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Cerebrovascular Disorders (D Jamieson, Section Editor)

Telestroke's Role Through the COVID-19 Pandemic and Beyond

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Abstract

Purpose of review The goal of this paper is to discuss the role and utilization of telestroke services through the COVID-19 pandemic and to suggest future directions to sustain and increase patients' access to stroke expertise.

Recent findings Telestroke is an innovative and effective tool that has been shown to improve access, quality of care, and outcomes of patients with acute stroke syndromes in resource-limited areas for the last two decades. The COVID-19 pandemic posed a significant challenge and strained healthcare systems worldwide, but it created novel and unique opportunities to expand and increase the utilization of telehealth and telestroke services to deliver personalized healthcare across the continuum of stroke care outside of traditional settings. This rapid and widespread increase in telestroke use was facilitated by the removal of many legislative and regulatory barriers which have limited patients' access to stroke expertise for many years.

Summary As the public health emergency ends, there exists a unique opportunity to optimize and expand upon the pandemic-related rapid growth of telestroke care. Optimal utilization of telehealth and telestroke services will depend on maintaining and improving required infrastructure, laws, and regulations, particularly those governing reimbursement and licensing.

Introduction

Stroke is a leading cause of death and disability in the USA and worldwide [1, 2]. In the three decades since the advent of alteplase, the first acute stroke therapy, there has been significant improvements in outcomes of patients who have access to intravenous thrombolysis and endovascular interventions including mechanical thrombectomy [3, 4•]. In this time there has been an increase in the complexity of the indications for intravenous thrombolysis and endovascular interventions. The current intricacy of acute stroke treatment options and indications has increased the value of having immediate access to vascular neurologists. Given the availability of such effective treatments and limited time windows, there has been a strong emphasis on early recognition of stroke symptoms by the public, immediate activation of emergency medical services (EMS), transfer of patients to a stroke center, and rapid diagnostic work up in emergency departments [5, 6]. To achieve these goals, multiple campaigns were launched to improve these phases of care: education of the public to recognize early stroke signs, establishment of stroke systems of care, integrating EMS and stroke-ready emergency departments, and creation and deployment of hospital-based stroke teams to perform immediate patient evaluation and treatment [7, 8]. Despite these efforts, only a minority of patients with acute ischemic stroke (AIS) receive potentially disability-minimizing and lifesaving acute stroke therapies [9]. This is in part due to regional disparities in access to acute stroke care, as rural and even some underserved areas often lack necessary resources including timely access to stroke expertise [10•].

Telemedicine, the use of real-time audio or audiovisual technology to deliver healthcare services, is a convenient telecommunication tool that connects a patient to a healthcare professional without the need to be in the same room. While available for decades, telemedicine struggled to gain widespread acceptance compared to the traditional healthcare delivery model of in person office-based or hospital-based evaluation [11]. Perhaps the earliest successful adoption of telemedicine came in the late 1990s as vascular neurologists began leveraging telemedicine to provide emergent stroke care for patients presenting with acute stroke syndromes located in rural and underserved communities. Since then, telemedicine for stroke, or telestroke (TS), has been developed to allow patients access to subspecialty vascular neurologist expertise to evaluate and assess eligibility for acute treatment [12]. TS systems allow earlier administration of thrombolytic therapy in rural areas, facilitate transfer of candidate patients to thrombectomy-capable centers, reduce health-care costs through optimizing disposition (thereby avoiding unnecessary transfers), and expand patients' access to specialized stroke experts [13, 14•]. These key advantages are why currently approximately 30% of emergency departments in the USA rely on TS for acute stroke treatment [15].

