

SYSTEMATIC REVIEW

The Practice of Emergency Medicine

Telehealth use in emergency care during coronavirus disease 2019: a systematic review

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Abstract

Objective: The coronavirus disease 2019 pandemic has presented emergency departments (EDs) with many challenges to address the acute care needs of patients. Many EDs have leveraged telehealth to innovatively respond to these challenges. This review describes the landscape of telehealth initiatives in emergency care that have been described during the coronavirus disease 2019 pandemic.

Methods: We conducted a comprehensive, systematic review of the literature using PubMed, supplemented by a review of the gray literature (ie, non-peer reviewed), with input from subject matter experts to identify telehealth initiatives in emergency care during coronavirus disease 2019. We categorized types of telehealth use based on purpose and user characteristics.

Results: We included 27 papers from our review of the medical literature and another 8 sources from gray literature review. The vast majority of studies (32/35) were descriptive in nature, with the additional inclusion of 2 cohort studies and one randomized clinical trial. There were 5 categories of ED telehealth use during the pandemic: (1) pre-ED evaluation and screening, (2) within ED (including as a means of limiting staff and patient exposure and facilitating consultation with specialists), (3) post-ED discharge monitoring and treatment, (4) educating trainees and health care workers, and (5) coordinating resources and patient care.

Conclusion: Telehealth has been used in a variety of manners during the coronavirus disease 2019 pandemic, enabling innovation in emergency care delivery. The findings from this study can be used by institutions to consider how telehealth may address challenges in emergency care during the coronavirus disease 2019 pandemic and beyond. Because few studies included cost data and given the variability in institutional resources, how organizations implement telehealth programs will likely vary. Future work should further explore barriers and facilitators of innovation, and the impact on care delivery and patient outcomes.

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1 | INTRODUCTION

1.1 | Background

The coronavirus disease 2019 pandemic has presented emergency department (ED) physicians, staff, and health care systems with a myriad of challenges. EDs have been tasked with addressing the acute care needs of patients presenting with a novel, contagious illness, while also maintaining the everyday demands of their patient population.¹⁻⁸ Many EDs have leveraged technologies such as telehealth to innovate and treat patients safely. Telehealth is defined as the “provision of health care remotely by means of a variety of telecommunication tools, including telephones, smartphones, and mobile wireless devices, with or without a video connection.”⁹ Prior to coronavirus disease 2019, telehealth was used for consultations (eg, telestroke), transfer decision-making, patient interviewing, triage, and telemonitoring.¹⁰⁻¹⁵ One such example includes telehealth to enable virtual evaluation of ED patients boarding for the ICU in the ED or awaiting transfer to the ICU in another hospital. In this system, ICU doctors could remotely monitor vital signs and conduct 2-way video communication with patients in the ED boarding.¹⁵ Additional studies demonstrated associations with decreased length-of-stay and wait time without compromising quality of care or costs.¹⁶ Yet, its use was limited by many barriers including cost of development, reimbursement, legal concerns, patient adoption, and technology challenges.¹⁷⁻²⁰ Provisions passed in the CARES Act removed or lowered many of these barriers and included multiple notable changes for emergency care; the use of telehealth has expanded exponentially.²¹ For example, the CARES Act stipulates that telehealth services be reimbursed at the same rate as in-person visits, reimbursement offerings for remote patient monitoring were expanded, and the Act allows for medical screening exams (MSEs) to be performed via telehealth.²¹

1.2 | Importance

In addition to the more traditional ED applications of telehealth such as tele-stroke and remote consultation, the recent rapid expansion in telehealth has been accompanied by many innovative uses of the technology in the emergency care setting. With this increased use of telehealth, the importance of evaluating the numerous applications of telehealth has grown. A review may shed light on how telehealth could be further used as the pandemic evolves and identify themes regarding emergency care telehealth use during a pandemic.

1.3 | Goals of this investigation

Our objective is to identify and describe innovations in telehealth that have been published in emergency care during the coronavirus disease 2019 pandemic. We aim to characterize ED innovations in telehealth with the goal of informing health care workers and institutions of tele-

health use during this time. To achieve this aim, we performed a systematic review of the academic and gray literature to identify telehealth innovations in emergency care during the coronavirus disease 2019 pandemic.

2 | METHODS

2.1 | Study design

We conducted a systematic review using a prespecified search protocol in collaboration with a medical research librarian, and we followed PRISMA guidelines to ensure a systematic approach and collect pertinent data for our review.

2.2 | Search strategy

We first searched the medical literature, using PubMed to identify relevant articles published in 2019–2020, given the nascency of the novel coronavirus. The articles were screened to solely include those that involve the use of telehealth for care in the ED, care by emergency medicine staff, or the care of emergency conditions during or related to the coronavirus disease 2019 pandemic. We excluded those articles that did not primarily describe a telehealth innovation, were not related to emergency care, and were not related to coronavirus disease 2019. We defined telehealth innovation by the novel use of telehealth modalities in emergency care of patients during coronavirus disease 2019 that includes the expansion of previous telehealth initiatives, including changes in resource allocation or structural improvements, as well as novel applications of telehealth. Our complete search protocol including exact dates and terms reviewed are included in Supporting Information Appendix.

