The following is an exact copy of the original whitepaper written in 2018 by the Telehealth Section of the American College of Emergency Physicians (ACEP) with the omission of the definition of emergency telehealth and the "Preamble." The preamble was edited by the current ACEP Telehealth Section Chairman for correctness. August 7, 2019.

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Preamble

In late 2016, members of the American College of Emergency Physicians (ACEP) Telehealth Section (Telemedicine Section at the time) embarked on a review of currently available literature, related to various areas of telehealth, to evaluate current research and to suggest the future directions of telehealth research. It was discovered that there is a lack of established specialty guidelines or evidence to support reaching certain conclusions in the reviewed literature. However, certain information was available that lends credence to the current and potential value of telehealth. It is hoped that such an undertaking will encourage more research and studies that will produce evidence-based guidelines that will guide all specialties towards the best use and practices of telehealth today and into the future.

Introduction

History and Clinical Perspectives in Different Environments

Telehealth, the two-way real-time communication between two parties, has been used in healthcare typically between provider and patient or between two healthcare providers. This modality can serve as a vehicle that enables the delivery of high-quality, cost-effective, convenient and efficient health care to patients in near and remote locations. It can improve the quality of care being delivered by supplementing services currently available or providing services that may otherwise be unavailable. Telehealth improves access to care, improves the quality of care and can provide high quality care in a cost-effective manner.

The words *telemedicine* and *telehealth* have traditionally been used interchangeably and have been linked to terms such as tele-emergency medicine, telepsychiatry, teledermatology, telestroke, etc. to refer to specific types of telehealth. While these terms might indicate a specific specialty or form, they all fall under the umbrella of telemedicine or telehealth. The term *telemedicine* tends to imply providing service when there is a sick or injured patient. The term *telehealth* appears to be broader and more inclusive, encompassing not only providing services to the ill or wounded patient but also screening, prevention, maintenance, and follow-up services. Thus, it is recommended that telehealth should be the term used to describe and include all specialties and services related to healthcare delivered via two-way real time communication described above. This document will utilize that recommendation.

The ability to care for patients remotely has proven to be of value in a variety of settings including but not limited to acute and emergency care, inpatient settings and during disasters. Telehealth has been used for decades and has facilitated and enhanced care for hundreds of thousands of patient encounters. If one includes teleradiology, telestroke, telepsychiatry and teletrauma, millions of patients have benefited from the use of telehealth. The advent of low cost, high bandwidth data transmission has introduced a host of new applications, but qualitative and quantitative studies describing outcomes, cost effectiveness and other metrics are limited. Although telehealth offers many opportunities and much potential, patients, providers and payers demand evidence to facilitate further development of the field.

Moving forward, it is crucial that the emergency medicine community formulate the appropriate telehealth research questions that need to be asked and answered. Telehealth has made great strides and has positively impacted many lives but its full potential has yet to be realized. It is anticipated that telehealth use will continue to grow exponentially and is part of the solution to the growing healthcare problems being faced. While the potential of and opportunities in telehealth are great, it is essential that uniform quality metrics are established in order to maximize safe, consistent and optimal patient outcomes as well as optimal service and convenience to patients. To this end, this group embarked on a review of literature currently available, related to various areas of telehealth, to see what research and/or findings have already been performed and demonstrated. The goal is to help direct all medical specialties, including emergency medicine, towards additional studies and research that need to be performed to demonstrate the advantages, utility, and best practices of telehealth.

Literature Based Progress in Telehealth

Methods

We performed a systematic review of two bibliographic databases (PubMed/Medline and EMBASE) from 1974 to September 2016 with the help of a medical librarian. The librarian performed an eight-step search using combinations of over 70 terms including "telemedicine," "telehealth," "mHealth," "mobile health," and "evidence-based medicine."

Study design

We assessed the retrieved literature for studies that described use of experimental study designs (e.g., randomized controlled trials, crossover trials, and quasi-experimental trials).

Types of interventions

We searched the literature that reported on emergency telehealth or telehealth applied in acute unscheduled care. In the process, we found many papers describing tele-emergency medicine activities; additionally, we discovered and included additional EM applications of telehealth. We excluded articles that did not involve a real time face-to-face component (those that were purely telephonic or store and forward). We also excluded papers focused solely on teaching or research. Similarly, we removed papers that were limited to concepts and opinions where no data was collected.

Types of participants

We retained telehealth papers that including direct to consumer interactions and peer to peer (consultation by or to an emergency physician). We generally excluded those that did not occur in real time, such as a consult for a biopsy interpretation since that would be categorized as a store and forward consult.

Types of outcome measures

The outcomes presented in these studies varied widely. Many of them simply identified feasibility. Still others looked at performance metrics of the technology including time to physician, time to connection, and frequency of dropped connections. Several studies were able to identify process variables including time of diagnosis, time to triage, and agreement between in-person versus telehealth providers. Driven by increasing consumer awareness, many studies focused on elements of convenience and customer satisfaction. Few studies identified outcomes known to correlate with clinical care including efficacy of triage to a trauma center, time to cardiac catheterization lab activation, or identification of stroke amenable to revascularization. A limited number of studies focused on patient centered outcomes such as mortality, functional status at discharge and need for readmission.

Search methods for studies

We searched two bibliographic databases. Online Supplemental Appendix A contains the details of our search strategy, including all sources searched, the search terms used, and a description of our search vocabulary (Appendix A). We reviewed 16,826 records from the PubMed and EMBASE databases. We identified 3,509 duplicates which were removed from the databases. A total of 13,317 records remained.

Data collection and selection of studies

Screening

Co-investigators (MR and GL) independently screened titles and abstracts to identify relevant publications and research. We excluded records that appeared to be book chapters, conference abstracts, newsletters, dissertations, or theses. An investigator, (FXG) adjudicated disagreements against inclusion/exclusion criteria including: a) studies describing the population of interest (acute unscheduled care via telehealth); b) studies describing face to face encounters; c) the titles and/or abstracts describing one or more outcomes of interest. We achieved good agreement using the kappa statistic between screeners.[1] A total of 480 (3.6%) articles were selected for full text reviews.

Full-Text Review

Co-investigators reviewed full-text articles grouped into topical categories and worked independently to abstract key information. We used discussion amongst co-investigators to address any disagreements in data abstractions. Co-investigators searched the bibliographies of retained literature to identify relevant research.

Emergency Telehealth Definition

We employed a modified delphi process for drafting the emergency telehealth definition statement. Stakeholders from ACEP Emergency Telemedicine Section were asked to contribute concepts to the document. Comments were synthesized into the definition and recirculated through an iterative process until saturation was reached and no new topics were introduced.

Review of Relevant Literature in Emergency Telehealth

Telehealth literature was divided into three general sections and then further broken down into specific subject areas as shown below. Some journal articles overlapped areas and were therefore reviewed for applicability in more than one section. Each subject will be discussed separately in the sections which follow.

I. Operations

A. Telehealth for Improving Access to Care
B. Telehealth and Patient Satisfaction
C. Education via Telehealth
D. Telehealth in Mobile Health

E. Telehealth for Chronic Care

II. Service Lines

A. Provider-to-Provider Telehealth
B. Telehealth in a Prehospital Setting
C. Telehealth for Urgent Care
D. Telehealth for Emergency Medicine
E. Telehealth for Skilled Nursing Facilities

III. Specialty Care

A. Telehealth for Pediatrics
B. Telehealth in Dermatology
C. Telehealth for Wound Care
D. Telehealth for Orthopedics
E. Telehealth for Otolaryngology
F. Telehealth for Ophthalmology
G. Telehealth in Trauma
H. Telestroke/Neurology
I. Telehealth for Behavioral Health and Telepsychiatry

Methodology by which Literature Metrics were Identified and Reported

The National Quality Forum (NQF), in response to a request from the US Department of Health and Human Services (HHS), recently convened a multi-stakeholder Telehealth Committee that was charged with identifying a conceptual foundation for the development of measures for assessment of quality in telehealth care. The work resulted in publication of a final report, "Creating a Framework to Support Measure Development for Telehealth."[2]

The NQF framework is organized into four main domains for telehealth requiring measurement (Table 1).[2]

1) access to care

2) experience

3) effectiveness

4) financial impact/cost

Quality of care crossed into all of these domains, as it is intertwined with each one of these metrics. For example, untimely care represents poor quality and ineffective care represents low quality care. An important distinction of this framework highlighted that telehealth is a new method for care delivery, not a new type of healthcare. Because of this, the above metrics are applicable to already existing ways of thinking about the quality of our healthcare and can, and should, be applied to evaluating our telehealth programs, methods and future research.

Table 1: Domains and Subdomains of the National Quality Forum Telehealth Measurement Framework[2]	
Domain	**Subdomain(s)**
Access to Care	• Access for patient, family, and/or caregiver • Access for care team • Access to information
Experience	• Patient, family, and/or caregiver experience • Care team member experience • Community experience
Effectiveness	• System effectiveness • Clinical effectiveness • Operational effectiveness • Technical effectiveness
Financial Impact/Cost	• Financial impact to patient, family, and/or caregiver • Financial impact to care team • Financial impact to health system or payer • Financial impact to society

Articles were reviewed for these 4 criteria and the authors have attempted to closely match them in each section.

I. Operations

A. Telehealth for Improving Access to Care

Forty-nine studies were identified related to telehealth access to care. Eight were excluded because the full text of the articles was not available and one was excluded because it was a book chapter. Twenty-five articles were excluded for several reasons including papers without reported data or metrics, historical reviews on the history of telehealth, and one study where the effectiveness of telehealth was not the focus. The remaining fourteen articles were included, and the following metrics within those studies were identified.

Metrics

The included studies examined telehealth on access to specialist care and closely related topics of adoption, quality, and business models. Clinical settings for these studies were broad and included both urban, rural, remote, and international health care environments.

1) *Access* – There are a variety of metrics used to measure specialty care access via telehealth modalities that fall into general categories of quality of life, travel savings, time saving, time to access/diagnosis, completeness of evaluation and disease specific clinical outcomes. Examples from our review include use of the SF-12v2 (the abridged version of the 36 item Short Form Health Survey measuring health related quality of life), travel time/distance, time to diagnosis, time to specialist examination, time to treatment asthma control child abuse and sexual abuse examination total exam quality scores, exam completeness, and exam accuracy.[3-5]
2) *Experience* – A survey of providers in a Spanish health system found that provider perceived usefulness and staff interest in using telehealth impacted the probability of using or the intention of using telehealth.[6]
3) *Effectiveness* - One paper identified a subset of the MNCommunity Measurement 2013 Quality Metrics (Minnesota) as they related to telehealth for Diabetes, Vascular Disease, Asthma, and Depression.[7]
4) *Cost* – A number of studies addressed reduced costs as measured by miles saved, time saved, and CO2 production or travel cost.[8] For travel cost, either true costs or a surrogate were used. In the VA system, travel pay from the VA to the patient was used as a cost surrogate.[9,10] One paper examined business models for 9 telehealth centers at hospital systems and academic medical centers. They grouped the business models into 5 categories: a) Grants, b) network membership fees, c) revenue driven clinical services d), per encounter charges, e) and mixed models.[11]

   Other specific metrics for obstetrics and gynecologic care include increase in rate of pregnant women getting ultrasounds and identification of high risk pregnancy.[12] For

stroke, metrics such as the percent of population with access to stroke care within 60 minutes and access to stroke care for people over the age of 65 were identified.[13-15] For behavioral health access, improved access to psychotherapy for patients with PTSD was noted.[12-15]

Gap Areas and Conclusions

Developing metric recommendations for how telehealth improves access is challenging. It is important to understand the context of the services provided and their comparator. In some cases, telehealth was compared to no care at all and thus improved access. In other cases telehealth was a more time efficient mode of care overall. Interestingly, for some services, telehealth may improve the exam quality, especially for services that local onsite practitioners provide infrequently. The access metrics in this section addressed the National Quality Forum areas of cost, effectiveness and access, but not experience. Additional studies are needed to better define the role of emerging use of telehealth for improving access to all types of care. Review of available literature on the impact of telehealth on access to care yielded a variety of disparate direct metrics. The most notable are travel related and time to specialty evaluation. Additional measures might be developed if the approach examines current access challenges and measures how telehealth may directly impact those barriers.