The outbreak of coronavirus disease-19 (COVID-19) and its declaration as a pandemic by the World Health Organization (WHO) on March 2020 had a disruptive and devastating impact on countries, regions, and people's lives worldwide [16]. The combination of overcrowded hospitals, high workforce absences, staffing turnover, and mandatory social distancing orders helped to catalyze a rapid acceptance of care provided via telemedicine. A recent report from the US Department of Health and Human Services (HHS) showed that telehealth visits for Medicare patients increased dramatically from approximately 840,000 visits in 2019 to 52.7 million visits in 2020 [17]. For Medicare visits, behavioral health specialists had the highest increase in telemedicine utilization, with about 50% of their visits conducted via telehealth by the end of 2020 compared with a 1% rate of telemedicine visits in 2019 [17].

The pandemic forced the medical system to rapidly adapt, and acute stroke care was no exception. Early in the pandemic, acute stroke care pathways were significantly impacted as full adherence to published guidelines became challenging in the setting of an influx of critically ill patients with COVID-19, personal protective equipment (PPE) shortages, and limited hospital bed and staff availability [18]. Driven by these factors, the role and application of teleneurology and TS have grown and expanded during the COVID-19 pandemic. Therefore, this review aims to discuss the role, utilization, and implementation of TS through

the COVID-19 pandemic and suggest future directions to optimize future TS practice.

Telestroke role and utilization during COVID-19 pandemic

Telestroke code activation and acute intervention

As previously discussed, TS is an essential component of stroke systems of care in high-income countries, where it is used to rapidly evaluate patients with acute stroke symptoms at locations in rural or underserved areas [10•, 13, 14•]. In the early months of the pandemic, there were significant changes in TS utilization linked to patient-level behaviors. Several reports showed delays and decreases in acute stroke patient presentations to emergency departments, and lower rates of mechanical thrombectomy (MT) compared to pre-pandemic levels [19•, 20–22]. One retrospective study from a single US comprehensive stroke center (CSC) showed that there was a 38% decrease in new stroke diagnoses in the first 6 weeks following the declaration of COVID-19 pandemic compared to the 5-month period prior to the pandemic [19•]. Another retrospective study of neuroimaging data on patients with suspected acute stroke across 97 hospitals in 20 states showed a 17.1% and 16.7% decrease in the incidence of large vessel occlusion and severe strokes on computed head angiography (CTA) and CT perfusion studies, respectively, in the pandemic period (March 1 to May 10, 2020) compared to the pre-pandemic period (November 4, 2019, to February 29, 2020) [23]. Additionally, a report from one US-based hub-and-spoke network showed 50% reduction in the number of TS activations and stroke diagnosis during the telestroke encounters in the first 30 days following the declaration of the pandemic [24••]. Several possible causes of this decrease have been proposed. Firstly, many patients with mild strokes chose to remain at home rather than present for emergency evaluation due to the fear of exposure to COVID-19. These patients would either not present at all or present to the emergency department (ED) outside the window for any urgent acute intervention and thus beyond the time where acute TS services would be utilized. Secondly, strokes were more likely to go unrecognized due to social distancing requirements, as individuals remained at home and were less likely to go to work or visit friends and family. Thirdly, given the role of systemic infections as a trigger for stroke [25], it is possible that there truly were fewer strokes as social distancing, hand hygiene, and masking decreased the incidence of infections such as during the COVID-19 pandemic [26]. Later studies showed slow recovery in the number of stroke code activations by the ED during the pandemic [27].

USA's federal and state legislative and regulatory changes

Though TS activations were reduced early in the COVID-19 pandemic, subsequently the utilization and application of telestroke has broadened across the continuum of stroke care as the legislative and regulatory barriers to its use have been lowered throughout the USA [28••]. This was driven by

the need to mitigate the risk of potential COVID-19 exposure that may occur with in-person encounters, preserve PPE, and maintain high quality care for stroke patients.