The search was conducted by the research librarian who was blinded to the study hypothesis and shared with the authors (TAJ and KSZ) for review. Two authors (TAJ and KSZ) screened all titles and abstracts independently for potential relevance, and the authors then met to resolve any disagreements. To identify appropriate articles for inclusion and exclusion, the authors were not blinded to the study objective. Initially, if there were any question of relevance to our research question, we erred on the side of inclusion. The full texts were then reviewed, and the authors conducted an additional meeting to resolve any disagreements. We then examined the references of included and relevant excluded articles for any additional articles that were potentially relevant. Next, we performed a Google search to identify relevant news articles, press releases, funding announcements, research and technical reports, briefings, and other unpublished literature.

2.3 | Data extraction and synthesis

Relevant records were screened by the research team to identify both novel applications of telehealth and in-scope studies using the same

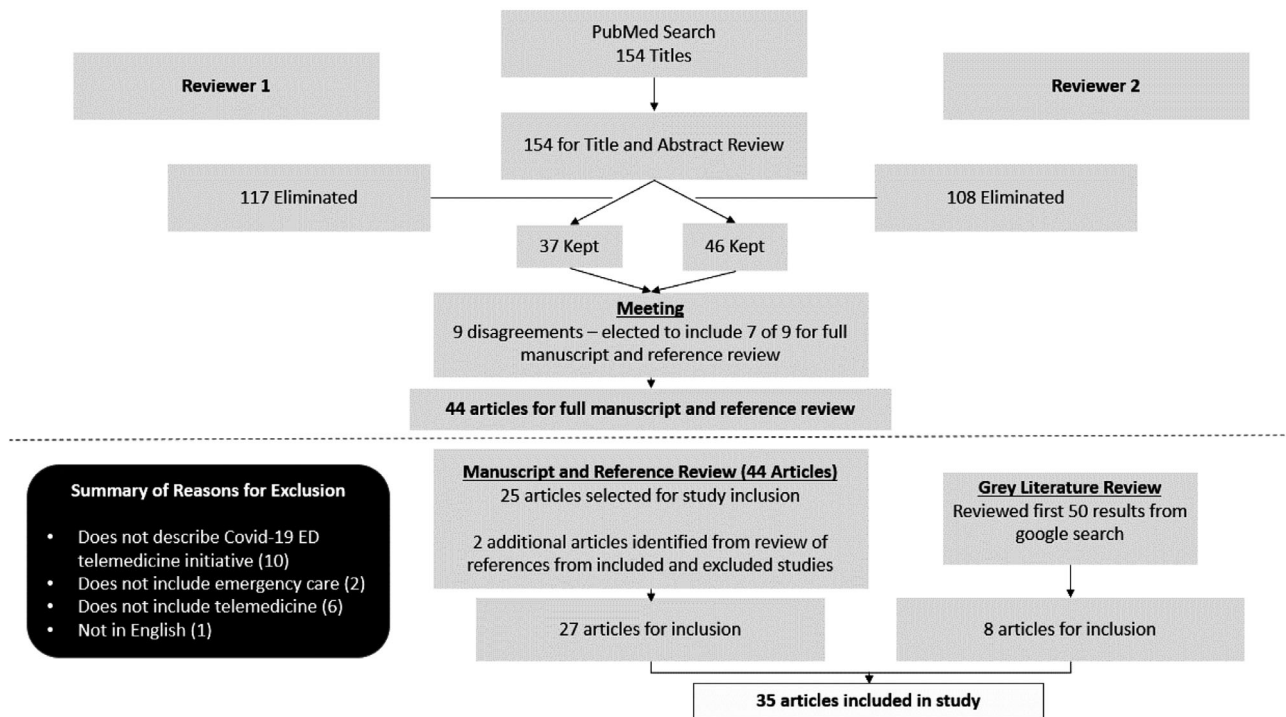


FIGURE 1 Review flowchart

inclusion criteria used in the peer-reviewed literature review. After relevant references from the peer-reviewed medical literature and gray (ie, non-peer reviewed) literature were identified and screened (Figure 1), we developed a standardized form for data extraction of pertinent details that was used for both the primary literature and gray literature review. This included how telehealth was used, the extent of patient and staff involvement, and categorization of the innovation. Data were independently extracted by one investigator (TAJ) and reviewed by 2 investigators (TAJ and KSZ) after extraction. The data abstractor was not blinded to the objective of the review. Any disagreements were resolved through discussion, and any studies identified in the gray literature review that had previously been included in the primary literature review were excluded. Summaries of extracted data are provided in Tables 1 and 2. Preliminary themes were cultivated based on review of extracted data and discussions among the authors. The investigators then conducted brief meetings with 3 additional subject matter experts, all of whom hold leadership positions in telehealth at their respective institutions and have published review articles on telehealth in peer-reviewed medical journals, to review and refine these themes.

3 | RESULTS

3.1 | Literature search

The PubMed search yielded 154 potentially eligible articles for inclusion. After title and abstract review by 2 investigators, 44 were identified for full text review (Figure 1). Two additional articles were identified by review of references from included and relevant excluded

studies. After full-text review of 46 articles, 27 articles met the criteria for inclusion. The complete PRISMA flow diagram for study inclusion and exclusion as well as search protocol is presented in Figure 1. The most common rationale for exclusion was studies that were not related to the pandemic, to the ED, or to emergency care. Data extracted from the articles included study publication data (including title, author, etc), description of the innovation, population/end user of the innovation, location (ED vs remote), outcomes, and challenges. Categorization and major themes were refined based on evaluation of the completed review. Of note, many telehealth applications stretch across multiple categories. We have attempted to discuss the initiative in the category in which it most appropriately fits, yet there were also instances in which innovations were included and discussed among multiple categories.