B. Telehealth and Patient Satisfaction

Twenty seven articles were included and reviewed in the patient satisfaction section as related to telehealth. Eight were excluded and 2 could not be downloaded. Exclusions included articles that were descriptions of possible telehealth interventions, stance pieces on telehealth, an overview of India's health system and possible telehealth barriers, a veterinary intervention that didn't include humans, and one was excluded for being a review of instruments to measure satisfaction. Two articles had no abstract, description, nor ability to download on any site, and were excluded by default rather than intentionally. Seventeen articles were included in the final review.

Metrics

1) *Access:* A few studies used data indirectly linked to satisfaction to evaluate telehealth interventions. One study focused on travel time saved in rural Australia, finding 500km of travel was avoided in the 120 patients seen in a refugee clinic.[4] Another study reported how many in-person visits were replaced by e-visits in a specialized inflammatory bowel disease clinic. The study found that those with risk of poor follow-up who had replaced their in-person visits with telehealth visits had better access to care.[16] An audit of commercial telehealth companies evaluated variation in quality between different companies for 8 common complaints finding no statistically significant difference in visit quality between the companies.[17] One study evaluated the difficulty of cases correlating with care quality in store and forward visits.[18] A study in Brazil evaluated the potential to decrease patient referral to inpatient services in an observational retrospective survey looking at provider satisfaction results and their subsequent referrals. Using tele-consults, they found that patient referrals were avoided by 78%.[19]
2) *Experience:* Ten studies were surveys of attitudes about telehealth after implementing in varied settings, whether home visits or rural clinics. Patients and providers were asked how they judged their visit for convenience, patient safety, care quality and costs.
   Overall the surveys found a high acceptance and satisfaction rate of telehealth. A study using tele-urology for chronic condition follow-up in rural clinics found that there was no significant worsening of condition that required a trip back to the urban center. Approximately 89% of patients appreciated the convenience and 87% thought the quality was the same, echoing the actual findings of outcomes.[12]
   A group of NPs, physicians and patients were watched during a telehealth encounter by impartial observers finding that a tele-consultation led to more patient empowerment and comfort in asking questions.[13]
   Two studies led focus groups to evaluate telehealth implementation. One study looked at patients in underserved African American and Latino communities and the other was on staff perceptions on using telehealth in a hospice unit.[14,15] The focus groups in the telehospice group thought telehealth was a positive way to communicate but an extra tool to use rather than a substitute.
3) *Effectiveness:* One only study was a randomized controlled trial. Peritoneal dialysis patients were randomized to a telehealth support group versus no support group (standard)

and evaluated whether it decreased need of hospitalization rate and costs.[16] The study found decreases in all study measures including cost and need for hospitalization concluding that telehealth was useful in stable long-term patients.

4) *Cost:* The above study also evaluated cost and found a decrease in cost and need for hospitalization further creating cost savings.

The negative satisfaction outcomes were mainly concerns about safety. Patients in Los Angeles from the African American and Latin communities were concerned about how telehealth could be used and were unsure how quality could be maintained, it should be noted that this was about attitudes and the group had not used telehealth.[14,17] The study that evaluated store and forward consults found a decrease in quality when the cases were more difficult.[18]

Gap Areas

The use of telehealth is relatively new and the majority of patients have not used it. Overall the studies on satisfaction were geared toward patients in rural or remote areas where access is an issue. However, this leads to a gap in assessing access and satisfaction levels in those who are in urban areas and may also use telehealth. Also, most of the outcomes were self-reported attitudes. While a few had more concrete data outcomes such as avoided admissions, appointments and travel, further studies could use more of the concrete data and also use it to extrapolate cost savings.

Conclusions

While limited, the reviewed articles showed overall positive results that using telehealth was convenient to patients, led to increased satisfaction, decreased travel and had no noted worsening outcomes. Further studies can focus on concrete data outcomes to evaluate how telehealth can possibly decrease costs, increase access and evaluate potential unmet needs within telehealth.

C. Education in Telehealth

Eighty-six studies were identified relating to telehealth in education. Fifty-nine were excluded for reasons such as being outside of scope, lacking outcome metrics, opinion pieces, articles of legal nature, and lacking a video component. Additionally, 9 articles were excluded for reasons of appropriateness, being more relevant in satisfaction, orthopedics, telestroke, provider-to - provider or access sections. Eight articles were not located.

The remaining 10 articles focused on telehealth education in the United States, the United Kingdom, Scotland and Australia. These were separated into three categories: provider education, patient education, and the need for standardization. Quantitative metrics were somewhat limited however much descriptive data is available.

Metrics:

1) *Access:* Krupinski et al. highlighted the importance of establishing a core program champion and developing support staff with established job descriptions post-pilot phase to avoid program disruptions.[19] They go on to highlight ATP's efforts to expand telehealth 's reach by offering 500 hours of continuing medical education to American and international healthcare providers and support staff across numerous specialties.

2) *Experience and effectiveness in providers:* In the article by Brebner et al., 1003 videoconference calls were completed in Scotland with a high level of satisfaction among users in emergency medicine, clinical psychology, tele-ultrasound and medical education.[20] 150 of the 1003 videoconference calls were specific to medical education and noted no statistical difference in subsequent student examination results. The authors noted problems only when new staff members lacking telehealth training were using the platform, prompting them to suggest telehealth-specific licensing requirements. A panel of 51 telehealth experts in nursing, nursing facilities, and technicians concluded that 14 additional core competencies above those required for traditional nursing were necessary for success in telehealth professional activities.[21] These included providing psychosocial support to patients, assessing and supporting patients' ability to use technology, promoting a healthy patient lifestyle, evaluating the care plan, and providing instruction in self-care.

   Nitzkin et al. ran 1826 matched pair observations comparing a telehealth examination to conventional in person examination.[22] They found that for ophthalmology, physical therapy, and cardiac auscultation, 86.5% of telehealth findings were identical to the criterion standard compared to 91.2% of findings gathered and interpreted via conventional medical methods. Some specialties, such as radiology, were found to lend themselves well to telehealth findings. Tracings and images were interpreted at a 92% reliability level, whether reviewed conventionally or via telehealth. Ultimately, the researchers concluded that clinicians lacking telehealth training or knowledge of their platform's limitations inherently missed more findings of clinical importance than those providers recognizing

system limitations and/or with telehealth experience. However, the authors recognized subsequent advances in technology as a possible resolution. While written 21 years ago, it is important to keep this in consideration while developing future standards.

Jarvis-Selinger et al. pointed out the importance of adequate training for potential users to increase the rate of adoption.[23] They also highlighted the value of standardizing the environment in which a healthcare provider accepts videoconferences, noting that a consultant's office could encourage patients interacting via telehealth for the first time to feel more comfortable.

In the proposal by Weinstein et al., the authors recommend training to begin early in a telehealth program's development and be specific to the program's outlined goals.[24] Broens et al. recommended that all users of a telehealth program's platform be trained in its capabilities.[17] The authors recommend training to begin early in a telehealth program's development and be specific to the program's outlined goals. Broens et al. recommended that all users of a telehealth program's platform be trained in its capabilities.[17]

The paper by Doolittle et al. highlights some of the differences by which organizations define effectiveness such as cost savings or increased access to care.[25] Weinstein et al. also highlight this, noting that useful measures of success are particular to individual organizations and include achieving specific clinical outcomes, satisfaction, and cost effectiveness.[24]

3) *Effectiveness in patients:* Skoczynski et al. evaluated the role telehealth can play in managing COPD patients including smoking cessation counseling, breathing strategies, stress management, review of action plan, nutrition counseling, and pathophysiology of chronic lung disease.[26] These can be achieved via interactive lecturing, feedback and reinforcement, assessment of information needs and electronic transmission of written material allowing for customization to the individual patient.
4) *Costs:* In a review by Krupinski et al. of the Arizona Telemedicine Program (ATP), the authors noted that ATP uses their robust statewide network to share resources and reduce costs by providing live interactive telehealth training via videoconference to future telehealth providers.[27] These providers remained within the system to provide store-and-forward and real-time telehealth services to 1+ million teleradiology, dermatology, psychiatry, cardiology, hematology, infectious disease and incarcerated patients.

Gap Areas and Conclusions

Three key metrics identified in telehealth education were identified: effectiveness in patients and providers, access to care and cost savings. While these are promising, much additional research

is needed. In many of the manuscripts reviewed, education was not the main focus of the study and a lack of clear metrics was evident. Though there is value in adapting existing methodologies for our purposes, performing research specific to education in telehealth is necessary.

Future research into legal roadblocks to provider access to telehealth and education may prove valuable if broader adoption is to be achieved.

D. Telehealth in Mobile Health

A total of 23 articles were reviewed on mobile health (mHealth). Eleven articles were excluded for focusing on creating tools or apps, how to use or upload pictures to an app, or being opinion pieces on mobile health without any intervention. Two articles were unavailable; one without a listed author was excluded by default. Ten articles were included in the review. The studies focused on using or evaluating mobile health interventions in various study settings and are overlapping in the NQF framework measures as noted below.

Metrics

The manuscripts included the following broad categories:

1) *Access:* One study looked at evaluations of an eConsult service at a set of originating (spoke) centers needing specialist care for Hepatitis C and use of teledermatology services for increasing access to specialists.[28-30] All studies accessing specialists found that physicians felt their care benefitted by being able to speak virtually to specialists.

2) *Experience and effectiveness of chronic care applications:* A review of apps sharing asthma data with healthcare providers did not find tele-monitoring to improve symptom control or decrease oral steroids.[31] A study on heart failure and COPD patients related that the biggest barrier to use of home telehealth was tech issues followed by not understanding the utility of telehealth visits.[32]

2) *Effectiveness of digital image evaluation:* Another group of studies evaluated using digital images as replacement for in person or video visits, specifically for dental caries and post op vascular surgery visits.[33,34] The results showed that using images did not worsen outcomes compared to in person visits. There was no video visit component to these studies.