In the pre-pandemic era, there were many concerns about the risks that telehealth systems pose to the security and privacy of patient's information and how this can adversely affect patients and clinicians [29]. However, the Department of Health and Human Services announced that they would not impose penalties for noncompliance with Health Insurance Portability and Accountability Act (HIPAA) rules and regulations in connection with good faith provision of telehealth during the public health emergency [30]. TS professionals are generally fully licensed, registered, and credentialed at the remote site where patients are located and the originating site where practitioners are located. All states in the USA require physicians to be licensed to practice in their home state and some states require professionals using telehealth technology across state lines to have a valid state license in the state where the patient is located [31]. The credentialing process is time-consuming and involves redundant paperwork thus limiting telehealth professionals' practice to certain geographic areas. During the COVID-19 pandemic, many states waived their telehealth licensure requirements, including TS, which helped expand and ensure adequate access to stroke care [32]. In addition, Centers for Medicare and Medicaid Services (CMS) and other commercial payers have expanded coverage and reimbursement for telehealth services during the pandemic which allowed professionals to bill for their encounters similar to in-person visits thus increasing healthcare access to patients at their homes and long-term care facilities [33•]. The geographic reach of TS and telemedicine during the pandemic expanded to include urban and suburban areas. This expansion was facilitated by CMS and other payers who temporarily expanded reimbursement for telestroke and telemedicine to include urban areas and patients in their homes whereas prior to COVID-19 pandemic, reimbursement was largely limited to patients physically present at a health care facility located in a rural area [34].

By removing regulatory barriers, telemedicine was able to rapidly scale across the healthcare delivery continuum. TS was no exception, as it was deployed in many novel ways across all phases of care: acute emergency consultations, inpatient management, stroke rehabilitation, and outpatient follow-up.

Acute stroke care and inpatient management

Acute emergency TS consultations were previously limited to underserved locations, but the technology was quickly implemented in urban emergency departments and CSCs. Most centers operated under the assumption that all acute stroke patients had COVID-19 infection until testing returned; thus, many centers leveraged in-house TS technology in the emergency department for acute stroke alerts to help deliver timely and efficacious care while preserving PPE and minimizing the risk of infectious exposure to the stroke team [35]. Clinicians could review histories, examine patients, discuss

treatment options, and obtain informed consent without the need to enter or deploy the stroke team to the patient's room [36]. Moreover, TS became even more important as a tool to identify the best candidates for hospital transfer, as the pandemic led to severe bed shortages at tertiary care hospitals. TS has been shown to limit unnecessary transfers of patients who could be safely managed by local facilities, especially patients with mild stroke syndromes or stroke mimics. This optimization of disposition maximizes tertiary care hospital resources by avoiding unnecessary inter-institutional transfers [14•]. This role of TS offered many advantages during the pandemic including minimizing healthcare costs, decreasing unnecessary utilization and thereby increasing availability of medical transport resources such as emergency medical services (EMS), allocating the limited higher level of care beds and resources to patient population who will most likely benefit from them, and reducing the potential for infectious exposure to patients, transport, and treating teams. The American telestroke association proposes that TS is a service designed to provide assessment, diagnosis, management, and disposition decision-making services to patients presenting with acute stroke syndrome [31]. Given the increased complexity and intricacy of patients presenting with acute neurological symptoms, the authors envision that TS services should be mainly utilized to help diagnose and manage patients presenting with acute stroke syndromes and differentiate this patient population from those presenting with stroke mimics for which the management can be deferred to the health care professionals requesting the TS service.

Beyond acute hospital care and evaluation, TS became a useful tool at many centers for the inpatient management of patients following acute stroke. As centers faced dramatic staff shortages and focused on PPE conservation, telemedicine assessments of patients already in the hospital became more commonplace. These telemedicine evaluations could be performed either locally or remotely based on the needs or the capabilities of each hospital. Many institutions, including both academic and nonacademic institutions with extant stroke care teams, started using in-hospital TS to evaluate patients following AIS. This allowed these institutions to limit stroke team infectious exposure in the setting of staff and PPE shortages without compromising the educational experience for medical trainees [37, 38]. Smaller hospitals without existing stroke care teams became prime candidates for the development and expansion of inpatient TS service lines in which patients with mild stroke syndromes could be treated locally while still receiving subspecialty care through remote TS evaluation. These novel care delivery models have expanded the role for telestroke services while decreasing the need for transfer to CSCs in an environment where hospital capacity became a major challenge [39•, 40].

