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# Improving Access to Care: Telemedicine Across Medical Domains

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## Keywords

telemedicine, health services accessibility, outcome assessment, digital divide

## Abstract

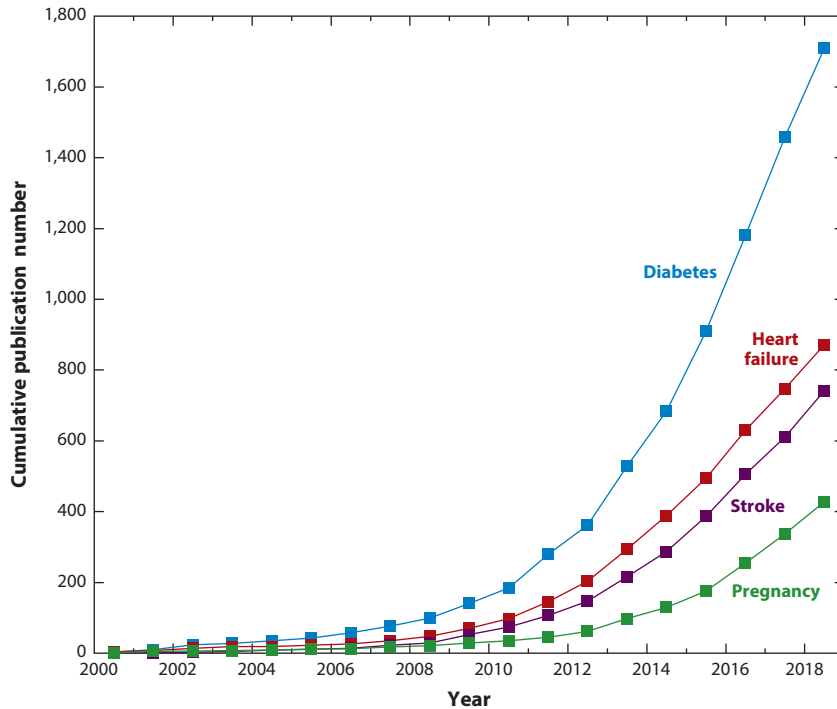
Over the past 20 years, the use of telemedicine has increased exponentially. Its fundamental aim is to improve access to care. In this review, we assess the extent to which telemedicine has fulfilled this promise across medical domains. Additionally, we assess whether telemedicine has improved related health outcomes. Finally, we determine who has benefited from this novel form of health care delivery. A review of the literature indicates that (a) telemedicine has improved access to care for a wide range of clinical conditions ranging from stroke to pregnancy; (b) telemedicine in select circumstances has demonstrated improved health outcomes; and (c) telemedicine has addressed geographical, but less so social, barriers to care. For telemedicine to fulfill its promise, additional evidence needs to be gathered on health outcomes and cost savings, the digital divide needs to be bridged, and policy changes that support telemedicine reimbursement need to be enacted.

## TELEMEDICINE: DEFINITION AND TRENDS

Telemedicine, the provision of medical care via the use of telecommunication technology, has evolved dramatically over the past two decades. Although the field has undergone remarkable change in recent years, its fundamental aim has remained constant: to improve access to care (28). Although our current health care system is faced with several areas of needed reform, the urgency of improving access to medical care remains of central importance. Overcoming barriers of access will require resourcefulness and thoughtful innovation, and in this review we examine the evidence that telemedicine has provided thus far in addressing these fundamental concerns. Numerous systematic and meta-analysis reviews have investigated the extent to which telemedicine has improved access and related health outcomes, but these reviews are often limited in scope to a specific medical condition. Literature examining the utility of telemedicine across medical domains is lacking, and for the purposes of this review, we look to investigate the utility of telemedicine through the lens of four diverse, prototypical medical conditions. The selected conditions discussed further in this review are stroke, heart failure, diabetes, and pregnancy (statistics for the prevalence of these four conditions are provided as well). These prototypical conditions were chosen, as they each have been thoroughly studied with regard to telemedicine and span acute versus chronic as well as primary versus specialty care. These common and costly medical conditions will allow for examination of broad applications of telemedicine use, highlight common themes related to access, and help identify further areas of needed improvement. For the purposes of this review, we focus our discussion on recent notable publications from the past decade with emphasis on the application of telemedicine within the United States.