3) *Cost and effectiveness of telehealth compared to standard comparison:* The only randomized controlled trial in this group was a study evaluating using telehealth with digital cameras for treating pressure ulcers in a home care setting, patients were randomized to weekly visits with telehealth and wound care, weekly visits with only wound care, and customary care. They evaluated time to heal, costs, LOS, wound status and found that the group with telehealth had longest non-healing wounds, length of stay and costs. However, that group had the largest initial wound size so they were unable to determine if these results had any significance.[35]

Gaps

Most of the studies in this group had to be excluded for evaluating how technology may be used rather than evaluating patient use, satisfaction and clinical outcomes. The studies included did

give useful information about how to move forward with using telehealth, namely that digital images may be a useful replacement for in person visits, that tech issues are a large barrier for using telehealth, and that specialist access helps remote providers provide better care to their patients. The only randomized controlled trial did not have an equal distribution of illness severity in the groups likely introducing bias, solidifying that even health technology research needs to be standardized to show significance. Further studies are needed that evaluate patient care and quality and a comparison of telehealth versus standard care, rather than an evaluation of how an app works.

Conclusion

Mobile health, including the use of telehealth and apps, is new, as reflected in the sparse amount of information and data available. There were few articles, mostly reviews, and had little or no clinical outcomes. A few studies showed positive outcomes with using digital images for patient care which leads to optimism that patient safety can be maintained while using mHealth. Barriers to patient and provider understanding of telehealth and tele-monitoring's utility still occur. There exist many opportunities for further and improved research on the safety and quality of apps, tele-monitoring and home telehealth.

E. Telehealth for Chronic Care

Forty-one studies were identified related to telehealth and chronic care. Twenty articles were excluded. Reasons for exclusion included the type of article (conference abstracts, clinical practice guidelines not involving telehealth, descriptive articles), focus of interaction (modification to EMR, texting, diagnostic microscopy), or lack of clinical data. One article was not able to be located. The remaining twenty-one articles were included, and the following metrics within those studies were identified.

The included studies utilized telehealth for the management of chronic care illnesses such as diabetes, cardiovascular disease (hypertension, CHF, arrhythmia), strokes, urologic (colic, hematuria), respiratory illness (COPD, asthma, chronic ventilator, sleep apnea), and gastroenterological diseases (hepatitis, inflammatory bowel disease). Within these studies, several endpoints were examined including operational outcomes/metrics, clinical outcomes, patient satisfaction, patient knowledge, travel/time savings, ED visits, access to care, and improved diagnostics. Clinical settings for these studies included locations across the United States, Europe and Australia. Studies were performed in both home and hospital environments of care. No study was specifically conducted in an emergency center or urgent care. Interventions included contact by telephone, two-way video, automated messaging, and remote electronic monitoring.

Metrics

Within reviewed studies on telehealth use for chronic care management, the following metrics were identified:

1) *Access:* In one study of patients with inflammatory bowel disease, patients who had access to electronic visits and electronic messaging had an improvement in the two-month follow-up rate after active disease (40% for in-person visits vs 70% for electronic visits).[36] There were no noted differences in complication rates or unplanned ED visits. Dykes was able to show that the percent of patients receiving a follow-up appointment within 2 months of a visit for active inflammatory bowel disease improved from 40% to 70% with the use of alternate care through telehealth visits[23].

2) *Experience:* Safir revealed a high acceptance of a telephonic consultation with a urology clinic for a 20-25 minute structured telephone encounter to determine if additional urology follow-up was required.[12] Additionally, 98% of patients preferred the telephone encounter to face-to-face clinic visits. Factors affecting this preference included transportation and logistic issues for an in-person clinic visit.

3) *Effectiveness*
   a. Rate of ED visits or hospital admissions - One article on the use of video clinic visits and photographs identified no differences in hospital admissions, wound healing, or amputation for patients followed with telehealth compared with patients seen at the in-person clinic.[37] However, mortality was noted to be higher in the telehealth group for

unclear reasons. A Cochrane review of telehealth for COPD examined the impact of team-based interventions through telehealth vs. face-to-face encounters.[38] Overall ED visits were reduced using telehealth encounters with no change in mortality and an increase in quality of life. However, a different Cochrane review on the efficacy of remote asthma check-ups for adults and children was not able to determine any impact on ED utilization or hospitalizations due to the low number of hospital encounters in both study populations.[4] Another study of patients with chronic lung disease who had been hospitalized and placed on long term oxygen therapy did not show any improvements in hospital admissions, home visits, or quality of life for patients utilizing tele-monitoring.[39]

b. *Clinical outcome*: A control matched study of tele-conference visits for hypertension care in rural areas noted that more patients met their treatment goals when visits were conducted via telehealth.[40] An evaluation of post CVA patients noted equal results in the ability to assess apraxia between in-person and telehealth evaluations.[41] The use of off-site telemetry monitoring demonstrated an increase in accurate and timely notifications of monitored events for the remote-monitored group.[42] Additionally, standardization of use through remote telemetry reduced the number of non-ICU patients monitored by 15.5% compared with the previous 13 months using on-site telemetry.

4) *Cost*: Long term cost effectiveness for patients with a raised cardiovascular risk was examined in a randomized controlled trial of 42 general practices in England.[43] Education, BP monitoring, and medication compliance were delivered via telehealth for 12 months. The article concluded that the probability that an intervention was cost effective increased as the effect of the intervention persisted over time. Cost effectiveness for the telehealth intervention was demonstrated after only one year of long-term effectiveness. Using home telehealth to facilitate communications between patients, clinicians, and administrative staff for patients with congestive heart failure noted decreased costs and decreased readmissions while improving patient satisfaction with the care experience.[44] A study of peritoneal dialysis patients that were given access to monthly visits that alternated between in-person and telehealth visits demonstrated savings in transportation, but the savings were less than the cost of the technology needed to perform the remote encounters.[16]

Gap Areas and Conclusions:

Five key metrics for chronic care management via telehealth were identified in the studies reviewed – ED/hospital utilization rates, clinical outcomes, cost effectiveness, travel/time reduction, and access to care. Patient attitudes toward the use of telehealth were generally favorable. Although not all chronic telehealth interactions led to decreased utilization of emergency center visits or hospital admissions, most studies suggested that telehealth interactions were non-inferior compared with in-person care. One RCT noted no difference in wound healing or amputation but a slight increase in mortality for the group using telehealth.[45] No additional study noted a worsening clinical outcome for patients utilizing telehealth strategies. Future studies of cost need to include the costs of the telehealth equipment when comparing against the costs of standard care.[16] The studies that examined telehealth effects on

travel and access to care were mostly based in rural populations. More studies are needed to assess the impact of telehealth on travel and access in urban areas where different barriers to transportation and access may exist. Overall, the reviewed studies illustrate the potential for telehealth to decrease hospital re-admissions, improve clinical outcomes, lower the cost of care, and increase access to care for patients with chronic conditions. However, more studies will be needed to define which chronic health conditions benefit most from telehealth interventions such as tele-monitoring, remote visits, and standardized education.

II. Service Lines

A. Provider to Provider Telehealth

Twenty-seven articles referencing provider-to-provider telehealth and its use were identified. Sixteen articles were excluded for a variety of reasons ranging from non-generalizable description pieces (e.g. case studies), review papers, policy statements, experimental protocols, and assessment tools. The remaining eleven articles were included for analysis.

Telehealth applications between providers in the literature varied greatly in terms of subjects investigated, study settings, topics investigated and study measures. The subjects ranged from prehospital providers, specialty consultants, ICU nurses, respiratory therapists and general practitioners. Of note, many of the studies were done in remote or rural settings in countries as diverse as Portugal, France, Brazil, Italy. One study was performed at 10 international field sites within the Doctors without Borders organization.[46]

Metrics

The papers covered a broad range of topics from technical aspects of telehealth such as obstacles in cellular communication to improvement in neonatal resuscitation rates via video-assisted consults.

1) Access, *Experience and Effectiveness:* The most helpful studies directly compared e-consults to face to face (FTF) consults by measuring correlation of diagnostic accuracy, provider and patient satisfaction and speed of consult. One study reported faster times to obtain and perform e-consults than FTF consults.[47] In this cohort, both patients and providers preferred e-consults to FTF consults and there were no adverse events. There was an unintended consequence of doubling the number of requested consults over the study period. In another study teleneurology consults by general practitioners led to more downstream testing than similar FTF consults.[48] It was found that neonatologist tele-consults resulted in better resuscitations evidenced by a faster mean time to establish effective ventilation in the intervention group (2 min 42 s vs 4 min 11 s). A study by Fang assessed if a real-time audiovisual link to a neonatologist improved resuscitation of neonates in a simulated trial with pediatric residents.[49]
2) *Effectiveness:* A study investigating obstacles to telemedicine use reported that insufficient time was the most common reason 89.8% of EMTs did not initiate a call; 54% reported they were unable to reach the call center physician despite multiple attempts.[50] Nurses agreed that teleICU improved patient care; they also identified several barriers to its use.[51] An Italian study found medical management to be satisfactory in 79% of cases in their

investigational group; Use of telemedicine consultations prevented medical error vulnerability in 56% and mitigated it in 15%.[52] Adherence to depression management guidelines by nursing home practitioners was improved by geriatrician tele-consultation recommendations.[53]

3) *Cost:* Four studies attempted to partly address the question whether tele-consultations could potentially avoid a patient face to face referral or visit indirectly resulting in a reduction in overall cost.[28,48,54,55]. However, the group of providers studied, differing clinical settings and mixed results made it difficult to reach a unifying conclusion.

Gap Areas and Conclusions

Overall, many of the studies were of poor to mediocre quality suffering flaws in design or power making it difficult to reach any satisfying conclusion. The current literature investigating provider-to-provider tele-consultations is sparse and many gaps exist. Little is known regarding the scope or type of tele-consults that are currently performed, their effectiveness or how to improve future tele-consults between providers. Key questions in future research should include, but not be limited to, studying availability of provider to provider consultations, appropriateness of tele-consultations, accuracy of diagnoses, avoidance of downstream face to face consults, cost effectiveness, conditions that are or are not amenable to tele-consultations, and satisfaction of providers and patients.

B. Telehealth in a Prehospital Setting

Fifteen prehospital articles were identified by the abstractors for full text review. Eight were excluded. Among these, 2 were excluded for being simulations, an additional 6 were excluded for not including a real time or face to face clinical interaction.[50,56-63] One additional paper lacked any data and was limited to opinion or consensus.[61] Six papers remained for inclusion.

Metrics:

Among the topics addressed in the prehospital telehealth literature studies were:

1) *Access:* One study addressed ED triage in nursing homes and rural settings.[64] A few studies evaluated telehealth as an adjunct for prehospital triage in the context of disaster evacuations and transfer from rural centers.[65,66]
2) *Experience and Effectiveness:* One study evaluated the use of telehealth in decreasing reperfusion time for stroke patients.[67] We also included a case report of use of a mobile stroke unit for the evaluation and triage of an intracranial hemorrhage.[68] The outcomes assessed were highly variable, demonstrating a variety of intermediate outcomes including decreased reperfusion times, decreased ED visits, and decreased evacuations from a disaster scene.[65-67,69]
3) *Cost:* None of the studies assessed cost.

Gap Areas and Conclusions:

The key findings of the papers in this section demonstrated that use of telehealth is feasible for prehospital assessments and specialist consult with respect to triage and treatment. The specialists were able to provide decision support to paramedics and other prehospital providers. None of the studies were able to demonstrate a benefit with respect to mortality or functional outcomes.