The gray literature review identified 8 additional relevant articles. These included a national presentation on telehealth in the ED sponsored by the Society of Academic Emergency Medicine, articles from national medical societies on their websites, as well as multiple initiatives described first-hand by healthcare organizations, both as descriptive articles on institutional websites and in medical journals. These articles were further reviewed and categorized in a similar manner as described above.

3.2 | Pandemic-related uses of telehealth in emergency care

Multiple novel telehealth initiatives were identified from the included articles and expert review (Table 1). We identified 5 categories of

TABLE 1 Included studies

First author	Study title	Source	Description of innovation	Category of innovation
Kristal R	A Phone Call Away: New York's hotline and public health in the rapidly changing coronavirus disease 2019 pandemic ^a	Health Aff (Millwood)	A hotline for coronavirus disease 2019 screening; tiered system including initial conversations with RNs and ability for up-triage to emergency physicians. Additional functionality included the scheduling of virtual urgent care visits.	Pre-ED
Annis T	Rapid implementation of a coronavirus disease 2019 remote patient monitoring program ^a	J Am Med Inform Assoc	Patients were enrolled in a remote monitoring system if they screened in for coronavirus disease 2019 symptoms. This included identification from ED visits and escalation in care based on flagged responses.	Pre-ED
Snapiri O	Delayed diagnosis of paediatric appendicitis during the coronavirus disease 2019 pandemic ^a	Acta Paediatr	Multiple cases of appendicitis resulting in delayed diagnosis with the use of telemedicine.	Pre-ED, within ED
Hollander J	Virtually perfect? Telemedicine for coronavirus disease 2019 ^a	New England Journal of Medicine	JeffConnect, which has been expanded during coronavirus disease 2019 times to offer forward triage, robust care coordination throughout a health system, including ambulatory care, the ED, and inpatient.	Pre-ED, within ED, care and resource coordination
UVA Health	FCC grant to expand UVA Health's coronavirus disease 2019 telehealth care	Newsroom.uvahealth.com	UVA has expanded telehealth in the ED and medical center to reduce patient and staff exposure. They have also developed a robust system of remote examination with input from ED staff and includes a partnership with long-term care facilities, assisted living centers, and skilled nursing facilities.	Pre-ED, within ED, care and resource coordination
Hayden E	Telehealth in EM during the Covid crisis: lessons learned	SAEM Teleconference	Numerous innovations described during this conference including on-site telehealth, remote monitoring post-discharge, tele-consulting, resource allocation, and education.	Pre-ED, within ED, post-ED, tele-education, care and resource coordination
Samuels EA	Innovation during coronavirus disease 2019: improving addiction treatment access ^a	J Addict Med	Developed a hotline as a "tele-bridge" clinic where people with moderate to severe opioid use can be linked with a waived caregiver.	Pre-ED, post-ED
Khatri UG	Opioid use disorder and coronavirus disease 2019: crashing of the crises ^a	J Addict Med	Anecdotally describes virtual treatment for OUD including providing high risk patients with phones to keep them connected, as well as iPads at homeless shelters.	Pre-ED, post-ED

(Continues)

TABLE 1 (Continued)

First author	Study title	Source	Description of innovation	Category of innovation
Ko K	Launching an emergency department telehealth program during coronavirus disease 2019 ^a	Journal of Geriatric Emergency Medicine	The San Diego County Senior Emergency Care Initiative, in which 3 EDs have partnered with nursing homes to use telehealth as a tool for remote monitoring and triage. Other examples include telehealth as a way to communicate with rural EDs and forward triage used to assess triage decisions for patients with symptoms of coronavirus disease 2019.	Pre-ED, care and resource coordination
Chou E	Onsite telemedicine strategy for coronavirus (coronavirus disease 2019) screening to limit exposure in ED ^a	Emerg Med J	Initial interview after screening patients is done via iPad or iPhone in the ED.	Within ED
Lin CH	A double triage and telemedicine protocol to optimize infection control in an emergency department in Taiwan during the coronavirus disease 2019 Pandemic: Retrospective Feasibility Study ^{a,b}	J Med Internet Res	After initial triage, attending physicians discuss initial findings via video with patients. Then, they don PPE to complete any other evaluation necessary.	Within ED
Turer RW	Electronic personal protective equipment: a strategy to protect emergency department providers in the age of coronavirus disease 2019 ^a	J Am Med Inform Assoc	Describes the general concept of ePPE and strategies that may be used in the ED.	Within ED
Lau J	Staying connected In The coronavirus disease 2019 pandemic: telehealth at the largest safety-net system in the United States ^a	Health Aff (Millwood)	Describes a robust system of telehealth in NYC health and hospitals that included within ED care, tele-consult, and tele-palliative care.	Within ED
Israilov S	National outreach of telepalliative medicine volunteers for a New York City safety net system coronavirus disease 2019 pandemic response ^a	J Pain Symptom Manage	Volunteers were recruited via social media (Twitter, LinkedIn) to help with tele-palliative care. This consisted of physicians, chaplains, NPs, nurses, social works, students, and PAs.	Within ED
Hemingway JF	Emerging practice patterns in vascular surgery during the coronavirus disease 2019 pandemic ^a	J Vasc Surg	Vascular surgery consultations from the ED and inpatient units were initially conducted virtually if patients were stable.	Within ED
Grange ES	Responding to coronavirus disease 2019: The UW medicine information technology services experience ^a	Appl Clin Inform	Describes a robust IT system that incorporates telehealth in the ambulatory, emergency, and critical care settings.	Within ED
Wittbold KA	iPad deployment for virtual evaluation in the emergency department during the coronavirus disease 2019 pandemic ^a	Am J Emerg Med	Describes iPads used to conduct screening history and exams in the ED.	Within ED
Chauhan V	Novel coronavirus (coronavirus disease 2019): leveraging telemedicine to optimize care while minimizing exposures and viral transmission ^a	J Emerg Trauma Shock	Describes general recommendations and broad initiatives for using telehealth in the ED and inpatient setting.	Within ED