Initially utilized for the timely management of urgent conditions such as trauma and stroke (56, 61), telemedicine has rapidly expanded into a means of providing comprehensive care across multiple medical domains. Ranging from acute to chronic, as well as primary to specialty care, telemedicine has successfully been implemented in a wide variety of medical conditions such as heart failure (57), diabetes (106), and even pregnancy (62). With innovations in portable device technology and increasing broadband availability, telemedicine has made great strides in the modalities used to achieve this aim. Through the use of smartphones, videoconferencing, and mobile wireless sensors patients can currently receive medical care, often in the comfort of their own homes, saving time and unnecessary cost. Extending beyond the confines of clinic interactions, these tools are being utilized to gain better insight into disease progression and recovery and to assist in achieving optimal medical treatment (82, 92). As the full potential of these applications is still being realized, telemedicine continues to provide new and innovative means of health care delivery.

Concurrent with the expanding applications and modalities of telemedicine use, interest has also grown significantly. As evidenced by the growing number of annual telemedicine-related literature publications (105), interest in telemedicine across multiple medical specialties has increased exponentially (7, 10, 27, 33) (**Figure 1**). Alongside increasing interest, patient utilization of telemedicine services has also been on the rise. Recent analysis of the largest database of private commercial insurance claims in the United States revealed that national telemedicine utilization grew 53% from 2016 to 2017 and was the fastest growing means of health care delivery, accounting for 0.11% of all national medical claims that year (34). Similarly, another large pool analysis of commercially insured individuals from 2005 to 2017 revealed an average annual compound growth rate between 45% and 61%, with the fastest rate of growth seen in primary care telemedicine visits (6). Federal telemedicine utilization demonstrates similar rates of increased uptake. Examination of rural Medicare beneficiary claims from 2004 to 2014 revealed a comparable average growth rate of 45.1% annually for telemedicine mental health–related visits (67). While it is clear that interest



**Figure 1**

Cumulative PubMed publications since 2000 with Medical Subject Headings (MeSH) terms including “telemedicine” or “telehealth.”

in, and utilization of, telemedicine is growing, the essential questions remain: Does telemedicine improve access to care and, importantly, which patients will gain benefit?

## COMPONENTS OF HEALTH CARE ACCESS

Access to health care relies on the use of available resources in attempts to achieve optimal health outcomes (46). It is composed of three main components: entry into the health care system, an adequate supply of services available, and timely provision of care (Table 1) (77). Unfortunately, issues related to health care access continue to remain of vital concern. According to the US Centers for Disease Control and Prevention (CDC), approximately 10% of adults aged 18–64

**Table 1 Components of health care access amenable to telemedicine intervention**

Components of health care access (77)	Limitations addressed by telemedicine
Entry into health care system	Transportation barriers (e.g., lack of transportation, long geographic distance to health care facility, cost of transportation, limited access to vehicle, unreliability of public transportation, inability to drive due to disease)
Adequate supply of services available	Provider availability (e.g., physician shortages in medically underserved areas)
Timely provision of care	Long wait times (e.g., excessive wait times for next available provider as deterrent to seek care when needed)

delayed or did not receive access to needed medical services, and this estimate more than triples for those living below the national poverty line (73). Individuals face many significant barriers to health care access, and when care is accessible it is often unsafe (37) or inefficient (85). Fortunately, the emergence of telemedicine has shown promise in improving health care access by addressing the current inadequacies of each of its components.

### **Entry into Health Care System**

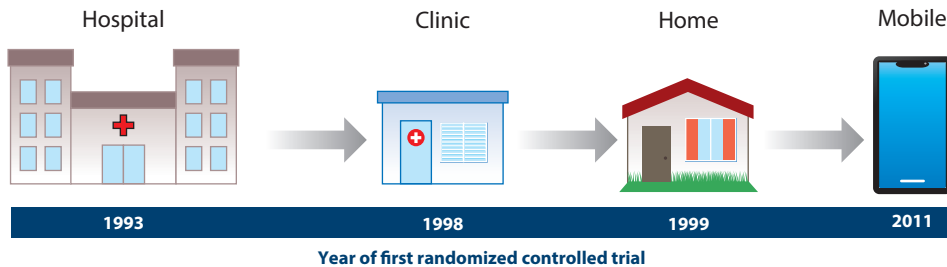
The first step in gaining access to health care services is entry into the health care system. Unfortunately, many barriers prevent even insured individuals from entering the health care system, and one of the most significant barriers is transportation. For patients living with chronic diseases who require frequent office visits and medication adjustments, reliable transportation is often necessary for receiving appropriate medical care. Additionally, many patients cannot drive themselves owing to physical and sensory limitations that accompany their disease. Three of the most commonly cited transportation barriers include lack of availability, geographic distance, and cost (52). Greater travel distance to medical centers has been shown to result in less frequent health care utilization and worse health outcomes. Patients in rural communities are especially vulnerable. For example, a study of patients with type 2 diabetes reveals that the further patients resided from their primary care provider, the less likely they were to use their insulin and the more likely they were to have poor control of their diabetes (58). It is clear and well documented that lack of reliable transportation and geographic distance remain significant barriers for receiving adequate access to health care services.