Stroke telerehabilitation

Telerehabilitation (TR) of stroke patients (the use of telecommunication devices by healthcare professionals to provide evaluation and rehabilitative

services for disabled patients at remote locations) is a novel approach that has emerged over the last decade as a promising tool for remote administration of supervised therapies to stroke patients. Geographical location, socioeconomic status, and logistics surrounding transportation all often impede access of stroke patients to traditional comprehensive rehabilitative services. In the pre-pandemic period, multiple randomized clinical trials and systematic review using TR therapy for stroke survivors have suggested that it may have better or equal outcomes on motor and higher cortical function compared to traditional in-clinic therapy [41, 42, 43•]. A non-inferiority clinical trial by Cramer and his colleagues randomized 124 poststroke patients to either receive intensive TR therapy at home targeting arm movement or traditional in-clinic rehabilitation therapy and showed that TR had comparable efficacy for improving motor function and educating stroke patients [43•]. In addition, TR for stroke patients has been shown to be more cost-effective compared to the traditional in-person clinic intervention [44].

During the COVID-19 pandemic, rehabilitation centers have become less available for stroke patients as a protective measure to minimize the exposure of both patients and healthcare professionals to the virus. This is important as stroke patients are vulnerable to infections and COVID-19 has been associated with higher 60-day mortality in patients with ischemic stroke compared to the general public [45]. TR for stroke patients offers several advantages during the pandemic as it ensures patients' safety and their access to continuous, intensive rehabilitative services to maximize post-stroke recovery. Additionally, TR allows stroke patients to circumvent the logistics of transportation which became more challenging during the pandemic given the mandatory social distancing and limitation of unnecessary travel. TR may also help improve patients' psychiatric health by providing social interaction. This social interaction is critical given that clinically significant symptoms of depression affect approximately one third of stroke patients and studies have shown increased prevalence of psychiatric comorbidities during the COVID-19 pandemic in this patient population, likely due to social isolation [46, 47].

Ambulatory telestroke care

Early in the pandemic, nearly 1 in 4 outpatient visits were missed, leading to poor resource allocation, health care professionals and patients frustration, and suboptimal care [48]. Fortunately, there was a rapid transition of visits from face-to-face to telemedicine, which became widely used to preserve the continuity of care for outpatients across different subspecialities including neurology with good patients and healthcare professionals satisfaction [37, 49, 50]. This helped expand the utilization of teleneurology and TS to provide and enhance long-term care for stroke patients beyond the acute care phase.

The adoption of TS as a tool for follow up visits with stroke patients in the outpatient setting after hospitalization or emergency visits during the pandemic created new opportunities to provide and continue long-term care for this patient population. Stroke patients face logistical challenges surrounding transportation to healthcare facilities for follow-up care as

stroke patients often have residual disability including mobility and vision impairment and arranging appropriate transport is time consuming for patients, families and post-acute facilities (i.e., inpatient rehabilitation hospitals and long-term care facilities). Moreover, transportation to in-person visits is not without risk as stroke patients are vulnerable to COVID-19. A virtual care delivery model for stroke patients has the potential to overcome these logistical challenges without compromising patient safety and can improve satisfaction by decreasing the travel burden and waiting time. The adoption and increased utilization of teleneurology and TS for ambulatory and long-term care was facilitated by pandemic-related social distancing, lessening of regulations and improved reimbursement.

Global impact of COVID-19 on telestroke

TS networks exist in most high-income countries and some middle income countries [51]. The COVID-19 pandemic impacted different countries' utilization of TS networks to varying degrees and also led some low to middle income countries to establish TS programs [52]. For example, TS is almost non-existent in the Middle East and North Africa (MENA) region, but during the COVID-19 pandemic, many of these low- to middle-income countries' legislative authorities have realized the importance of TS and expedited their efforts for a possible coordinated TS system in the MENA region [52].

