telehealth

Table 2.

Voting response rate and attendance for Breakout Groups on Day 1 (Round 2 of voting) and Day 2 (Round 3 of voting)

Breakout Group	Day 1	Day 2
Educational Needs and Outcomes	51.7 (15/29) *	55 (11/20)
Healthcare Access	72.2 (26/36)	75 (21/28)
Quality and Safety	66.7 (18/27)	61.9 (13/21)
Research Facilitation	72.2 (26/36)	76.9 (20/26)
Workforce	50 (9/18)	50 (7/14)

* Denominator=attendance

Table 3.

Number of potential research questions per breakout group.

Breakout Group	Round 1	Round 2	Round 3
Educational Needs and Outcomes	16	17	10
Healthcare Access	28	31	9
Research Facilitation	4	7	2
Quality and Safety	20	21	5
Workforce	26	27	10
Total	**94**	**103**	**36**