### **Adequate Supply of Services Available**

The supply of services available once patients enter the health care system proves to be another significant barrier to health care access. Issues related to provider availability remain of vital importance, as projections indicate that there will be a growing shortage of practicing physicians, estimated between 46,900 and 121,900, by the year 2032 (1). This growing discrepancy between supply and demand presents a crucial barrier to health care access and warrants intervention. Provider availability largely influences health care utilization and access to treatment, and again this is especially true among resource-limited rural communities. Less than 12% of physicians in the United States practice in rural communities (87). In addition, among these physicians practicing in rural communities, there is a high turnover rate, which further weakens therapeutic rapport and has been associated with patient vulnerability (9). Therefore, lack of physician availability, especially in rural communities, remains another notable barrier to health care access.

### **Timely Provision of Care**

Receiving care within a reasonable timeframe is also a crucial component for accessing appropriate health care. Unfortunately, timely access to health care still presents a major barrier for many people. For example, most patients seeking acute care in the emergency department face exceptionally long wait times before being able to see a provider. Prolonged wait times have been shown to be associated with increased morbidity and mortality as well as decreased patient satisfaction (42, 47, 97). Wait times for appointments to see an outpatient provider may also limit health care access, and in general, the more specialized the care, the longer the wait. Research has shown that wait times for specialty care can range from months and in certain cases to more than a year (48, 54). Long wait times to receive both acute care in emergent settings as well as chronic care in outpatient settings are a concerning deterrent, preventing patients from seeking health care in the



**Figure 2**

The migration of telemedicine from the hospital to mobile device by year of first randomized controlled clinical trial at each location.

first place. Furthermore, if patients decide to wait, the care they receive may not be within the appropriate timeframe of when treatment would be most effective.

## HEALTH CARE ACCESS AND OUTCOMES

As telemedicine evolves, it will continue to transition care away from medical institutions, and patient-centered home delivery models of care are to become more routine (**Figure 2**). In doing so, issues related to transportation and geographic distance will serve as less of a barrier to entry into the health care system and ideally lead to improved access. Telemedicine also has the potential for providers to increase their reach of practice through facilitating communication between specialists and community providers to assist in delivery of timely care. Systematic reviews have shown that telemedicine has been effectively implemented to provide a wide range of medical services, both routine and specialized, and has led to greater access to care. In addition, telemedicine has demonstrated similar, and in select circumstances better, health outcomes when compared with traditional care models (32), while proving capable of decreasing unnecessary hospitalizations and costs (19, 89).

Frequently cited clinical limitations of telemedicine include the inability to perform comprehensive physical examinations, sacrifice of patient–provider relationships, fragmentation of care, and the potential for overprescribing/excess health care utilization. These concerns are often unsubstantiated, and while it is important to anticipate the potential shortcomings of telemedicine, innovative solutions are continuously being adopted to overcome potential barriers to implementation. Examples of such solutions include the use of user-friendly devices to gather vitals and data to facilitate remote clinical assessment, as well as utilization of interchangeable electronic health records to enable sharing of information among various providers (28).

Overall, the promise of telemedicine seems encouraging, and we look to further examine notable examples of its efficacy through the lens of four diverse, prototypical medical conditions with the goal of recognizing common themes and identifying areas of needed improvement. These medical conditions include stroke, heart failure, diabetes, and pregnancy.

## STROKE

The management of acute and urgent medical conditions, including stroke, illustrates one of the most impressive applications of telemedicine. Stroke affects 795,000 patients in the United States annually, is the fifth leading cause of death, and amounts to an estimated annual total cost of \$40.1 billion (8). First proposed by Levine & Gorman in 1999 (56), telestroke is now commonplace in helping combat the shortage and inequitable distribution of acute stroke specialists.

Hub-and-spoke telestroke networks promote real-time communication and data sharing between single tertiary care centers and multiple community emergency departments via videoconferencing and mobile devices (36). Patient video assessments coupled with the transmission of computed tomography (CT) brain imaging data allow for comprehensive stroke centers to assist in the treatment management of patients in remote locations. This approach is particularly useful as timely intervention is essential when deciding whether a stroke is the result of either an intracranial bleed, which may require surgical intervention, or a clot, which may be amenable to intravenous (IV) thrombolysis treatment that could be administered immediately.