Future studies need to move beyond feasibility and look at patient centered outcomes including mortality and functional status. Descriptions of both under and over-triage must also be addressed. In addition, studies must be performed to validate the use of prehospital telehealth for triage and intervention. In these cases, defining the incremental benefit of the prehospital intervention beyond that of the paramedic evaluation alone are necessary.

C. Telehealth for Urgent Care

Six studies were identified related to telehealth and urgent care. Three articles were excluded: one because it was a consensus document not in English, one was only a commentary, and the other was not related to urgent care. The remaining three articles were included, and the following metrics within those studies were identified.

Of the three included studies, one evaluated adherence to sinusitis treatment guidelines using asynchronous e-visits, one assessed the safety and effectiveness of acute care telehealth in children with and without special needs, and the other assessed pediatric telehealth comparing home versus school-based care.[70-72]

Metrics

In studies on telehealth use for urgent care, the following domains were assessed.

1) *Access*: Although not directly assessing access, McIntosh found the pediatric acute care in the home was thought to be more convenient than alternatives by 94.5% of respondents.[72]
2) *Experience*: McIntosh studied satisfaction and found that 97.6% of respondents were satisfied with care at home
3) *Effectiveness:* found that compared to children without special needs, children with special needs were just as likely to be able to complete the visit, and were no more likely to require 1 day or 3 day in person visits.[71] They had similar adverse event rates, demonstrating the telehealth is just as effective for children with special needs as other children. Smith found that a brief educational intervention was able to improve guideline compliance for treatment of sinusitis in 29 providers.[70]
4) *Cost:* None of the studies assessed cost

Gap Areas and Conclusions

There were small number of studies in urgent care, one was with asynchronous care and two with synchronous audio with video visits. Clearly more data is needed to determine the impact of synchronous and asynchronous forms of telehealth on access, cost, experience and effectiveness.

D. Telehealth for Emergency Medicine

Sixty-one manuscripts relating to telehealth use in emergency medicine were reviewed. Thirty-eight were excluded: nine were descriptive, eight were opinion pieces, seven did not describe outcomes relevant to emergency medicine, four were telephone only, four involved only transmission of data (images, video clips or EKGs), three were letters to the editor, one was an economic analysis, one was written in Italian only, and one was not a telehealth study. Additionally, fifteen papers were included in other sections (telestroke, prehospital, pediatrics or ophthalmology).

Metrics

Specific outcome-based metrics are limited in this group of studies. However, some useful descriptive data are available.

1) *Access:* Two manuscripts described platforms used to decrease emergency department utilization while providing alternative access to care.[69,73] One was used in a senior living community and the other in a correctional facility. These studies showed significantly decreased utilization and also decreased wait times.

   The two manuscripts in this section demonstrated significant decrease in ED utilization in the populations studied. In the senior living facility, ED utilization decreased by 34% annually compared to a control group.[64] In the correctional facility population, 38% of patients avoided transport out.[73]

2) *Experience:* One paper described the use of telehealth to aid in the initial care and appropriateness of evacuation decisions for patients in a mass casualty scenario.[57] This was a simulation that took place in Lithuania. The participants felt positively about the use of telehealth in maximizing resource utilization during a mass casualty event.

   Another study was a description of a robust "TelEmergency" program in rural Mississippi at a variety of sites.[74] This program relied heavily on advanced practice providers and the overall goal was to provide timely emergency care to those who otherwise would not have had access to it. They demonstrated both high patient and hospital administrator satisfaction by those who used the service. Although clinical outcome data are not reported, the performance improvement parameters are described in detail. 87.3% of patients felt they received care that was as good as or better than they would have received with an in-person physician and 91.2% stated they would be likely to re-utilize the system if necessary. 85.6% rated their care as good or excellent.[74]

3) *Effectiveness:* Three manuscripts described use cases in tele-consultation, wherein a health care provider at one location was able to utilize a telehealth platform to consult another physician.[75-77] These papers demonstrated diagnostic accuracy comparable to in-person visits and also expedited throughput times.

In one study involving plastic surgery consultation, there was 85.7% agreement between in-person and telehealth consultation.[75] A portion of this difference can likely be attributed to differences in provider opinion that did not relate to the modality used. The telehealth group was seen in an average of 8.9 minutes and the in-person group 48.7 minutes**.**

Another study described telehealth use in a rural setting to decrease medication errors in pediatric critical care cases. The use of telehealth was shown to decrease these errors from 12.5% to 3.4%.[78] Some of these errors may not have been clinically significant.

4) *Cost:* None of the studies assessed cost.

Gap Areas

Metrics describing clinical outcomes are lacking. Additionally, it is difficult to determine which metrics are relevant given telehealth platforms are frequently used not as an alternative to in-person care, but as an alternative to no care at all. The "TelEmergency" study by Galli provides preliminary satisfaction data (from both patients and hospital administrators) but no specific outcome data.[74] Performance improvement described in this paper may serve as a tool for other systems interested in implementing such a system and data from such programs will likely be of use going forward.

Conclusions

Although limited, the limited data on emergency medicine applications of telehealth are encouraging. They suggest that its use decreases ED utilization and expedites care without sacrificing diagnostic accuracy or patient safety. There are still many opportunities for further research, especially in the way of clinical outcomes and patient safety.

E. Telehealth for Skilled Nursing Facilities

Eight studies were identified related to telehealth and skilled nursing facility care. Five articles were excluded for being protocol descriptions without reported data or metrics, reviews on the history of telehealth, and one study where the effectiveness of telehealth was not the focus. The remaining three articles were included, and the following metrics within those studies were identified.

The included studies utilized telehealth for skilled nursing care to assess impact on ED utilization, quantify perceptions of telehealth functionality in nursing homes, and assess attitudes of patients and providers towards telehealth use in nursing homes. Clinical settings for these studies included adult senior living communities in the United States and a geriatric hospital in France. A national conference was used by Drissen to survey nursing home physicians about attitudes towards telehealth.[79]

Metrics

In studies on telehealth use for skilled nursing facilities, the following metrics were identified.

1) *Access*: In the one study, telehealth was used to provide medical access to residents of a senior living community.[64] This study was able to document a 34% decrease in the rate of ED use for residents of an adult living community over a one-year period.
2) *Experience:* After surveying nursing home physicians, Drissen identified that these providers agreed with the potential of telehealth to improve timeliness of care, care effectiveness to prevent avoidable hospitalizations, and resident privacy.[79] The survey participants also expressed a desire for the availability of a digital stethoscope and high-quality video/audio.
3) *Effectiveness:* Esterle directly observed telehealth sessions to analyze their impact on professional work practices and care organizations.[80] This study identified three key features for the success of a telehealth program including starting the program with an effective project manager, developing trust in the person assisting at the origination site, and understanding that the physician at the origination site may experience a sense of humility due to direct review of his/her care by another physician. The use of telehealth under ideal circumstances was able to reduce transports to specialty consultants and effectively increase access to care.
4) *Cost:* None of the studies assessed cost.

Gap Areas and Conclusions

Developing metric recommendations for the use of telehealth in skilled nursing facilities is limited by the low number of relevant studies identified within the search parameters. Additional studies are needed to better define the role of telehealth in skilled nursing facilities. Review of available literature on the use of telehealth in a skilled nursing facility setting provided few direct metrics. Outcomes may be measured by the rate of ED transfers or avoidable hospitalizations.

While such outcomes may be an indirect measure of cost effectiveness, future studies should include a direct assessment of the impact on total cost of care for skilled nursing residents. Additional measures might be applied to organizational aspects of a telehealth program and establishing minimum equipment and system performance needs.

III. Specialty Care

A. Telehealth for Pediatrics

Thirty articles referencing telehealth and it use in care of pediatric patients were identified. Nineteen articles were excluded for a variety of reasons; some were opinion papers or editorials, others were only descriptive in nature with no metrics provided. Some were excluded as they were only reviews of new innovative practices, patient acceptance, liability, or future potential. There were 7 pay-per-view articles which were dismissed based on review of the free available abstract which suggested there were no metrics included. The remaining 11 articles were included and several trends were noted.

Telehealth applications for pediatrics ranged over a wide range of topics predominantly telemental health, but also including care of diabetic, critical care, inflammatory bowel disease, hearing screening, fetal urologic abnormalities, acute care for children with regular and special needs, physician ED teletriage, pediatric hospitalized patients (in the ED, ward, and intensive care units), neurology, international radiology, direct to consumer (home, child care, schools, and detention centers), sexual assault, and remote craniotomy supervision following trauma.

There are a number of studies which look at patient/family satisfaction, most of which suggest that telehealth is often favored over an in-person encounter. Most of the encounters described are not emergent and generally not time sensitive. As a result, there are almost no time measurements reported in the articles. But a number of items are described which have the potential for tracking time intervals for quality improvement purposes.

Metrics and Gap Areas

Metrics looking at time from consult request to initiation, diagnosis, and conclusion are lacking. The following metrics were identified in the Pediatric studies.

1) Access

- A successful feasibility report was provided by pediatric radiologists from 18 countries who were providing reports for store and forward radiographs of children in South Africa. While patients did not have to travel and received radiograph interpretations from radiologists rather than just primary care physicians, there were no comparison groups. Language barriers (between the radiologist and the local primary physician) existed as were there challenges due to older x-ray machines and internet bandwidth for image transmission. Legal limitations due to medical licensure where also mentioned. More studies will be need to assess sustainability of services like this to underserved children in developing countries.[81]

- Jones describes the setup of a telemental health program for children exposed to trauma. The process of developing this cognitive-behavioral therapy in an existing rural outreach facility is discussed, but there is no patient data.[82]

2) *Experience*
   - Parents rated neighborhood pediatric telehealth services very favorably, with convenience being the highest rated advantage. Negative responses were for lack of toys in waiting area, delayed call in by physician, having to go elsewhere to get prescriptions filled, and one report of equipment failure.[72] Costs to maintain staff and facilities compared to cost to families will require additional investigation.
   - Pediatric telepsychiatry is an area which is rapidly growing. Diagnostic accuracy is very good and patients and families often prefer having the patient in their home environment.[83]

3) *Effectiveness*
   - Avoidance of Transfer: While one study looked at avoidance of transfer of patients with a variety of complaints because of telehealth evaluation and treatment recommendations, it was retrospective. It also had no more than 7 patients with a particular diagnosis, and many of the other 16 diagnoses with only a single case.[84] Many more ailments remain which need investigation as well as prospective study designs.
   - Acute Care services: One study looked at acute care services and the need occurrence of in-person encounters for the same problem within 1-3 days, finding a 5.3-8.9% duplication for children in regular childcare and schools and those with special healthcare needs, respectively, and an overall 16% duplication of visits at 3 days. Adverse events following telehealth consults were 0.5% and 0.3% for the same respective groups.[71]
   - Use in minor conditions: There are reports concluding that telehealth is reliable means of diagnosing minor conditions, such as skin rashes, as well as minor trauma-related conditions such as wounds, facial lacerations, and burns in children. The inter-rater reliability ranges from 82-100%.[85] This type of study is lacking for other conditions for which a remote encounter may be inadequate.
   - Dharmar's study of 322 rural ED consultations concluded that telehealth consultations with video provided highest quality care and were more likely to result in change of diagnosis 47.8% of the time, and yielded the highest parental satisfaction. This compared to telephonic consults which changed the diagnosis only 13.3% of the time and had lower parental satisfaction.[86]
   - Internal QA/CQI chart reviews and reporting of concurrence and incidence of discordance is an area needing further validation. While a simple circulatory and neurologic exam was checked for inter-rater reliability in a PICU setting, this is still an area of research for other settings and conditions.[87]
   - There are recommendations to integrate care with other healthcare providers to reduce complications of polypharmacy.[88] As pediatric psychiatry expands via telehealth, guidelines similar to those for adult psychiatry will need to be developed and their impact studied.[83]

4) *Cost*

- Joshi writes a descriptive piece pointing out that the American Academy of Pediatrics embraces the concept of providing comprehensive care in the most efficient manner at the least expense to the patient's home. Teleneurology can provide that in the home, particularly for conditions such as "epilepsy, movement disorders, dementia and headaches where inspection is more critical than palpation… [Telehealth] is even more uniquely applicable to pediatric neurology where a majority of the exam in an uncooperative toddler is through inspection."[89]
- This area is variably and tangentially acknowledged, but there are no studies or guidelines addressing this, either from the development, implementation, or consumer sides.