(Continues)

TABLE 1 (Continued)

First author	Study title	Source	Description of innovation	Category of innovation
Hron JD	Rapid implementation of an inpatient telehealth program during the coronavirus disease 2019 Pandemic ^a	Appl Clin Inform	Leveraged a multidisciplinary team to rapidly design, implement and iteratively improve inpatient telehealth using videoconferencing.	Within ED
Hamm J	Telemedicine in the emergency department in the era of coronavirus disease 2019: front-line experiences from 2 institutions ^a	JACEP Open	Robust system of ED telehealth at 2 institutions that includes within ED telehealth and access to consultants.	Within ED
Redford G	Delivering more care remotely will be critical as coronavirus disease 2019 races through communities	www.aamc.org	At the ED at University Medical Center New Orleans, appropriate patients were triaged to 6 video-equipped rooms. From there, ED physicians use videoconferencing to evaluate the patient, with just 1 nurse in personal protective equipment (PPE) in the room.	Within ED
Medical city health-care	Innovating telehealth during times of unprecedented change	www.medicalcityhealthcare.com	The Medical City Healthcare system has used a teleconferencing software to aid initial nursing triage by patients in the ED.	Within ED
Schmitt K	Telemedicine is proving to be a key piece of protective equipment for emergency departments	www.centerforhealthcarejournalism.com	At Stanford University Medical Center's ED, they have used iPads in each patient room, connected to a central hub of ED physicians. Added benefits include more frequent checks with patients as well as the ability to interact without needing to wear full PPE.	Within ED
Weill Cornell Medicine	Telemedicine training proves vital during coronavirus disease 2019 crisis, increasing access to care	news.weill.cornell.edu	At Weill Cornell Department of Emergency Medicine's Center for Virtual Care (CVC), they have used telehealth for tele-screening in the emergency department as well as a tool to train other health care staff on the use of telehealth.	Within ED, tele-education
Adams S	Telemedicine comes of age in the coronavirus disease 2019 pandemic	www.acepnow.com	Rush University expanded their online platform by facilitating video visits. Emergency medicine residents in particular played an integral role in scaling telehealth visits, specifically by creating training modules, recruiting practitioners, pilot testing, and conducting visits for patients.	Within ED, tele-education, pre-ED
Chandra S	Zooming-Out COVID: virtual clinical experiences in an emergency medicine clerkship ^a	Med Educ	Rotating EM students used zoom to contact patients; specifically, those who were treated and discharged from the ED with coronavirus disease 2019 or those without.	Post-ED, Tele-education

(Continues)

TABLE 1 (Continued)

First author	Study title	Source	Description of innovation	Category of innovation
Li Z	Evaluating a nurse training program in the emergency surgery department based on the Kirkpatrick's Model and clinical demand during the coronavirus disease 2019 pandemic ^{a,b}	Telemed J E Health	In an emergency surgery department, they developed a virtual training platform for nurses to prepare for new roles during coronavirus disease 2019.	Tele-education
O'Connell A	Effective use of virtual gamification during coronavirus disease 2019 to deliver the OB-GYN core curriculum in an Emergency Medicine Resident Conference ^a	Cureus	An EM program developed an Ob-Gyn training module virtually using gamification for EM conference.	Tele-education
Hanel E	Virtual application of in situ simulation during a pandemic ^a	CJEM	To better educate care team on treatment of respiratory failure for coronavirus disease 2019 patients in the ED, they developed a simulation video that was shared virtually and included virtual breakout groups.	Tele-education
Zhou T	The Distance teaching practice of combined mode of massive open online course micro-video for interns in emergency department during the coronavirus disease 2019 epidemic period ^{a,c}	Telemed J E Health	A large academic institution developed a video teaching platform for emergency nursing care.	Tele-education
Suppan M	Teaching adequate prehospital use of personal protective equipment during the coronavirus disease 2019 pandemic: development of a Gamified e-Learning Module ^a	JMIR Serious Games	Development of an e-learning module for emergency care staff to appropriately learn how to don-doff PPE.	Tele-education
deLima Thomas J	Development of a palliative care toolkit for the coronavirus disease 2019 pandemic ^a	J Pain Symptom Manage	Creation of a toolkit for staff to have quick access to palliative care resources, developed a web app, instructional videos, and paper cards.	Tele-education
Salman S	Inter-hospital communication and transfer practices during coronavirus disease 2019 pandemic in Karachi, Pakistan. A brief overview ^a	Pak J Med Sci	Hospitals in Pakistan developed a WhatsApp chatroom as a link between multiple hospitals to appropriately allocate resources, communicate re: bed availability and care coordination.	Care and resource coordination
He S	The story of ^b GetMePPE and GetUsPPE.org-Rapidly deploying digital tools for better healthcare ^a	J Med Internet Res	The development of a website and hashtag to connect PPE shortages to people and institutions with PPE available.	Care and resource coordination
White J	Emergency telehealth network working together amid coronavirus disease 2019	USDA.gov	Augusta University developed a telehealth hub in rural Georgia that uses telehealth to connect ED doctors at 5 hospitals to diagnostic and educational experts.	Care and resource coordination

ED, emergency department; EM, emergency medicine; IT, information technology; NP, nurse practitioner; OUD, opiate use disorder; PA, physician assistant; PPE, personal protective equipment; RN, registered nurse.