This frequently utilized hub-and-spoke model of telemedicine care has proven especially useful for underserved patient populations, including rural and ethnically diverse communities (41, 61). For example, a recent notable study in the state of Texas demonstrated that telemedicine has expanded access to acute stroke care for 1.5 million Texans, with no evidence of racial or ethnic disparities (61). Telemedicine not only increases access to specialty stroke care, but also results in positive clinical outcomes with noted improvements in health service efficiency. Studies have shown that telemedicine stroke networks improve accuracy of diagnosis (68), increase rates of timely IV thrombolysis treatment (18), and reduce interhospital patient transfers (Table 2) (59). These claims have been further supported by systematic reviews that validate remote telemedicine stroke care as a suitable alternative to traditional in-person models of care. For example, a recent meta-analysis review including 1,863 patients concluded that within a 3-h treatment window telemedicine-guided IV thrombolysis treatment is as safe and effective as care provided at stroke

**Table 2** Recent select studies investigating the role of telemedicine in stroke

Author	Year	Participants	Intervention	Outcome
Keplinger et al. (49)	2016	1,863 patients across 7 prospective clinical control trials	Systematic review and meta-analysis of timely thrombolysis within 3-hour treatment window	Telemedicine guided treatment is as safe and effective as care provided at traditional stroke centers
Lyerly et al. (61)	2016	1.5 million Texas residents from US Census Bureau data	Access to acute stroke care via telemedicine	Telemedicine expanded access to acute stroke care without evidence of racial/ethnic disparity
Chalouhi et al. (18)	2013	1,643 telemedicine stroke consultations provided over 28 rural/community hospitals within Northeastern United States	Rates of appropriate thrombolysis treatment for eligible patients following telemedicine implementation	Telemedicine implementation in underserved communities resulted in higher rates of stroke thrombolysis treatment compared with national averages and resulted in fewer patient transfers to primary stroke centers
Nelson et al. (74)	2011	Analytic cost-effective model of telestroke using prior published literature and estimates from Southwestern US hospital networks	Statistical analysis including total cost of equipment maintenance and medical care as compared with quality-adjusted life years	Despite initial upfront fees, telestroke is shown cost-effective especially when accounting for the cumulative lifetime expenses of medical care follow-up that are influenced by timely intervention

centers (49). Finally, despite a considerable initial price tag on its implementation, telemedicine in stroke has also proven cost-effective for both patients and hospitals (74, 95).

In addition to the frequently utilized hub-and-spoke prototype, modalities of telemedicine for the treatment of stroke are continually expanding. More recent applications of its use include mobile stroke emergency units that utilize point-of-care laboratory testing and telemedicine conferencing to bring care directly to patients in urgent need (86). These mobile stroke unit ambulances are equipped with onboard CT brain imaging devices coupled with real-time videoconferencing to allow for hyperacute assessment and treatment of stroke patients prior to them being seen in the hospital. Concurrent with improvements in timely treatment intervention, continued advances in multimodal imaging techniques have also assisted with clinical decision making and have shown promise in improving the efficacy of telemedicine application in stroke (26). Last, beyond the acute phase of stroke management, telemedicine has shown capable of facilitating poststroke rehabilitative services at home with greater improvement in functional scores when compared with usual care (21). Future applications of telemedicine in stroke will likely continue to optimize timely intervention of acute treatment management while also expanding on available health care services available at home during the chronic phase of recovery.

## HEART FAILURE

Heart failure is one of the most common chronic diseases in the United States and is increasing in prevalence. Parallel to our rapidly aging population, rates of heart failure continue to rise as this disease currently affects greater than 5.7 million individuals in the United States and is predicted to increase by 46% by the year 2030 (72). Patients with congestive heart failure are prone to acute exacerbations, which require urgent medical evaluation and treatment to restore cardiopulmonary function. Furthermore, the rate of hospital readmissions in patients with heart failure continues to remain high, with certain studies demonstrating more than 20% being readmitted within 30 days and more than 50% within 6 months of discharge (76). Telemedicine has proven successful in reducing rates of hospital readmissions and mortality in patients with heart failure through early detection and appropriate treatment management (23).

One of the most common telemedicine applications for the treatment of heart failure involves the use of telecommunication messaging and videoconferencing for remote patient management. These tools assist in patient education to improve compliance, allow for timely medication adjustments, and help manage the complex medical comorbidities that are often present in this patient population. One of the most impressive and notable recent randomized controlled studies examining the efficacy of telemedicine in heart failure is the TIM-HF2 (Telemedical Interventional Management in Heart Failure II) trial. This longitudinal study of 1,571 participants demonstrated that utilization of telecommunication tools resulted in a significant reduction in days lost due to unplanned cardiovascular-related events (50). Furthermore, although additional studies are warranted, automated telecommunication software has also shown promise in reducing the risk of rehospitalization among underserved rural patients (51).