Conclusions

Pediatric application of telehealth is a relatively new field despite being in an area in which many health care providers would like to have ready access to consultations for more complex patients. It is also a vehicle to provide services to rural and remote areas where pediatricians and psychiatric services are scarce. This novel area presents many areas for research and development of metrics to ensure timely, prompt, and topnotch care. Further development needs to occur in rapidly expanding areas like pediatric telepsychiatry, chronic disease management (e.g. sickle cell), direct to consumer apps compared to inner city and rural/remote centers. Convenience, safety and avoiding unnecessary transfers due to travel time and distance require more investigation. Identifying areas where pediatric interactions differ from adult counterparts must be studied, such as distraction techniques which are more difficult to perform virtually with a restless child. Just as with adult telehealth, policies to establish and or select qualified providers, clear identification of the patient, access and sharing of medical records, cost analysis, and diagnostic accuracy, recidivism, and errors must be well established to help obtain governmental legislative and financial support of these endeavors.

B. Telehealth in Dermatology

Sixteen articles referencing telehealth and it use in dermatology were identified. Nine articles were excluded for a variety of reasons; some were opinion papers or editorials, others were only descriptive in nature with no metrics provided. Some were excluded as they were only reviews of new innovative practices, international applications, or referring physician and patient acceptance. There were 2 pay-per-view articles which were dismissed based on review of the free available abstract which suggested there were no metrics included. The remaining 7 articles were included and the following teledermatology highlights were identified.

Metrics

Teledermatology applications included physician-initiated consults, both within the US and internationally, as well as direct to consumer services. The American Telemedicine Society has published guidelines which are aimed primary for the physician/clinic-initiated consultation and less about direct to consumer care.

1) Access

A VA study reported that they decreased the time until face to face consultation from mean of 64.2 days to 20.3 days with the use of telehealth.[90]

2) Experience and Effectiveness

One study suggested that total agreement between in person and smartphone teledermatology was 54%, partial agreement was 27%, and disagreement was 19%.[30] The diagnostic accuracy for subspecialty teledermatology for pediatrics and geriatrics is 65% and 88% respectively.[91] More experienced dermatologists rendered more accurate diagnoses via smartphone apps than less experienced ones did in face-to-face in-patient encounters.[30] As many of these encounters are performed in a store and forward fashion for later evaluation, quality of photographs taken by the primary provider or patient were critical, including focus, background, angles, close-ups, and overall photo.[30] Training staff who initiate consults to take optimal photos was suggested by several authors.[30,92,93]

3) Cost

Direct to consumer use of credit cards to pay for teledermatology services to purchase apps and provides another area for future reporting.[92] Interestingly, the applications are usually free but require in app purchases of consult services ranging from $0-79, some of which are covered by commercial insurance.[92]

Gap Areas & Conclusions

Teledermatology systems can be improved by providing guidance on best practices, using pre-filled referral forms, follow-up on cases after tele-consultation, and establishing standards for clinical photography. While intuitive, this was not found to be practiced by the majority of specialists. Minimal standards have been suggested, as well as external credentialing to evaluate them. The American Telemedicine Association created guidelines for teledermatology.[94] Metrics to objectively demonstrate compliance with recommended guidelines must still be developed. Cost analyses of in and outpatient teledermatology services are still lacking.

C. Telehealth for Wound Care

Six articles referencing telehealth and its use in wound care were identified. Two articles were excluded; one because it could not be located and the other because it was an opinion without objective measurements. The remaining four articles were included and the following metrics and/or conclusions were identified.

Metrics

Two of the studies focused on post-operative wounds, one on acute traumatic wounds and one on pressure ulcers. There were 80, 35, 173 and 103 patients, respectively, in the four papers.

The various take home messages from the articles reviewed were as follows:

1) *Access:* Telehealth can improve access, decrease travel time and requirements at a lower cost.[95]
2) *Experience:* Many patients preferred telehealth wound care checks to in-person follow up.[95]
3) *Effectiveness:*
    - Telehealth using smart phone digital imaging for evaluating post-operative vascular surgery wounds is comparable to in-person evaluation with regard to most wound characteristics.[34]
    - Telehealth wound care video images allowed the ability to distinguish between minor and non-minor wounds, predicted the need for hospital management, and had high degree of sensitivity and specificity. The study demonstrated that wound characteristics and management decisions appear to correlate well between video and bedside evaluations.[96]
    - Telehealth in pressure ulcer wound care is useful but had limited power when it does not include wound size or type.[35]
    - The Vella 2015 article specifically pointed out that "many patients preferred (tele-wound follow up) to in-person follow up." [95]
4) *Cost:* Cost was reported to be lower but no specific figures were reported.[95]

Gap Areas

Full papers were not available and reviewer relied on information available in abstract/conclusion. Only 4 studies were available, had a limited number of enrollees and didn't compare a standardized type and size of wounds. Having larger studies and multiple studies of similar patient populations that resulted in similar outcomes would provide more confidence in benefits. Internal QA/CQI chart reviews and reporting of concurrence and incidence of discordance is an area needing further validation. It would be helpful to find objective,

quantifiable metrics that address experience, costs, effectiveness and access in order to demonstrate potential benefits instead of assumptions or statements based on opinion.

Conclusions

Telehealth for wound care offers the possibility to improve access, lower costs, improve patient satisfaction while having a high degree of sensitivity and specificity. Further research and studies would be useful in determining this potential value and its various applications.

D. Telehealth for Orthopedics

Five articles referencing telehealth and it use in care of orthopedic patients were identified. One article was excluded because it was a local guideline developed for clinical decision support and an eConsult program.[97]

Metrics

Telehealth applications for orthopedics included consults for evaluation of musculoskeletal injuries and rehabilitation.

1) *Access:* One article described a retrospective chart review from orthopedic consultation for musculoskeletal injuries occurring in the military theatre.[98] All civilians were excluded. Charts from 2009-2012, including 597 consults, 305 of the upper extremity and 221 from the lower extremity were examined. 87% were male, and 93% were service members with a mean age of 29. While the article text was unclear, it appeared that the majority of these consults were store and forward. The main outcomes were avoidance of MEDEVAC (medical evacuation) when the local provider was considering it. They were able to avoid 26 MEDEVACS concluding that Tele-orthopedic consultation in military theatre was feasible and could prevent some MEDEVACS.
2) *Experience and Effectiveness:* Three articles related to telerehabilitation were included.

    - The first article was a prospective comparison of in person and then telehealth evaluation of patients with elbow injuries recruited from a physiotherapy clinic.[99] This small study of 10 patients in Australia compared diagnoses and inter-rater reliability and was able to demonstrate high levels of agreement.
    - The other two articles were reviews. The first examined published studies on musculoskeletal conditions and rehabilitation after elective orthopedic procedures.[100] They included 13 trials totaling 1520 participants focusing on the effects of home tele-monitoring by phone or video on rehabilitation for orthopedic conditions like osteoarthritis and procedures like hip and knee arthroplasty. The focus was clinical outcomes, pain, quality of life, disability and function. When compared to controls they found statically significant effects in favor of telerehabilitation over standard care in respect to physical function and disability.
    - The second review article was a systematic literature review from 2000-2014 focusing on telerehabilitation post knee replacement and knee arthroplasty.[101] They included 6 studies with 408 participants from Canada, Australia, and Spain. They only included randomized trials evaluating efficacy, quality of life or patient reported outcomes that compared physical therapist interactions with either telephonic/video interactions or in person conventional rehabilitation. Metrics included change in range of motion, QOL, and WOMAC Score (Western Ontario and McMaster Universities Osteoarthritis Index). They found evidence of the

efficacy of telerehabilitation on physical ($p < 0.05$) and functional ($p < 0.001$) measurements on the participants, before and after treatment.

3) *Cost:* None of the studies assessed cost.

Gap areas

There are gap areas in the evaluation of tele-orthopedics effectiveness. Areas of future research include efficacy and best practices for real time and store and forward tele-orthopedics. More specifically, it would be helpful to examine those diagnoses that often prompt orthopedic consultation to the ED.

Conclusions

Orthopedic applications of telehealth are a relatively new field. Orthopedics is an area in which many health care providers would like to have ready access to consultations for more complex patients as well as to provide services to rural and remote areas where services are scarce. There is more literature regarding orthopedic telerehabilitation than acute care consultation; however, our review does suggest that telerehabilitation can be effective and that tele-orthopedic consults are feasible for improving access. The topics cover the areas of access and effectiveness; however, neither area contains research on cost or patient experience. This novel area presents many areas for research and development of metrics to ensure timely, prompt, and high-quality care.

E. Telehealth for Otolaryngology

Four articles referencing telehealth and it use in care of otolaryngology (ENT) patients were identified. The one article excluded was from the European Respiratory Society regarding home tele-monitoring for chronic ventilator dependent patients which was only included in otolaryngology because it did not fit in any of the other categories.[102] The article reviewed the literature and concluded that there was not enough evidence yet to make recommendations.

Metrics

Telehealth applications for ENT ranged from hearing and audiology services to general ENT care and ENT related care.

1) *Access:* One article described the successful feasibility testing of a telehealth model for a pediatric hearing screening program in Tajikistan.[103] Reeve et al in 2014 described the use of a remote ENT specialist to improve access to care for indigenous populations in Australia, which reduced time to ENT consult and improved primary care management for pediatric ENT complaints.[104]
2) *Experience:* There were no direct experiential reports
3) *Effectiveness*: We included only one paper from reviewed articles. A study from the UK as a prospective randomized crossover trial of 72 inpatient and outpatients with COPD or chronic respiratory disorders evaluating the effect of home tele-monitoring on hospitalization for acute exacerbation.[39,105] They evaluated time to first hospitalization, respiratory admits over 6 months, and health related quality of life [hospital anxiety and depression scores (HADS), EuroQol-5d (EQ-5d), and self-efficacy using the Stanford self-efficacy scale]. There were no differences in the control and tele-monitoring groups.
4) *Cost*: None of the studies assessed cost.