Early in the pandemic, some TS networks worldwide reported a decrease in telestroke code activations similar to that which was observed in the USA [24••, 53, 54]. One pandemic-era report from the Spanish region of Catalonia showed that their 14 TS centers experienced more than 30% reduction in TS code activations and > 50% decrease in thrombolysis treatment in the first 7 weeks following the declaration of the pandemic compared to the 7-week period pre-pandemic [53]. However, reports from western China and Chile each showed that their TS systems and networks did not face any significant reduction in stroke codes or reperfusion therapy in the first year of the pandemic compared to the year before [55, 56].

The role of TS also expanded during the pandemic beyond the acute care phase for many stroke patients worldwide. For instance, one study from Australia assessed the utilization of TS for ambulatory stroke clinics in rural areas with almost non-existent stroke expertise from November 2018 to August 2021. This study showed that the TS clinic was very well attended by patients and led to both a decrease in travel and wait time for patients as well as significant medical interventions including medication adjustments, additional investigations, and enrollment in clinical trials [57•].

The impacts of the COVID-19 pandemic on TS practices and utilization worldwide are similar to what has been observed in the USA in that the pandemic affected the number of TS activations and rates of reperfusion therapies early in the pandemic, led to expedited changes in the legislative systems, and expanded TS deployment beyond the acute care phase. Such expansion and legislative changes predict a possible future increase in the application and impact of TS on patients' care worldwide.

The future of telestroke care: beyond the pandemic

Policy concerns

Though the COVID-19 pandemic has strained the healthcare care systems around the world, the pandemic also provided the impetus for rapid and dramatic upscaling of virtual telehealth and TS utilization and its widespread acceptance by patients, healthcare professionals, and payers. This rapid growth was facilitated by digital technology, positive evidence from the use of telemedicine in prior epidemic situations, and loosening of regulatory and billing requirements during the pandemic [58••, 59]. As worldwide vaccination campaigns have been launched and the number of cases of and mortality from COVID-19 infection have declined, the initial restrictions are being gradually lifted and some countries have ended the state of emergency related to the pandemic [60, 61].

In the USA, return to pre-pandemic regulatory principles would have lasting negative consequences. Following the pandemic-related legislative changes, the convenience, connectivity, and capabilities of telemedicine have streamlined many aspects of care delivery, leading to positive impacts on patient care. The authors recommend lawmakers carefully consider making these changes permanent in order to continue to deliver high value telestroke care. For example, the temporary expansion of reimbursement for telehealth services related to stroke care continuum by CMS and other commercial payers can be continued in both urban and rural areas and licensure requirements of state medical boards for telemedicine and TS can be relaxed. The possibility of nation-wide licensing service would allow easier access to stroke expertise for patients across state lines and reduce the burden of redundant paperwork. These are only a few examples of how legislative changes can help to stimulate the growth of telemedicine to meet the needs of our patients.

While it is difficult to predict future regulations, the authors envision the continued growth of TS services across the continuum of stroke care (Fig. 1).

Prehospital telestroke

Telemedicine-enabled ambulances and mobile stroke units (MSU) allow real-time audio–video consultation with vascular neurologists who can evaluate potential acute stroke patients in the prehospital setting (Fig. 2). The MSU allows for the administration of thrombolytic therapy en-route and has been shown to significantly decrease treatment times and improve patient outcomes [62]. Yet, the widespread use and deployment of these modalities has been limited given the associated costs, need for resource allocation, and lack of significant reimbursement by current payers [63–65]. Given these limitations, their use has not increased during the pandemic, but widespread prehospital TS deployment would offer several advantages. For example, pre-hospital TS can screen for thrombolysis contraindications in patients