Another recent and impressive application of telemedicine for heart failure management involves implantable hemodynamic sensors (2). These sensors are implanted into the patient's pulmonary artery to send information about the patient's pulmonary arterial pressure into a central service center monitored by the providing physician. When the pulmonary arterial pressure exceeds a certain threshold, indicating potential heart failure exacerbation, the physician can be alerted. A notable study examining the efficacy of these devices demonstrated a 37% greater reduction in rehospitalization rates during the 15-month follow-up period compared with controls (2). Therefore, the use of both remote patient management telecommunication as well as implanted

**Table 3 Recent select studies investigating the role of telemedicine in heart failure**

Author	Year	Participants	Intervention	Outcome
Koehler et al. (50)	2018	1,571 heart failure patients, from 200 medical practice locations across Germany	Remote patient management system combining patient telecommunication with daily transmission of health status data	Remote management resulted in a lower percentage of days lost due to unplanned cardiovascular hospital admissions during the first year of follow-up
Lin et al. (57)	2017	11,758 heart failure patients across 39 randomized controlled trials	Systematic review and meta-analysis of heart failure-associated mortality and hospital admissions for telemedicine versus standard care	Telecommunication and home sensor monitoring both significantly reduced heart failure-related hospitalizations and mortality
Krum et al. (51)	2012	405 patients from rural, remote general practitioner offices across Australia	Interactive telecommunication software paired with cardiac trained nurses to assist in treatment management	Telecommunication resulted in a significant reduction in hospitalizations among rural patients when compared with usual care
Abraham et al. (2)	2011	550 heart failure patients across 64 medical centers in the United States	Efficacy of cardiac hemodynamic sensor monitors in guiding medication adjustments and treatment management	Remote telemedicine sensor monitoring resulted in significantly fewer hospital readmission rates compared with standard treatment at six-month follow-up

sensor monitoring has demonstrated better outcomes through improved continuity of access to care.

These positive outcomes are further supported in systematic literature reviews. Recent systematic and meta-analysis reviews of home telemonitoring and telecommunication systems demonstrate that all-cause mortality and heart failure-related hospital admissions were reduced for both interventions (45, 57). As demonstrated by numerous studies, telemedicine has shown promise in the early detection of acute heart failure through hemodynamic sensor monitoring and improved outcomes related to patient management through home-based telecommunication interventions (Table 3). Future applications that incorporate both modalities and are adapted to specific patient needs may provide further continuity of health care access and even greater benefit for related health outcomes.

## DIABETES

Diabetes remains one of the most common and costly medical conditions in the United States. According to the CDC, an estimated 30.3 million people have diabetes, affecting 9.4% of the total US population and costing more than \$245 billion annually (15). Given the considerable extent of disease burden, primary care providers are frequently the ones left to manage treatment, often with limited available resources and suboptimal results. To help address the growing concern of diabetes, multiple modalities of telemedicine have been employed with promising success. Over the past decade, various applications of telemedicine, including videoconferencing, mobile health technology, and cloud-based management programs, have shown similar, and in certain circumstances better, health outcomes when compared with traditional care models.



In the management of diabetes, routine laboratory testing is commonly employed to measure blood glucose levels, and hemoglobin A1c (HgbA1c) is utilized as a specific biomarker for disease progression. In general, higher levels above the expected normal range provide evidence of poor disease management and correlate with worse clinical outcomes. A recent notable study investigated the efficacy of remote health monitoring via virtual visits in reducing HgbA1c six months following a telemedicine intervention. In this randomized clinical trial, participants in the telemedicine intervention group demonstrated significantly improved HgbA1c levels compared with traditional care (0.41% greater HgbA1c reduction) (38). Another impressive recent trial utilized cloud-based technologies incorporating patient self-tracking tools, shared decision-making interfaces, secure text messages, and virtual visits that demonstrated similar benefit. The telemedicine intervention group again achieved greater reduction in HgbA1c when compared with traditional controls over a three-month period (1.2% greater HgbA1c reduction) (43).

These telemedicine interventions have also shown to be particularly useful for underserved and vulnerable diabetic patient populations. This result is perhaps best exemplified by the IDEATel study. This 5-year longitudinal study recruited 1,665 patients residing in ethnically diverse and medically underserved areas in New York who were referred from their primary care providers. Patients enrolled in the intervention group had a home telemedicine unit capable of videoconferencing and glucose tracking, as well as providing patient access to clinical data and educational resources. Over five years, this study found an additional HgbA1c reduction effect of 0.29% in the telemedicine intervention group when compared with usual care (90, 100). Another recent study of vulnerable populations investigated the use of telemedicine to improve access for pediatric patients with type 1 diabetes in rural Wyoming. This study concluded that remote telemedicine consultation proved noninferior to in-person annual visits with comparable health outcomes and resulted in significantly less time missed from work/school (103).