^aIndicates peer-reviewed article.

^bIndicates cohort study.

^cIndicates randomized clinical trial.

TABLE 2 Overview of types of telehealth and innovation in emergency care during coronavirus disease 2019

Category of use	Telehealth targeted user(s)	Connected participant(s)	Examples
Pre-ED/pre-hospital	Patients considering an ED visit	ED staff	Patient evaluation and screening by ED staff prior to ED presentation ^{22,23,25,46}
			Hotline for ED staff to communicate with patients before and after an ED visit ^{22,26}
			iPads and digital health initiatives at sites including community centers, healthcare offices, nursing facilities, etc. to connect patients with ED staff
Within ED	ED patients	Triage staff	Remote triage screening ^{22,27-29,31-34,38,53,67}
	ED trainees or APPs	Remote attendings (off- or on-site)	Remote attending supervision ^{22,28,29}
	ED patients	ED staff	As a tool for PPE conservation ^{22,25,27-37}
	ED patients	Remote visitors	Connecting patients with "virtual visitors" ^{22,38}
	ED patients	ED staff	Remote monitoring in the ED ^{22,28,34,42}
	ED patients	Off-site specialists	Connection with off-site specialists (eg., telestroke, or tele-critical care from a hub to a spoke) ^{22,23,44}
	ED patients	In-hospital specialists	In-house consulting services providing ED evaluations remotely ^{22,38,42,43}
	ED patients and staff	Out-of-ED palliative care specialists	Tele-palliative care program to aid health care workers in facilitating palliative care discussions ^{40,41}
Post-ED discharge	Discharged ED patients	ED or other health system staff	Post-ED discharge remote monitoring ^{22,45,46}
			Hotline for ED staff to communicate with patients before and after an ED visit ^{22,26}
			Tele-bridge clinic for substance use disorder treatment ^{24,47}
Education	Students/trainees off-site	Education faculty off-site	Medical student and EM resident training ^{28,30,45,48-50}
	Paramedics, RNs, APPs, physicians off-site	Pandemic preparedness leadership on- or off-site	Pandemic preparation for all care-giver groups (ie, RNs, APPs, physicians, Paramedics) ^{49-52,25,30}
	ED staff	Palliative care specialists off-site	Digital palliative care toolkit for physicians and nurses ^{40,53}
Care and resource coordination	ED staff	Healthcare workers, industry, general public	National network of PPE database founded by ED physicians ⁵⁶
	ED resource nurse and operations staff	Other ED operations leadership	Interhospital communication platform for ED resource coordination ^{22,23,55}
	ED staff	Long-term care healthcare workers and patients	Care coordination with long-term care and skilled nursing facilities before and after ED visits ^{22,23,27}

APP, advanced practice providers; ED, emergency department; EM, emergency medicine; PPE, personal protective equipment; RN, registered nurse.

TABLE 3 Themes of telehealth use in emergency care during coronavirus disease 2019

Category of use	Summary of findings
Pre-ED/Prehospital	In the pre-hospital setting, telehealth has been used as a screening tool for patients with emergency care needs and to aid in care coordination in the pre-hospital setting.
Within ED	Emergency departments have used telehealth as a tool to screen for acute care needs while limiting staff and patient exposure and the use of personal protective equipment.
Post-ED discharge	Emergency departments have applied telehealth post-ED discharge to extend care, particularly as a tool for follow-up and remote monitoring.
Education	Digital technology and telehealth have also provided platforms for new educational initiatives and strategies; enabling continued education for trainees, nurses, and physicians while limiting in-person contact.
Care and resource coordination	The use of telehealth has provided emergency departments and hospital systems with additional means to coordinate scarce medical resources during the pandemic.

ED, emergency department.

applications: (1) telehealth in the prehospital or pre-ED setting, (2) within ED telehealth, (3) post-ED discharge, (4) education, and (5) care and resource coordination. Table 2 provides an overview of the domains of use of telehealth with specific examples. The main take-aways from our review are included in Table 3.

3.3 | Pre-hospital telehealth

Five studies describe applications of telehealth in the prehospital setting for evaluation and screening of patients prior to ED presentation and for communication with patients before an ED visit.²²⁻²⁶ We included in this categorization studies that included the use of telehealth for emergency care before an ED visit, which encompassed studies involving emergency medical services (EMS), pre-ED remote monitoring by ED staff, and virtual medical visits by ED staff. One of these studies described telehealth for remote evaluation of patients before on-site care with evaluation being conducted by medical students, nurses and physicians, and other ED staff.²³ The program included a portal where patients with concern for coronavirus disease 2019 may initiate self-triage and report symptoms. ED nurses would perform the initial screening with advanced practice providers (APPs) or physicians making final tele-triage decisions. Other members of the care team, including students, social workers and medical assistants were used for other aspects of care including follow-up communication on test results. The study also describes the pre-ED evaluation of patients at skilled nursing facilities or long-term care facilities to enable appropriate triage of patients at risk for decompensation with coronavirus disease 2019.²³ A presentation from one institution described an initiative that links EMS with EDs using videoconferencing to appropriately triage patients, a process referred to in the literature as tele-triage.²² Another presentation specifically described a new partnership created during the pandemic between a city's emergency response and existing emergency medicine telehealth program to link doctors to field calls with first responders.²² These applications

also included unique considerations during coronavirus disease 2019 including directing patients with coronavirus disease 2019 exposure but no acute safety concerns to alternative testing locations rather than the ED. An additional institution developed a similar partnership with long term care facilities as described above.²⁷