Gap areas

There are large gap areas in the evaluation of tele-otolaryngology effectiveness. Areas of future research include efficacy and best practices for remote hearing evaluation in adults and children, store and forward consults as well as streaming video correlation for the ENT examination, and usefulness of remote emergency consultation to support originating site providers in complex ENT cases and emergencies among other areas.

Conclusions

ENT applications of telehealth are a relatively new field. ENT is an area in which many health care providers would like to have ready access to consultations for more complex patients. It is also a vehicle to provide services to rural and remote areas where services are scarce. There is very little literature regarding ENT telehealth or useful metrics for emergency physicians regarding experience or cost. Our review does suggest that hearing screening, general ENT and management and monitoring of chronic ENT and respiratory conditions is feasible. This novel area presents many areas for research and development of metrics to ensure timely, prompt, and high-quality care.

F. Telehealth for Ophthalmology

Three articles referencing telehealth and it use in care of ophthalmology patients were identified. One article was excluded because it was a program review at a single clinic primarily focused on operational outcomes.

Metrics

Telehealth applications for ophthalmology included emergency ophthalmology consults and diabetic retinopathy screening.

1) *Access*: Diabetic retinopathy screening: The article from Tsan was excluded because it was limited to a single VA clinic offering adult diabetic retinopathy screening; however, they did increase their rate of screening by offering telehealth access.[106]
2) *Experience and Effectiveness*: A study from Columbia University looked specifically at retinopathy of prematurity (ROP).[107] This was a prospective study comparing expert ophthalmology exams with telehealth exams using store and forward images. They used standard NIH ROP evaluation scales based on identification, severity, location and blood vessel appearance. They demonstrated agreement between the standard exam and telehealth exam at 86.5% with inter-rater reliability of 78%.
   A British study compared in person and telehealth consultations in emergency department patients.[108] The telehealth exam was facilitated by an ophthalmic nurse trained in slit lamp and Goldman applanation tonometry. The nurse conducted the exam supervised by the telehealth ophthalmologist. They found no clinically important disagreement between telehealth and in person evaluations. They did note more disagreement when the slit lamp was not used and less disagreement as the telehealth provider became more experienced. There was no difference in length of consultation.
3) *Cost:* None of the studies assessed cost.

Gap areas

There are large gap areas in the evaluation of tele-ophthalmology. Areas of future research include efficacy and best practices for real time and store and forward tele-ophthalmology. More specifically, it would be helpful to examine those diagnoses that often prompt ophthalmology consultation to the ED. Another area to examine is the value of store and forward tele-diabetic retinopathy screening in the ED.

Conclusions

Ophthalmology telehealth applications are a relatively new field. Ophthalmology is an area in which many health care providers would like to have ready access to consultations for more complex patients. It is also a vehicle to provide services to rural and remote areas where services are scarce. There is very little literature regarding ophthalmology telehealth; however, our review does suggest that tele-ophthalmology consults for ED patients is feasible in improving access, but there is little to no information on cost or patient experience. This novel area presents many areas for research and development of metrics to ensure timely, prompt, and high-quality care.

G. Telehealth in Trauma

Twenty-two trauma articles were identified by the abstractors for full text review. Fourteen were excluded. Among these, 5 were excluded as they represented only opinion or consensus. [109-112]). An additional 3 were excluded as they did not include a real time or face to face clinical interaction.[58,113,114] Three additional studies were limited to simulations, tests of feasibility, or educational activities.[115-117] Three studies were case reports of limited generalizability.[68,118,119] Although these were not included in the analysis, they did demonstrate the use of telehealth for evaluation of a traumatic head injury using a mobile stroke unit, telepresence during a trauma evaluation, and performance of pediatric craniotomy with telehealth support. Nine papers remained for inclusion.

Metrics

Among the topics addressed in the trauma telehealth literature studies were:

1) *Access:* There were no discussions regarding access in the papers reviewed.
2) *Experience:* There was no discussion of patient or provider experience.
3) *Effectiveness:* Use of telehealth in triage and treatment decisions.[120-126] The outcomes assessed were highly variable; while some studies focused on patient disposition, several were focused on agreement between a remote expert and the local provider, and others looked at intermediate outcomes of patient safety or clinical effectiveness.[120-123,126] Only one was powered for and assessed mortality.[124] One study was a review of 24 other publications that evaluated the assessment of trauma patients based on transmitted images. The outcomes assessed were feasibility.
4) *Cost:* There was no cost discussion in the papers.

Gap Areas and Conclusions

The key findings of the papers in this review were that the use of telehealth is feasible for trauma assessments and useful for decision support with respect to triage and treatment. None of the studies were able to demonstrate a benefit with respect to mortality. Of note, one of the studies noted that use of the tele-consult resulted in no difference in outcomes and delayed care.[123]

Future studies need to move beyond feasibility and look at patient centered outcomes including mortality and functional status. In addition to defining the benefit, future studies must also address potential adverse events associated with the tele-consult including delays in definitive care, misdiagnoses, cost, and utilization of diagnostic testing, extend of limited resources (i.e. blood, inpatient beds) and transport resources.

H. Telestroke/neurology

Fifty-eight articles referencing telehealth and its use in acute stroke care were identified. Thirty-one articles were excluded for a variety of reasons; some were opinion papers or editorials, others were only descriptive in nature with no metrics provided. Some were excluded as they were only reviews of new innovative practices, patient acceptance, liability, or future potential. There were four pay-per-view articles which were dismissed based on review of the free available abstract which suggested there were no metrics included. One article could not be found. The remaining 27 articles were included and the following telestroke metrics were identified:

Metrics

1) *Access and General Telehealth System Concepts as Applied to Telestroke:*

Telestroke is the one of the largest and oldest clinical telehealth applications. As acute stroke is time critical, successful systems are constantly scrutinizing and retooling their workflows and monitoring time stamps, always trying to reduce time to TPA administration. As a result, the literature has become very expansive with detailed analyses.

One report provides an overview of telestroke system tasks to monitor and points out what resources to use to track them.[127,128] These include the following:

- Develop clinical, operational, and technical processes. Use documented EMS protocols, patient identification, inclusion and exclusion checklists, CT scan protocols, roles, staff roles, thrombolytic pathways and care plans, telehealth consult video and chart reviews, documentation of patient informed consent and joint decisions, system failure contingency plans.
- Develop staff competency and confidence. Determine a needs analysis and a training strategy with priorities and objectives. Provide training resources and perform intermittent assessments of competency.
- Monitor clinical processes and outcomes. Create a data flowchart and data collection strategies. Develop meaningful reports of the data for the governance group to assess ongoing performance and monitor effect of changes.
- Monitor fidelity, quality, and acceptability. Questionnaires of patient and staff may provide useful satisfaction information.

The benefits of an onsite stroke telehealth champion cannot be overstated and are critical to the success of any program.

2) *Experience and Effectiveness:*

Average Times Reported in the Literature:

The time critical nature of acute stroke has prompted the careful dissection of the telestroke workflow into many discrete pieces. Many metrics are well described and serve as benchmarks for others to compare their services, whether they are providing the consult or receiving consultation services.

- Door to telestroke registration took 39 minutes; workflow improvement here has high impact potential in a 2013 study.[129]
- Door to consult initiation lags by only 16 minutes in a 2016 paper.[130]
- Head CT scan retrieval takes 2 minutes.[131]
- Time of consult initiation to tPA decision shows that a physically present vascular neurologist is faster than telehealth by 8.6 min and alteplase administration took 18 min longer in telestroke consults.[132]
- Door to alteplase administration averaged about 76-88 minutes.[129,133] Door to alteplase administration rate under 60 minutes is 13%.[129]
- Consult initiation to consult completion averaged 20 minutes.[130]
- Depending on whether or not tPA is given, the consult took 15 or 25 minutes, respectively.[134]
- Compared to telephone consults, telehealth was superior for correct diagnosis, management decisions, and documentation.[135-137]
- IV tPA delivery within 3 hours via telehealth systems compared to in person treatment at a stroke center, is as safe and effective as for symptomatic intracranial hemorrhage and mRankin scores at 3 and 6 months.[138]
- With support of telestroke, hospitals with no stroke unit were able to discharge patients an average of 3 days sooner.[139]
- Minimum recommended bit rate is 400 kb/sec; higher rates do not show any benefit.[140]
- With proper education and support, telestroke can positively affect the beliefs about the value of thrombolytic therapy[141]
- While telestroke consults take longer to initiate (11 min) and to conduct (32 min), than telephone only (2 min and 23 min, respectively), correct acute stroke treatment decisions are made correctly more often via telestroke systems (98%) than telephone only (82%)[142]
- Telehealth evaluation takes a little longer (10 minutes) than bedside evaluation (7 minutes) of acute stroke patient. Correlation between remote and in person examination is excellent[143]
- Telestroke technologies which allow for CT scan image transfer tend to perform better than technologies that do not.[144]
- Telestroke systems are increasing alteplase use to around 17% and even as high as 29% of acute ischemic stroke patients[130,145]
- Increase in drip and keep/admit patients[130]
- Post admission of telestroke managed patients increases personnel efficiency and positively impacts stroke outcomes[130]
- Telestroke safety is about the same as with physically present vascular neurologist[132]

- Thrombolysis protocol violation (0% versus 1%, respectively)[132]
- Post-thrombolysis symptomatic intracranial hemorrhagic complications (3% versus 1%, respectively)[132]
- Death during hospitalization (8% versus 6%, respectively)[132]
- Outcomes of patients (by modified Rankin score) receiving alteplase are the same if they were treated remotely and transported or treated on site[146]
- Agreement over the presence or absence of radiological contraindications to thrombolysis is excellent whether the comparisons were between tele-strokologist and neuro-radiologist or between spoke radiologist and neuro-radiologist[147]
- There is high inter observer reliability on ASPECTS score between live and telestroke provider[148]
- Telestroke systems are highly accurate in identifying patients with large vessel occlusions who may benefit from intra-arterial procedures and who need neurocritical care capability.[149]
- Telestroke may increase recruitment of patients into acute stroke thrombolysis studies including populations groups normally excluded from trials such as rural patients.[150]
- Provision of occupational or physical therapy to stroke patients by allied health professionals via high-quality videoconferencing systems is reasonable when in-person assessment is impractical.[151]
- Telehealth for hemorrhagic stroke provides rapid visualization of clinical information and neuroradiological data, providing neurosurgical expertise to community hospitals on demand and within minutes. Patients may be screened and treated at outlying hospitals and resource utilization can be optimized. While 1.4% of patients treated at the peripheral hospitals had secondary deterioration, telehealth allowed rapid necessary patient transfer and provided 96.5% accuracy in patient diagnosis and care.[152]
- Monitoring for potential barriers to use of a telestroke system must occur. Low rates of system use may be due to reluctance secondary to unfamiliarity or treatment delay perceptions. Although technical problems are fairly rare, they can include problems with sound or image quality, connectivity, or difficulties/delays getting access to equipment. Additional lack of staff confidence may lie in comfort of neurological assessment or CT scan reading or fear of clinical hemorrhagic or other complications. Lack of IT staff to support the technical system 24/7 may discourage use. Cultural differences and poor communication routes between disciplines, and centers may be confounding factors.[127]

3) Effectiveness within Specific Telestroke Metrics:

Consolidating more specific metrics to acute stroke patient care is useful to monitor effectiveness of telehealth vs bedside services.[153]

- General information to be reported should include a) spoke or originating site characteristics (rural, small hospital, in-house stroke, or mobile stroke unit), b) patient selection criteria, c) stroke triage protocol, d) patient characteristics, d) distances between hubs and spokes, e) logistics, f) time and resources for initial and ongoing education and training, g) cost, investments, and maintenance of the service, h)

monthly number of consultations, i) ready access to technical and personnel resources, and j) number of registered stroke patients in the telestroke network.