Numerous systematic reviews and meta-analyses have examined the efficacy of telemedicine in improving access and health outcomes for patients with diabetes (**Table 4**). These studies have consistently demonstrated that telemedicine provides similar or improved health outcomes compared with usual care, particularly for patients with type 2 diabetes, although data on cost-effectiveness remains uncertain for type 1 diabetes (35, 91, 94, 106). While reductions in HgbA1c provide an approximate overall measure of diabetic control, diabetes is a disease with numerous complications and associated comorbidities. As telemedicine technologies continue to evolve, its adaptation for the management of diabetic complications will also progress as evidenced already by its successful utilization in retinopathy screening (63) and diabetes related to pregnancy (69).

## **PREGNANCY**

An area of specialty care especially conducive to the incorporation of telemedicine is obstetrics. The use of telemedicine modalities including smartphone apps, virtual prenatal provider visits, and remote home monitoring devices during pregnancy has expanded tremendously in recent years (98). With nearly 4 million births occurring in the United States annually (66), telemedicine may stand to dramatically improve health outcomes for both mother and child as it expands access to this commonplace component of health care delivery.

Evidence for telemedicine as a means of improving prenatal health care access and outcomes is strong. Recent studies in obstetrics (**Table 5**) have shown that telemedicine results in lower prenatal stress, higher patient satisfaction, and a reduced number of clinic appointments needed, all while maintaining the current standards of practice (12, 65). In particular, multiple studies have evaluated the role of telemedicine in prenatal care involving the management of gestational diabetes as well as smoking cessation through virtual appointments via videoconferencing

**Table 4 Recent select studies investigating the role of telemedicine in diabetes**

Author	Year	Participants	Intervention	Outcome
Su et al. (94)	2016	9,258 diabetic patients across 55 randomized controlled trials	Meta-analysis systemic review of telemedicine for hemoglobin A1c reduction in type 1 and type 2 diabetes	Telemedicine intervention overall was more effective than conventional treatment, especially for patients with type 2 diabetes
Wood et al. (103)	2016	54 pediatric type 1 diabetic patients in rural Wyoming	Remote management via video conference virtual visits	Telemedicine was equivalent to in-person evaluation after one year follow-up; intervention families spent significantly less time away from work and school
Greenwood et al. (38)	2015	90 type 2 diabetic patients within large California health network	Remote treatment management incorporating virtual visits with feedback analysis of glucose tracking results	Statistically greater reductions in hemoglobin A1c were achieved in telemedicine intervention group when compared with usual care at 6 month follow-up
Shea et al. (90)	2009	1,655 diabetic Medicare beneficiaries residing in federally designated medically underserved areas in New York	Telemedicine via home unit with blood glucometer capable of videoconferencing nurse case managers and accessing health records	Telemedicine intervention demonstrated greater reduction in hemoglobin A1c for medically underserved patients over the five-year follow-up period

telecommunication systems. In these studies, participants have demonstrated optimal glycemic control quicker than those with in-person appointments only, and in certain studies the frequency of visits has been shown to decrease without detrimental consequence (84, 98). Smoking cessation in pregnant women has also been widely targeted through telemedicine with marked improvement in abstinence rates, especially when supplemented by telecommunication text message programs (39, 60, 98).

Another consideration for telemedicine in pregnancy is its ability to reach individuals in rural and low-income areas with limited access to specialty care. Multiple studies have evaluated the use of video calls in rural areas to aid in fetal cardiac evaluations and also to connect regional specialists with local providers to give guidance on necessary procedures. Both applications have demonstrated decreased travel time and costs, with some studies citing up to a ninefold decrease in expenditures for pregnant individuals in rural settings, with no evidence of harm or decrease in quality of care (24, 44). More recent evolving applications of telemedicine within obstetrics involve the use of remote monitoring devices. For example, sensors capable of remote fetal heart monitoring and uterine contraction tracking have also been tested in rural areas, with associated reduction in travel and hospitalization secondary to improved access to care (96, 104). Current systematic reviews of the role of telemedicine in obstetrics have demonstrated comparable efficacy to standard care with no evidence of harm, but further studies are needed to demonstrate unequivocal superior benefit and reduction in costs (62, 69). While results from the current literature are encouraging, future studies are likely to further explore and refine the use of remote monitoring applications, and larger cohort studies are needed to critically evaluate potential reductions in associated costs.