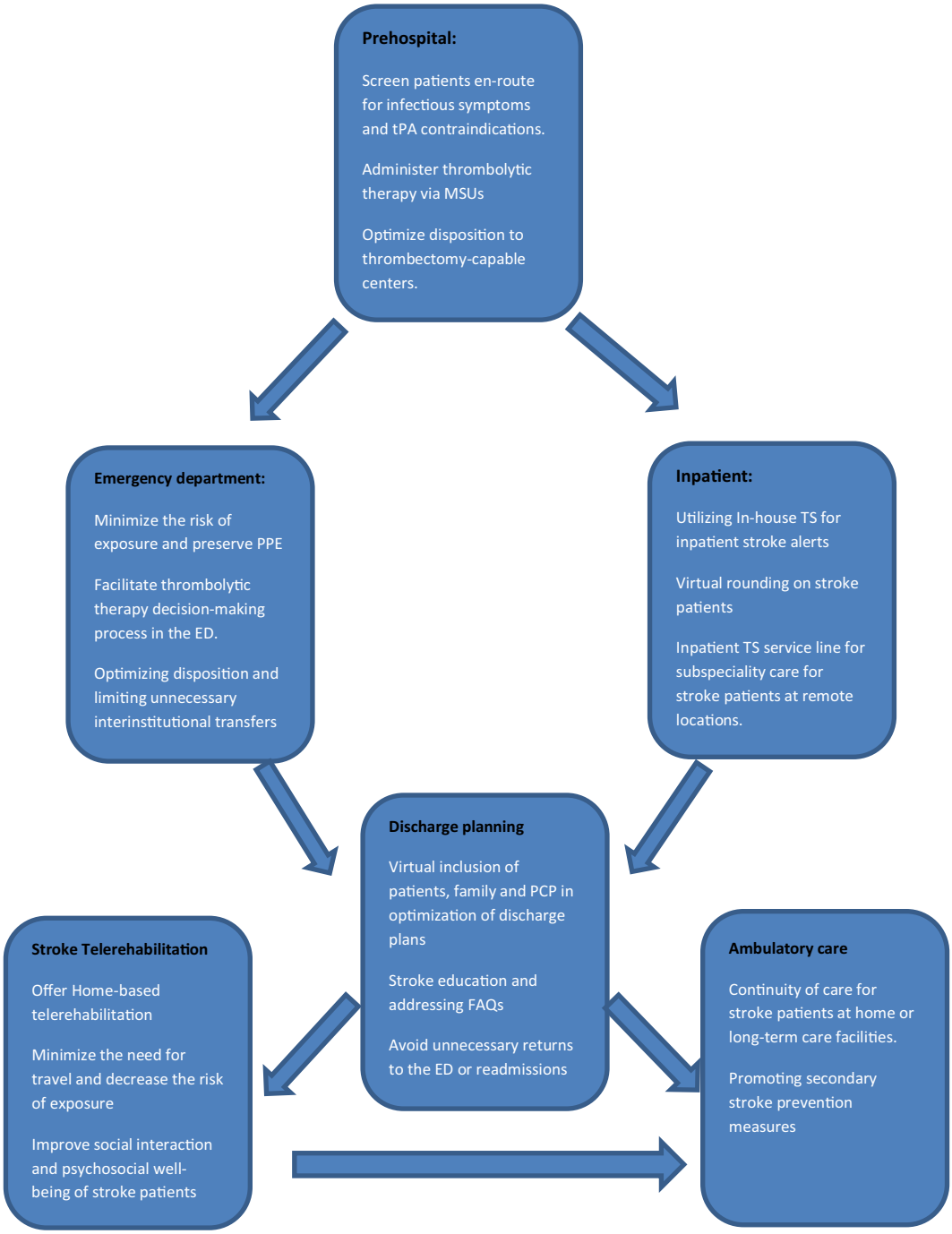

Fig. 1 Telestroke role across continuum of stroke care. This flowchart represents the authors' vision of telestroke role across stroke continuum of care in the future starting from prehospital assessment to stroke rehabilitation and ambulatory virtual visits. Abbreviations: ED, emergency department; FAQ, erequently asked questions; MSU, mobile stroke unit; PCP, primary care provider; PPE, personal protective equipment; TS, telestroke