- Telestroke system process indicators for patient treatment with tPA minimally include a) time from stroke symptoms onset to thrombolysis ("onset-to-needle") and b) time from admission to thrombolysis ("door-to-needle").
- Quality, utilization, and process reports for telestroke patient evaluation should address a) rate of systemic thrombolysis, b) intracerebral hemorrhages after tPA delivery, c) mortality, d) length of stay, e) patients unsuitable for inter-hospital transfer, f) transfer rate, g) adverse events during transfer, h) transport time, i) unnecessary transfers, j) duration of the consultation process, k) use of alternate procedures and therapies, and l) system technical failures.
- Patient health outcome – immediate, delayed, and follow-up indicators contain a) pre- and post-stroke scales, b) follow-up imaging, c) discharge disposition, d) pre- and post-stroke living situation, d) post discharge care required, and e) interval mortality

4) Cost:

Telestroke networks have become widespread around the world. There are significant upfront costs. Important considerations include health benefits gained and financial outcomes for the health system through fewer patient transfers or admissions to nursing homes. Overall, telestroke networks seem to be effective from a long-term, societal perspective. A cost-effectiveness analysis of a telestroke network showed when there is increased use of tPA, the effect of the initial costs of establishing a stroke telehealth service are balanced over the longer term by the reduced need for rehabilitation and advanced nursing care.[146] The study did not address presumed improved quality of life as a direct result of telestroke services. Bladin reported that a telestroke system results in more intravenous and intra-arterial thrombolysis, more patients discharged home independently, and, despite upfront and maintenance expenses, greater cost savings for the entire network.[146] Determining the clinical and economic impact of telestroke is vital to support policy makers in making informed decisions.[153]

Gap areas

In systems where the remote hospital is dependent on telestroke services, EMS training and response times should be measured. This will expedite getting patients with large vessel occlusions (LVO) to the closest, most appropriate facility. For patients deemed to be endovascular candidates, there is a new focus of 'door in - door out', i.e. time of patient arrival to the hospital to the time they are transferred out to an endovascular capable facility. This is a new concept and in a state of flux.

Conclusions

Telestroke is one of the oldest telehealth systems in existence and is fairly complex. Hence it has considerable maturity and has many guidelines and robust metrics already in use for this highly time sensitive diagnosis. It is also a dynamic field with ongoing changes in protocols and available treatments, most recently the evaluation and transfer for thrombectomy of LVO. As a result, new metrics continue to be created and measured as this field evolves. Telestroke metrics can serve as an excellent role model and template for other telehealth applications as they grow and mature.

I. Telehealth for Behavioral Health and Telepsychiatry

Forty articles referencing telehealth and its use in the care of behavior health were identified. Twenty-five articles were excluded for a variety of reasons including the following: opinion papers or editorials, descriptive papers with no metrics provided, no quantifiable measurements provided, only abstract available, no full article, and not enough information to determine any metrics, relevant critical actions or conclude any useful take home message as to the benefit or lack of benefit of telehealth for behavior health, and one paper was not found. The remaining fifteen articles were included and the following metrics and/or conclusions were identified.

Metrics

Behavioral health applications of the papers reviewed ranged over various patient populations including VA patients, children and adolescents, and international populations i.e. Australia, disaster settings, Medicaid patients, specific diagnoses i.e. PTSD and sleep apnea.

Some take home messages from the articles reviewed are as follows:

1) *Access*: Telepsychiatry increases access to care, enabling more patients to be seen.[154,155] It increases the likelihood of local treatment versus requiring transferring of the patient to an inpatient unit;[156] Telemental health helps in post-disaster settings;[157]

2) *Experience*: Patient/family satisfaction data suggests that telehealth is not inferior to and is often favored over an in-person encounter. The quality of telepsychiatry is similar to face-to-face care and has a high level of patient satisfaction.[158]

3) *Effectiveness*: Telepsychiatry is effective for psychiatric treatment.[159] It helps in post-disaster settings, reduces wait times and time to treatment, reduces outlier pediatric psychiatric medication prescribing, reduces unnecessary hospitalizations, and it increases the likelihood of local treatment versus requiring transferring of patient to inpatient unit.[156-161]

4) Cost: Telepsychiatry seems to be a cost-effective way of delivering mental health care particularly where access to emergency care is difficult and reduces unnecessary hospitalizations.[158,161]

Gap Areas

Overall, specific quantifiable metrics are lacking, papers and studies are based on small patient populations, there were unexplained reasons for patient drop out, full papers were often not available, and there was often reliance on the authors' conclusion. Often specific information regarding access, costs, experience and effectiveness were not specifically addressed or quantified. Internal QA/CQI chart reviews and reporting of concurrence and incidence of discordance is an area needing further validation. While numerous papers were reviewed, the areas studied were broad in terms of diagnoses, settings, ages, population, country, and often

small numbers of patients (n). It would be more useful and powerful to have more studies with higher numbers and if results are reproducible, it would provide more confidence in the findings. In addition, setting specific quantifiable and objective measures would be useful in demonstrating potential benefits as opposed to subjective or intuitive assumptions.

Conclusions

Telepsychiatry offers the possibility to provide much needed psychiatric care to many who currently do not have access or have difficulty obtaining care. It has the potential to provide care that may not be otherwise available and improve the quality of care in a cost-effective manner that patients prefer to in-person encounters. While the papers reviewed did not allow the reviewer to reach any conclusions scientifically with a high degree of confidence, there was a trend that telepsychiatry could be a potentially very useful and valuable service that could do significant good in many situations, for many patient populations and mental health conditions. Further research and studies would be useful in determining what the potential value is and in which applications.

Clinical Perspectives - The Current Use of Telehealth and Future Applications of Emergency Telehealth

This review demonstrates the extensive telehealth applications already in practice, what quality measures and diverse goals are being addressed, how it touches the specialty of Emergency Medicine (EM), and where gaps exist in our current knowledge. EM applications may include services or consultations in any variety of settings. These include, but are not limited to, an EM provider receiving consultation from a specialist, an EM physician providing care directly to a patient, an EM provider providing consultative services to a requesting health care provider, or a combination of any of the above. Some examples of how emergency telehealth applications are being applied, both domestically and abroad, are listed in Table 2.

Table 2: Emergency Telehealth Applications

Prehospital	Direct to consumer
Field care	Urgent unscheduled care
Ground transport care	Post discharge follow-up
Flight transport care	Direct observational therapy
Hospital based EDs (urban and rural)	Treatment maintenance/ monitoring
Supervision of Advanced Practice Providers	End of life care
Provider at triage	Field screening
Alternative care option	Maritime
Freestanding emergency centers	Cargo transport
Urgent care clinic	Cruise ship
Other maintenance clinics	Dive medicine
Observation units	Aviation in-flight emergencies
Skilled nursing facilities	Outer space
Rehabilitation Centers	Military / Battlefield
Areas with patient flight risk	International
Adult correctional care facilities	Disaster relief
Youth detention centers	
Immigrant refugee / detention camps	

The reviewed studies revealed that many different modalities of delivering care through telehealth are in practice including tele-monitoring, store-and-forward systems, texting, audio, and two-way video. While traditional store and forward technology has been used for years in

teleradiology, its EM use is limited to narrowly focused areas where static images along with a telephonic discussion between health care providers for STAT consults are sufficient, such as in. dermatology and orthopedics. This model is used in some dermatology direct to consumer applications and shows promise for patient follow-up, e.g. wound care. The typical emergency telehealth model is a real time consultation when immediate patient care assistance is desired. Most EM applications use live video feeds and contemporaneous data transfer for images and laboratory results.

Timely access is one of the key provisions of telehealth services. Delivering immediate specialty care to the patient is one of the key advantages of telehealth that has been repeatedly demonstrated. Otherwise, patients may be required to travel great distances, have worse outcomes in time sensitive conditions to receive the services of a specialist in person. There is likely no better example of this than the well-established telehealth services for acute stroke.

Telehealth applications provide effective, high-quality care and are frequently preferred by many patients, as well as families particularly parents of pediatric patients and families of elderly patients. As an example, telepsychiatric services provided to adult and pediatric patients have been proven accurate and effective in areas where these services are otherwise nonexistent or receding. Many psychiatric patients, especially those younger than 40, prefer telepsychiatry over the traditional in-person interaction. The use of trained Advanced Practice Providers (APPs) who practice alone in rural, remote, or low volume setting emergency departments, with real-time backup and supervision of a remote EM physician has proven to be a safe and highly effective manner to provide high-quality medical care where there would otherwise be no emergency care. It should be noted that this guidance may extend to less frequently performed procedures such as outline in Table 3.

Table 3: Procedural Supervision via Telehealth
Ultrasound
Complex laceration management
Needle or Tube thoracostomy
X-ray review
EKG review
Sepsis management
Cardiopulmonary arrest oversight/direction
Post cardiac arrest hypothermia/ fever prevention

The use of emergency telehealth supervised APPs is thought by many to be one of the most logical and viable solutions to keeping open the doors of financially strapped small community and rural EDs.

Telehealth must be used properly and professionally to provide optimal patient care. One study pointed out potential pitfalls to be avoided and serves to emphasize the need to include certain elements in every telehealth interaction.[162] These include but may not be limited to: proper patient identification, transparency of who is providing the consultation and their credentials, collection of an adequate history and physical examination, accurate diagnosis, current treatment practice, proper documentation, and communication and care integration with the appropriate health care provider. Not doing so will only undermine the credibility of this valuable care

delivery tool and jeopardize the future financial and legislative support of telehealth.

This paper has reviewed the current literature in many specialty niches which are intertwined with emergency medicine and the state of the research until this point. Many areas are in their infancy, but development can be anticipated in the prehospital, hospital and post hospital discharge environments to avoid readmission. Additional development may be expected in disaster response, care in austere environments, international relief, primary care, and refugee camp health care. Direct-to-consumer services continue to gain popularity, both for acute unscheduled care, as well as employee health services. Telehealth services may increase access to care by reducing geographic, cost, or time related barriers. Accessibility and convenience of telehealth services are to the point where many patients already prefer the virtual interaction to the face-to-face encounter. When the telehealth examination is insufficient, care may have to be upgraded to the in-person contact, and these standards still need to be set. Nonetheless, services may be provided to very remote areas which may otherwise require hours or days to reach specialized expertise or even basic services. Telehealth has progressed but the many potential opportunities for it to benefit and improve the lives of people across our country and the globe are only just starting to be realized. Telehealth applications, especially those where the effectiveness of telehealth has been clearly demonstrated such as telepsychiatry, teleneurology, and tele-ICU, deserve fair payment by payers regardless of where the care is delivered. Almost uniformly missing in the telehealth literature is factual demonstration of cost savings. Guidelines of medical conditions which are and are not suitable for remote evaluation and treatment are missing. Back up plans and protocols need to be developed and implemented in the event of transmission interruptions or other technical difficulties that might cause a telehealth encounter to run into interference or unintendedly terminate. Education, training, and ongoing quality assurance tools are used in only a few scattered areas. We must embark on an ethical and responsible course to implement telehealth in a manner that will ensure appropriate qualifications of those providing telehealth services, appropriate/parity reimbursement for telehealth services and most importantly, the delivery of quality care to patients in an efficient, timely and cost-effective manner. In short, the future application and expansion of telehealth into emergency medicine has enormous potential to help emergency providers care for anyone, with anything, at any time.