**Table 5 Recent select studies investigating the role of telemedicine in obstetrics**

Author	Year	Participants	Intervention	Outcome
Butler Tobah et al. (12)	2019	300 pregnant women from the Midwest, United States	Prenatal virtual visits supplemented by fetal home monitoring devices	Telemedicine intervention resulted in higher patient satisfaction, lower prenatal stress, and reduced number of clinician appointments all while maintaining standards of practice
Cuneo et al. (24)	2019	368 pregnant women from medically underserved areas in Colorado	Remote, off-site telemedicine fetal cardiac monitoring consult evaluation	Remote telemedicine consult provided comparable diagnostic quality with ninefold reduction in travel-related costs
Marko et al. (65)	2019	88 women with low-risk pregnancies from Washington, DC, area	Mobile prenatal care app to facilitate reduced in-person visits	Telemedicine via mobile app resulted in fewer in-person visits with no associated reduction in patient or provider satisfaction
van den Heuvel et al. (98)	2018	Systematic review of 71 studies investigating role of telemedicine in obstetrics	Studies spanned areas of smoking cessation, gestational diabetes, mental health, remote monitoring, and teleconsulting	Telemedicine interventions are suitable and safe alternatives to usual care; further studies are needed to investigate superiority of outcomes and cost

## COMMON THEMES

Through a critical review of the literature on telemedicine across medical domains, notable common themes emerge. After examination of the four diverse, prototypical medical conditions highlighted in this review, it is evident that the literature consistently indicates that telemedicine is a safe and suitable alternative to traditional in-person models of care. Furthermore, for certain medical conditions, telemedicine has resulted in improved health outcomes with associated reductions in cost (i.e., stroke, heart failure). In areas where unequivocal benefit in outcomes and cost reduction remains in question (i.e., pregnancy, type 1 diabetes), findings continue to indicate that telemedicine intervention is comparable with current standards of practice and does not impose any unnecessary risk or harm to patients. Additionally, telemedicine has proven capable of addressing current barriers to access, which is best exemplified by its ability to assist medically underserved patient populations, especially those residing in rural areas. Overall, a review of the current literature reveals that telemedicine is in fact fulfilling its fundamental aim to improve access to care and is doing so by innovative and continuously evolving means. The four medical conditions discussed in depth in this review were intentionally chosen as they span a diverse range of health care settings. These common themes are therefore likely applicable to a broader set of conditions, but it remains important that the implementation of telemedicine adapt to the specific health care needs and communities that are being served.

## BARRIERS TO IMPLEMENTATION

Despite improvements in access to care and health outcomes resulting from telemedicine intervention, numerous barriers may impede telemedicine's widespread adoption if left unaddressed.

These limitations arise from both the patient's and the physician's perspectives and span social, financial, and legal domains.

One of the predominant hurdles faced by telemedicine to improve access to care is the digital divide—disparities in communication technology literacy and access along lines of age, race, socioeconomic status, or geography (<https://www.pewresearch.org/topics/digital-divide/>). Owing to this divide, telemedicine favors individuals typically unburdened by the traditional care model, namely the young, white, and educated (29, 71). Age and level of education are the most-cited barriers to the use of telemedicine, with specific mentions of deficits in digital literacy named less often (88). Furthermore, patients may also be unable to access telemedicine programs owing to an inability to access Internet-enabled devices or to have broadband Internet in their home. This differential quality of bandwidth inhibits many rural patients from receiving care through telemedicine (30). However, cloud-based high-quality videoconferencing programs such as Zoom Cloud Meetings and GoToMeeting have much lower bandwidth requirements than Federal Communications Commission standards and may bridge this gap (5, 93). The digital divide affects not only the patients intending to receive care through telemedicine but also the remote health care staff. The most common barrier to the implementation of telemedicine reported by staff was difficulty adapting to and utilizing the technology (14, 88).

Beyond differential access and necessary skill in using technology, the adoption of telemedicine is inhibited by cost (3, 79, 81, 88). Before care is offered through telemedicine, health care organizations must invest in the necessary resources to conduct patient visits. These resources include but are not limited to expenditures on equipment, licensing fees, and also time spent training patients and staff to use the technology appropriately. Telemedicine offers the promises of time and cost savings and serves as a diversion from more expensive areas of care (11, 13, 31, 53, 70, 71, 75, 83), but these initial barriers may hinder the uptake of telemedicine before it can deliver on these promises.

Once telemedicine programs are established, the question arises about who will pay for the subsequent services provided. At present, 37 states have parity laws that require private insurers to reimburse care delivered via telemedicine (up from 29 states in 2016) (16, 28), but the services covered and required reimbursement vary from state to state and insurer to insurer. While Medicare does reimburse for select telemedicine services, the restrictions on what treatments are received, who can receive them, and where they are received are stringent. Only individuals in rural areas (with exceptions for end-stage renal disease, acute stroke treatment, and substance use disorders) are eligible to receive treatments in a short list of approved facilities (17). This list notably lacks the patient's home among the eligible sites, a disappointing fact given the age and mobility of many individuals enrolled in Medicare. In emergency response to the coronavirus disease 2019 (COVID-19) pandemic, the Centers for Medicare & Medicaid temporarily lifted restrictions and broadened coverage to include home visits and nonrural areas (22), but whether long-standing policy changes are to follow remains in question.