3.4 | Within ED telehealth

Three studies describe the use of telehealth for remote attending supervision of trainees by attending physicians.^{22,28,29} Several studies described the use of telehealth within EDs to preserve PPE, a term described as ePPE, and others highlighted telehealth as a tool to enable evaluation and remote monitoring of patients "in the ED" by providers "in the same ED."^{22,27,25,28-37} Two studies also described the use of telehealth to connect patients with "virtual visitors."^{22,38}

Seven of the studies included in the final review describe teleconsulting initiatives and the role of the specialist for emergency conditions during coronavirus disease 2019.^{28,38-43} Most of these studies describe either how specialist services interact with ED physicians or how specialists are able to interact with patients either for emergency conditions or in the ED. One article illustrated a robust system in which rural ED physicians can be connected to experts via a telehealth hub as a way to elucidate expert opinion and coordinate care.⁴⁴ This program includes a central hub connected to 5 rural hospitals via telehealth to help expand the reach of consultants and coordinate care. The institution received a grant to use telehealth in 2017, before coronavirus disease 2019, and they highlight the expanded use of telehealth to coordinate transfers of emergency patients, enable remote ultrasound, and provide virtual consultation.⁴⁴ The authors note that they have expanded the existing services during coronavirus disease 2019 and found additional uses of the platform, in particular virtual intubation enhancement and consultation, to be of greater importance during the pandemic.⁴⁴

3.5 | Post-ED discharge

Three studies described the use of telehealth as an extension of ED care for continued remote patient monitoring post-discharge,^{22,45,46} and 2 studies also described the use of a hotline for ED patients to connect with ED staff post-discharge.^{22,6} One of these “hotlines” involved a collaboration among ED staff and the city of New York and was created solely for coronavirus disease 2019 inquiries, including post-discharge monitoring.²⁶ In another study, medical students during their emergency medicine clerkship participated in virtual encounters with patients discharged from the ED who eventually tested positive for coronavirus disease 2019. The authors surveyed participants during the study; students felt engaged, valued, and appreciated the opportunity to perform clinical reasoning while preceptors appreciated the opportunity to continue to teach clinically with a virtual setting.⁴⁵ In another, patients screening positive for potential coronavirus disease 2019 infection were able to enroll in a remote patient monitoring program after a virtual appointment, urgent care, or ED visit. The program included an alert system and escalation system including residents and students supervised by an attending physician as well as nurse practitioner. Patient satisfaction data were elucidated with over 70% of patients reporting that they were extremely likely to recommend their virtual doctor.⁴⁶ The authors cited initial challenges including manual processes for enrollment and customization of the technology platform, which they attribute to the need to expeditiously develop the system.

Each of these programs was developed particularly to address coronavirus disease 2019 patients. Two studies also described the use of telehealth for the monitoring and treatment of patients with addiction.^{24,47} One of these studies describes an approach to use telebridge clinics, which are virtual clinics designed to treat patients with opioid use disorder (OUD). Providers with a DATA 2000 waiver can assess these patients and, if appropriate, prescribe buprenorphine to begin outpatient OUD treatment.²⁴ The virtual component of this program was expanded during coronavirus disease 2019 and also includes coordination with community resources to provide emergency telehealth care to patients with addiction.²⁴ An additional study described a coordinated initiative between EDs and skilled nursing facilities to appropriately triage patients discharged patients with coronavirus disease 2019.²³ This service was primarily used by nursing home staff to consult ED staff regarding potential escalation of care, as well as facilitate direct patient to provider interaction.²³

3.6 | Tele-education

Ten of the studies included in our review detailed tele-education initiatives with a wide array of scope for EDs.^{22,40,45,48–53} We included tele-education to encompass the application of information and communicative technologies in the delivery of distance learning as defined by Curran.⁵⁴ Educational initiatives ranged from preparing nurses for new roles to educating residents and medical students to providing vir-

tual resources related to specialty consultations in the ED. One study also described the use of a virtual simulation of a coronavirus disease 2019 respiratory failure patient with the aim of educating staff on coronavirus disease 2019 protocols and elucidating potential gaps. They found resource limitations and communication gaps, and the authors concluded that the virtual simulation method led to increased preparedness and protocol improvement.⁴⁹ Another study examined the use of an online course for teaching new nurses core ED skills, particularly during the coronavirus disease 2019 pandemic when they were unable to have in-person teaching. In this randomized clinical trial, a skill assessment demonstrated no significant gaps in learning with the video intervention, and participants reported greater overall satisfaction and ease of learning with the inclusion of a video platform model.⁵⁰ The most commonly cited outcomes among all tele-education studies were enjoyment in learning among end-users.^{45,48,50} Additional articles highlighted the use of virtual platforms as a means to educate physicians, physicians assistants, nurses, and other healthcare workers particularly on the use of telehealth.^{22,53} One article described the use of emergency medicine residents as an integral component of expanding telehealth, including educating other healthcare workers, developing training modules, and conducting patient visits.³⁰