Clinical Conclusions

With the goal of improving our understanding of the current literature on telehealth to aid in future research, this group reviewed 480 articles with 163 articles included. Studies were excluded based on various criteria including quality of study, relevance to the topic of telehealth and availability. The 163 studies were broken by topic into 19 separate sections as characterized above and evaluated by a team of reviewers all working within telehealth.

Many topic areas were newer and overall, the quality of studies suffered from small patient populations, low number of relevant studies and a lack of patient outcomes. The data was broad in terms of diagnoses, settings, population and countries which in itself was not problematic; however, it may have led to difficulty in reproducibility. Many of the section reviewers recognized that much of the current literature is underpowered to support strong conclusions regarding the clinical outcomes and relevant metrics. Of course, there were studies that did show positive results, demonstrating encouraging outcomes that telehealth increased access and expedited care; however, they were few in number within each group. The one notable exception was telestroke which has been around for much longer than the other areas of telehealth. It has considerable maturity, robust guidelines and metrics already in use and continues to move forward with the changes within the specialty such as transfer for thrombectomy.

Overall, telehealth has a lot of room for research; as a relatively new field, the gaps in knowledge are not necessarily surprising and there is no definite indication of what is to come. The recommendations for future research based on the articles reviewed, will look for reproducible studies examining accessibility, clinical outcomes, utility, cost effectiveness, and patient safety and standards. Patient safety could include validated clinical pathways evaluating accuracy of diagnosis, guidelines for best practices and also include the best education practices for both students and experienced providers. Aspects of technology that could be evaluated include the establishment of minimum equipment and system performance needs, the quality of picture and video required and if downtime leads to increased cost and decreased effectiveness. These are just some of the many potential areas that may serve as future quantifiable metrics.

While a number of descriptive papers indirectly suggested that standards are needed, one study found variable quality of direct to consumer teledermatology services and felt that minimum standard practices should be adopted (Table 4):[91-93,162,163]

Table 4: Recommended Minimum Standards for Telehealth Practice
• Licensure, credentials, and location of clinicians should be disclosed; patients should have choice of provider; ensure that providers are licensed in the state where each patient is located. • Verify identity of patients seeking care; establish an initial relationship with live interactive video prior to a store-and-forward relationship.

- Collect relevant medical history, including a history of present illness, review of systems, current medications, and allergies; if possible, obtain appropriate past medical records.
- Clinicians should ask appropriate follow-up questions to complete a patient's relevant medical history.
- Use laboratory studies in clinical scenarios similar to an in-person encounter.
- Use existing evidence-based guidelines to provide diagnoses and treatments.
- Provide meaningful informed consent; when prescribing medications, include discussion of risks, side effect risk risks, pregnancy concerns, and provide a clear follow-up plan.
- Identify the patient's primary health care provider(s) and provide medical records to relevant members, unless a patient opts out.
- Develop relationships with local physicians in all patient treatment regions, to avoid emergency department referrals.
- Quality assurance programs should be in place to monitor clinical performance, patient outcomes, including follow-up, and integrated ongoing care.
- To implement and enforce these standards, legislation, regulation, or a third-party certification process was suggested.

Future studies should also design their evaluations of telehealth based on the established NQF framework as that structure encompasses broad ideas on the quality of healthcare and is relevant to the various use cases of telehealth. As data and utilization increases, the amount of underpowered studies should also decrease leading to more confidence in outcomes. This project only included studies until September 2016 so there are likely newer studies and guidelines that we did not access for these recommendations.

Despite the lack of complete and exhaustive studies, there is encouraging work that shows that telehealth decreases emergency department utilization, improves access in remote areas for multiple use cases, expedites care, and has high patient satisfaction. As evidenced by the literature in telestroke, as telehealth increases in other use cases, improved future work in this burgeoning field might lead to better, cost effective, more efficient and accessible care for our patients at home, in hospital, rural and urban settings and anywhere in the world.

Appendix A

Details of the PubMed and EMBASE databases search strategy, including all sources searched, the search terms used, and a description of the search vocabulary.

History Save | Delete | Print view | Export | Email Combine using And Or Collapse

#8	#5 OR #7	7,273
#7	#3 AND #6	567
#6	**'government'**/mj OR **'medical society'**/exp/mj OR **ahrq** OR **'agency for health care policy'** OR **'agency for health care research'** OR **'agency for healthcare research'** OR **'american college of cardiology'** OR **acep** OR **'american college of emergency physicians'** OR **'american academy of neurology'**:ti OR **'american college of surgeons committee on trauma'** OR **'department of transportation'** OR **emsc** OR **'ems for children'** OR **jcaho** OR **'joint commission'** OR **'health resources administration'** OR **'health resources and services administration'** OR **hrsa** OR **naemsp** OR **'national association of ems physicians'** OR **nasemso** OR **'national association of state ems officials'** OR **'national coordinator for health information technology'** OR **nremt** OR **'national registry of emergency medical technicians'** OR **nhtsa** OR **'national highway traffic safety administration'** OR **va**:ti OR **vha**:ti OR **vhas**:ti OR **'veterans affairs'**:ti	171,089
#5	#3 AND #4	6,839
#4	**'evidence based emergency medicine'**/de OR **'evidence based medicine'**/de OR **'evidence based nursing'**/de OR **'evidence based practice'**/de OR **benchmark*** OR **best** NEXT/1 **practic*** OR **committee**:ti OR **consensus** OR **evidence**:ti OR **guidance**:ti OR **guideline*** OR (**position** OR **white**) NEXT/1 **paper*** OR **recommendation**:ti OR **recommendations**:ti OR **standard***:ti OR **'standards'** OR **statement**:ti OR **statements**:ti OR **summary**:ti	1,256,660
#3	#1 NOT #2	75,363
#2	**'conference abstract'**/it	2,311,434
#1	**'remote sensing'**/de OR **'telehealth'**/exp OR **'telemetry'**/de OR **apps** OR **audio** NEXT/1 **video** OR **audio** NEXT/1 **visual** NEXT/1 **communicat*** OR **audiovisual** NEXT/1 **communicat*** OR **bluetooth** OR **cell** NEXT/1 **phone*** OR **cellphone*** OR **cellular** NEXT/1 **phone*** OR **computer** NEXT/1 **based** NEXT/1 **communicat*** OR **digital** NEXT/1 **health*** OR **'digital medicine'** OR (**e** NEXT/1 **cardiol***):ab,ti OR **'e-care'** OR **e** NEXT/1 **consult*** OR **'e-health'** OR (**e** NEXT/1 **medicin***):ab,ti OR **e** NEXT/1 **visit*** OR **econsult*** OR **eemergency** OR **eicu** OR **emedic***:ab,ti OR **ehealth** OR **evisit*** OR **electronic** NEXT/1 **consult*** OR **hand** NEXT/1 **held** NEXT/1 **comput*** OR **handheld** NEXT/1 **comput*** OR **'ict health'** OR **interactive** NEXT/1 **telev*** OR **ipad** OR **ipads** OR **iphone*** OR **'m-health'**:ab,ti OR **'mhealth'** OR **mobile** NEXT/1 (**applicat*** OR **communicat*** OR **devic*** OR **health** OR **phone*** OR **tablet*** OR **tech*** OR **telephone***) OR **real** NEXT/1 **time** NEXT/1 (**audio** OR **interact*** OR **remote** OR **video***) OR **realtime** NEXT/1 (**interact*** OR **video***) OR **remote** NEXT/1 (**assessment*** OR **care** OR **clinical** OR **consult*** OR **monitor*** OR **patient*** OR **supervis*** OR **support**) OR **'tablet based'** OR **tablet** NEXT/1 **comput*** OR **smart** NEXT/1 **phone*** OR **smartphone*** OR **tele** NEXT/1 (**card*** OR **consult*** OR **health** OR **icu** OR **icus** OR **inte*** OR **manag*** OR **medic*** OR **ment*** OR **monitor*** OR **neur*** OR **nurs*** OR **oncol*** OR **operat*** OR **ophthal*** OR **rad*** OR **rehab*** OR **stroke** OR **support** OR **surg*** OR **ultras***) OR **telecard*** OR **teleconsult*** OR **teledent*** OR **telederm*** OR **telediagn*** OR **'teleglaucoma'** OR **'telehealth'** OR **'teleicu'** OR **teleinte*** OR **telemanag*** OR **telemed*** OR **telement*** OR **telemetr*** OR **telemonit*** OR **teleneur*** OR **telenurs*** OR **teleoperat*** OR **teleophth*** OR **telepathol*** OR **telepharmac*** OR **'telepractice'** OR **telepres*** OR **teleproctor*** OR **telepsych*** OR **telerad*** OR **telerehab*** OR **teleretin*** OR **telerobot*** OR **teleservice*** OR **telesonogr*** OR **telestroke** OR **telesupport*** OR **telesurg*** OR **teleultras*** OR **televaluat*** OR **televisit*** OR **video** NEXT/1 **conferenc*** OR **videoconferenc*** OR **videophone***	90,842

Appendix B

NQF Quality Measure Based Telehealth Literature Gap Analysis				
Area (number of applicable studies)	Experience	Effectiveness	Access	Cost
Operations (72)				
Improving Access to Care (14)	✗	✓	✓	✓
Patient Satisfaction (17)	✓	✓	✓	✗
Education (10)	✗	✓	✓	✓
Mobile Health (10)	✓	✓	✓	✓
Chronic Care (21)	✓	✓	✓	✓
Service Lines (31)				
Provider-to-Provider (11)	✓	✓	✗	✓
Prehospital Setting (6)	✓	✓	✓	✗
Urgent Care (3)	✓	✓	✓	✗
Emergency Medicine (8)	✓	✓	✓	✗
Skilled Nursing Facilities (3)	✓	✓	✓	✗
Specialty Care (77)				
Pediatrics (11)	✓	✓	✓	✗
Dermatology (7)	✓	✓	✓	✗
Wound Care (4)	✓	✓	✓	✓
Orthopedics (4)	✗	✓	✓	✗
Ophthalmology (1)	✗	✓	✓	✗
Ophthalmology (3)	✗	✓	✓	✗
Trauma (9)	✗	✓	✗	✗
Stroke/Neurology (27)	✓	✓	✓	✓
Behavioral Health and Psychiatry (15)	✓	✓	✓	✓

NQF National Quality Forum

✓ Indicates that there is a least some literature addressing this parameter.

✗ Indicates the literature is nonexistent in this area.

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