Fig. 2 Telestroke-enabled Ambulance and Prehospital Telestroke Assessment. The figure shows a patient with suspected acute stroke syndrome being transferred by EMS via a telemedicine-enabled ambulance with audio–video system allowing a vascular neurologist at the receiving facility to evaluate the patient en-route

with suspected acute stroke syndromes, and even administer thrombolytic therapy in patients being evaluated via MSU. In addition, it can optimize patients disposition, especially in cases of suspected large vessel occlusion as they can be directly transferred to thrombectomy-capable centers rather than transferring them to stroke centers which do not have this capability and subsequently, they transfer to CSCs, and this can delay access to appropriate treatment. Thus, deployment of TS in the prehospital setting can streamline the triage process prior to ED arrival and help decrease the door to needle and door to groin times in candidate patients which in turn can help improve their outcomes. Utilization of TS in future pandemics can also help to reduce patients' and health care professionals' infectious exposure, preserve PPE, and allow screening of patients en-route regarding respiratory or infectious symptoms which may affect their downstream care upon arrival to the hospital. Improved reimbursement by CMS and other commercial payers would stimulate the growth of prehospital TS care provided via telemedicine-enabled ambulances and MSUs, facilitating their utilization both routinely and in future public health emergencies. There is a large opportunity for growth of TS in this phase of care.

Inpatient telestroke

Telemedicine evaluations of stroke patients beyond the hyperacute phase have been utilized during the pandemic to limit stroke team exposure and provide continuous care to stroke patients both locally and remotely. This new pandemic-related role of TS opens the door for the development of care delivery models in which patients with mild strokes could be admitted locally and followed serially by a distant practitioner with stroke expertise, who is then able to recommend appropriate testing, review evaluation, and provide updated treatment plans. This would increase patients' access to stroke expertise and reduce burden on referral centers by decreasing patient transfers.

Ambulatory telestroke and stroke telerehabilitation

Home-based telerehabilitation has been shown to improve motor function in patients with stroke to a degree similar to standard in-person clinic intervention [66]. The adoption of and investment in stroke telerehabilitation and ambulatory telestroke can improve the ability to monitor stroke recovery at home, address medication compliance, reinforce secondary stroke prevention strategies, reduce the burden of travel (including time, pain, hassle, and expense to patients and caregivers), improve patient satisfaction, and decrease the risk of infectious exposure to this vulnerable patient population. However, broad implementation of post-acute telestroke care would require federal and state regulatory changes, development of infrastructure to support the connectivity, and security requirements of telehealth care in all geographic regions, and improved reimbursement by payers for these visits.

Education

COVID-19 pandemic disrupted traditional medical education for both medical students and clinical trainees, negatively impacting their educational experience and their mental health and well-being. Vulnerable groups with pre-existing mental health issues or from socially disadvantaged backgrounds were most affected [67]. Neurology training was no exception as trainees' exposure to bedside teaching, elective procedures, and non-COVID-related patient admissions was minimized. Telemedicine and telestroke emerged as an alternative platform to ensure continued education of medical students and clinical trainees and mitigate some of COVID-19's devastating impact on students and trainees' mental health [68]. Potential benefits of telestroke care in medical training include increased longitudinal care from the hyperacute phase through rehabilitation and ambulatory visits, improved access to more diverse patient populations regardless of patients' geographic location, and creation of new educational collaborations between institutions.

Conclusion

The pandemic created new care delivery models for telestroke and expanded its utilization beyond the acute phase to deliver personalized healthcare across the entire continuum of stroke care. As the public health emergency ends, expansion and optimization of telestroke services depend on maintaining the necessary infrastructure and the ability of the current reimbursement and legislative systems to adapt to allow broad utilization of telehealth and telestroke services beyond the pandemic.

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Compliance with Ethical Standards

Conflict of Interest
Ehab Harahsheh, Stephen W English, Courtney Hrdlicka, and Bart Demaerschalk declare no competing interests.

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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