3.7 | Care and resource coordination

Two studies in the database literature review describe robust digital initiatives to connect ED staff to other health care services and patients to develop effective resource coordination.^{55,56} These include the use of telehealth to facilitate interfacility transfers of coronavirus disease 2019 patients and as a means to source and distribute PPE for emergency health care workers. For interfacility transfers, authors in 1 study noted the absence of a systematic referral system resulting in significant delays before coronavirus disease 2019, and the use of telehealth to address this gap.⁵⁵ In this system, hospital medical directors and administrative leads were nominated to serve as primary institutional stakeholders and participated in mobile chatrooms among representatives at other participating institutions.⁵⁵ One presenter at the SAEM telehealth virtual conference also highlighted the use of iPads and telehealth to assist with interhospital care coordination as well as telehealth to enable patients to self-monitor vital signs.²² The presenter further described the robust process for care coordination and transfer with telehealth applications as both a means for remote assessment of patients before transfer as well as to facilitate clinician-to-clinician communication.

4 | LIMITATIONS

Our study has limitations. Given that coronavirus disease 2019 telehealth innovations remain in their nascency, we are limited by the number of articles that have been published on innovations in telehealth during coronavirus disease 2019. We included perspective from a small

group of experts to help mitigate these gaps. Soliciting feedback from experts helped identify unpublished telehealth applications that have been included in the discussion, yet it also may introduce unintentional bias from expert's opinion. In addition, the experts were coauthors on 2 included studies that could lead to bias, however, our use of a standardized data collection tool aimed to ensure capturing of objective data when available. An additional limitation is that we were not able to directly assess the technical quality of the innovations described; we leveraged proxies for this, such as user satisfaction to alleviate this limitation when available. Furthermore, few studies had yet to capture outcomes data. We highlighted the available outcomes data in the results, yet this remains a limitation of our work. The studies reviewed also did not include financial data, including the reimbursement data and cost data related to individual telehealth innovations. Some posited that costs may be prohibitive toward replicating their work, yet exact financials were not included. We included this information in the review when available, but this remained limited. Future research should consider cost-effectiveness of telehealth innovations and the relationship with patient outcomes. In addition, because our aim was to review innovations particularly related to coronavirus disease 2019, there remain other emergency care telehealth programs that may not have been captured in our search. These programs may have been implemented independent of coronavirus disease 2019, yet functionally have significant impact on coronavirus disease 2019 patients.

5 | DISCUSSION

In our systematic review of the use of telehealth for emergency care during the time of coronavirus disease 2019, we found multiple innovations described in the literature. This included studies detailing telehealth as a tool for pre-ED evaluation and screening, for augmenting on-site care, post-discharge remote monitoring and treatment, for tele-education, and for care and resource coordination during the coronavirus disease 2019 pandemic. The type of articles included in our review also varied. A vast majority (32/35; 91%) were observational or descriptive articles, with the remainder being cohort studies^{29,52} or randomized trials⁵⁰. Onsite telehealth was most frequently described, namely for remote triage, remote attending supervision, PPE conservation, infection control, connecting patients and families, and remote monitoring. After the use of onsite telehealth, the second most common application was related to education. With in-person education limited during this time, it appears that tele-education has been able to fill this gap, providing pertinent educational materials while limiting exposure. The same likely holds true for the use of tele-consulting services. In many studies, consultants endorsed conducting a majority of their patient interviews for emergency care virtually, and reported few, if any, care concerns in doing so.^{22,38,42,43} One additional application was the use of telehealth as a means to enable emergency care beyond the ED and assist in the coordination of care and resources throughout the care continuum.^{22,55,56}

Previous studies have examined the growth of telehealth prior to the coronavirus disease 2019 pandemic. For example, a recent sys-

tematic review described numerous applications of telehealth in emergency care.⁵⁷ In this study, the authors highlighted many studies describing telehealth as a tool to treat minor illnesses and facilitate specialist consultation with positive feedback regarding its use.⁵⁸⁻⁶⁰ They also examined the literature to catalog the outcomes included in their review, including the technical quality of the telehealth innovations, user perceptions, clinically processes described, inclusion of patient throughput, and economic outcomes. The authors found that although many studies reported processes, throughput data, and perceptions, there remained a paucity of data on economic outcomes of interventions. Our study differed in that our review focused exclusively on studies related to the coronavirus disease 2019 pandemic, yet the methodology and overall findings were relatively similar. Specifically, we too found limited studies, including financial data related to interventions, and a majority of studies in both reviews were case series or descriptive in nature. Other studies examined the use of telehealth as a means to screen patients in the ED. One study in particular leveraged telemedicine to screen patients presenting to the ED with lower acuity complaints.⁶¹ In this study, patients presenting to the ED with an Emergency Severity Index (ESI) level of 3, 4, or 5 were randomized to either in-person screening or remote evaluation via telemedicine by ED staff; the telemedicine group was associated with a decreased rate of patients left without being seen.⁶¹ These studies and others noted multiple barriers to implementation, including regulatory uncertainty and cost.¹⁷ Additional guidance has been provided by professional societies. The American College of Emergency Physicians (ACEP), for example, released a coronavirus disease 2019 field guide, which includes guidance on telehealth and tele-triage. This resource provides some examples of potential telehealth applications during coronavirus disease 2019 and a review of the technical and regulatory concerns.⁶²

Our study expands on this work by providing an updated review of telehealth initiatives in emergency care during coronavirus disease 2019. Given the dramatic change in the telehealth landscape during the public health emergency, we reviewed the literature to assess those newer initiatives that have been implemented during the pandemic. With this aim, we identified multiple applications that had been less described in the literature including tele-education and resource coordination. Furthermore, we identified the common use of telehealth as a means of infection control and PPE conservation, which had been less pertinent pre-pandemic.

There are likely many additional applications of telehealth during coronavirus disease 2019 that have yet to be documented in the literature, some of which were identified in our discussion with subject matter experts. One of these innovations involves the use of tele-pharmacy, which has been defined as the provision of pharmaceutical care through the use of telecommunications and information technologies to patients at a distance.⁶³ In the emergency setting, tele-pharmacy has been used for remote consultation, medication review, patient counseling, and remote dispensing of medications.⁶⁴ This practice remains in its nascency, but early data has demonstrated potential for cost-reduction and improved access to medications.^{65,64} Yet there remains a paucity of literature documenting the use of the practice

during coronavirus disease 2019, particularly related to emergency care. It remains plausible that tele-pharmacy would continue to be a natural fit to improve medication adherence and limit costs without undue exposure. Further research may help explore the use of tele-pharmacy during coronavirus disease 2019 and beyond.

Another application of telehealth raised during our expert interview was in using telehealth to augment medical research. There is potential value in using telehealth as a tool in nearly all stages of medical research (eg, to help researchers perform informed consent, for patient evaluations, or for post-discharge follow-up). In the ED in particular, there remains opportunity to use telehealth in this regard to remotely evaluate patients regarding clinical research. For example, these tools could be used to facilitate remote informed consent, assess patients for inclusion/exclusion criteria, or virtually speak with providers regarding patient eligibility. A study by Bobb et al.⁶⁶ found that patient comprehension of informed consent was noninferior using telemedicine when compared with standard in-person consent. Although our review did not find any examples of this particularly for coronavirus disease 2019 patients in the ED, it remains plausible that previous telehealth informed consent modalities may be leveraged during the pandemic.

Given the many applications of telehealth in the response to a public health emergency, it is important to consider why some organizations have been more able to use and scale telehealth innovations during crisis. Some studies included in our review described the creation of new innovations, including the application of technology and protocols not previously used at a given institution. Examples of this include the use of iPads to facilitate remote screening of patients in the ED during coronavirus disease 2019.^{31,32,35} Other studies described the expansion of pre-existing telehealth services to serve a broader patient population.³⁸ It may be that implementing and scaling a new telehealth infrastructure simultaneously with managing a pandemic response was beyond the capacity of sites that did not already have it. Additionally, telehealth has notable limitations. For example, 1 study in our review noted multiple cases of a delay in the diagnosis of appendicitis for telehealth visits, ultimately resulting in higher complication rates for this select population. The costs associated with telehealth also have the potential to be prohibitive, particularly for smaller or less-resourced systems. In fact, a recent survey of rural hospitals found cost to be the most commonly cited reason for lack of adoption of telehealth.¹⁷ Few studies included in our review contained data regarding the financial implications of the innovations described, consistent with previous systematic reviews finding inconclusive evidence regarding cost savings and financial requirements of telehealth programs in the ED.⁵⁷ It may be that given the novelty of many of these innovations in the early months of coronavirus disease 2019, the financial data had yet to be fully appreciated. As these data become available, future study of the costs of the innovations and potential financial gains presents an opportunity.

It remains to be seen how these vast array of telehealth applications will continue to be used. There are many factors, both internal and external to the ED, which play a role in determining the sustainability of telehealth in the acute care setting. As discussed in this review, virtual

visits lend multiple benefits including PPE conservation, infection control, and remote monitoring, which were commonly cited as motivating factors for telehealth implementation during the coronavirus disease 2019 pandemic. These benefits may not be as substantive without the presence of a novel infectious disease like SARS-CoV-2. It is also likely that multiple policy initiatives, such as the aforementioned CARES Act, have contributed to the increased use of telehealth. This has included the reimbursement of telehealth visits at similar rates to in-person visits as well as permitting MSEs via telehealth. How telehealth reimbursement will evolve remains unknown.

In summary, because previous studies have documented the expansion of telehealth during the coronavirus disease 2019 pandemic, our review highlights innovations in telehealth particularly for emergency care during this time. In this review, we have identified multiple themes regarding telehealth use in emergency care during the coronavirus disease 2019 pandemic. This study provides EDs and hospitals with a myriad of applications of telehealth during the coronavirus disease 2019 pandemic. The findings from this study can be used by institutions to consider how telehealth may address challenges in emergency care during the coronavirus disease 2019 pandemic and beyond. Future work should further explore barriers and facilitators of innovation, implications related to costs and reimbursements, and the impact on care delivery and patient outcomes.

AUTHOR CONTRIBUTIONS

TAJ and KSZ conceived the study. EH aided with study design and methods. KSZ, EH, LUP, JS, LHS and AM provided guidance on review methods and scope. TAJ and KSZ conducted the review. All authors reviewed findings, contributed to manuscript development and revisions. TAJ takes responsibility for the manuscript as a whole.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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