As interest in telemedicine grows, so has the number of claims submitted to third-party payers for care provided through this modality (102). Still, the complications of reimbursement impede the ability to demonstrate telemedicine's financial benefit (14, 55). Furthermore, billing code discrepancies for telemedicine services fail to accurately report the frequency at which services are received and reimbursed (4, 102). Many practitioners simply do not bill for telemedicine services due to a lack of reimbursement (4). Insurers are hesitant to reimburse telemedicine owing to limited evidence that it is cost-effective, and as a result a cycle ensues, with fewer practitioners willing to offer or bill for these services. In some cases of private insurers, reimbursements for telemedicine have decreased while charges have increased, further hindering progress toward convincing organizations to adopt telemedicine (102).

Last, there are legal concerns regarding the use of telemedicine that may make use of the technology daunting. According to one review, legal liability, privacy confidentiality, and security of data composed 11% of reported barriers to adoption of telemedicine (88). With the rise in popularity and interest in telemedicine, guidelines for improving the privacy, security, and HIPAA-compliance for these practices are similarly increasing (99). Still, there is no accreditation system to ensure that telemedicine programs are compliant; the responsibility to maintain compliance falls on providers (70). These concerns over possible breaches in privacy or the storage of data collected through telemedicine visits may further deter patients from opting to use this service.

Because telemedicine offers the ability to treat patients anywhere in the world, concerns over proper licensure also deter many organizations from adopting telemedicine. Practitioners must currently be licensed in the originating site that is the state where the patient is located at the time of care. Issues concerning proper licensure can incur additional costs when providing care across state lines (20, 78, 79). For patients who reside in multiple states or those who have a medical condition that limits mobility, this may inhibit their ability to receive consistent care from their primary provider or specialist. Inconsistencies between states regarding the delivery and reimbursement of telemedicine obligate practitioners to invest both time and resources to ensure that, regardless of their patients' locations, they are compliant with burdensome medical malpractice and liability laws (55, 80).

## **FUTURE DIRECTIONS**

Telemedicine is poised to transform health care with increased access and reduced burden on patients and providers, but progress in several areas would need to be made in order to expand its availability and use. Widespread broadband access is necessary to allow telemedicine to be used in rural areas that need it most, and more effort could be directed toward inclusivity in telemedicine (40). Public education on the availability of telemedicine as an alternative to in-clinic care, as well as guidance on when its use is appropriate or not, is crucial to expand our knowledge on its efficacy and cost-effectiveness (83). Incorporating incentives for the adoption of telemedicine, or disincentives for incomplete reimbursement of telemedicine services, may help overcome the ongoing cycle of underusing and under-reimbursing of telemedicine (88). In addition, large cohort studies or controlled trials are needed to help clarify telemedicine's efficacy and inform the policies surrounding reimbursements for telemedicine visits (25, 70). Future telemedicine studies should seek to expand on the common themes learned from the past and take into account the potential for unique adaptations that may better address specific concerns across medical conditions.

With many patients and practitioners reporting security and privacy concerns as reasons for disuse of telemedicine, establishing standards for infrastructure to ensure the confidentiality and security of patients' medical information would be helpful (107). Furthermore, the development of widely accepted protocols for care delivery via telemedicine would increase the ease with which telemedicine can be adopted throughout health care and pave the way for expanded use of telemedicine in both research and care.

Progress has been made with regard to licensure that allows physicians to practice across state lines. More than half of all US states are now part of the Interstate Medical Licensure Compact, an initiative to facilitate the expedition of multistate medical licensure (101). The initiative focuses on expanding physicians' ability to offer care in rural and underserved areas across multiple states through the use of telemedicine (64). Despite the increase in physicians licensed to practice in other states, it is still important for insurers, particularly Medicare and Medicaid, to offer fair and equal reimbursement for telemedicine services as in-person services. Moving forward, it will be necessary to include the patient's home on the list of approved originating sites for Medicare reimbursement. Without this expansion, telemedicine will be unable to fully serve those in need.

Telemedicine stands to revolutionize health care, deliver critical treatments to historically underserved patients, and ultimately save time and money for patients and providers alike. However, without taking action as outlined above, telemedicine will not realize its full potential as a means of providing care to those who need it most.

### SUMMARY POINTS

1. Interest in and application of telemedicine use across medical domains are rapidly expanding.
2. Systematic reviews consistently indicate that telemedicine is a safe and suitable alternative to traditional in-person models of care.
3. Telemedicine has proven capable of improving access for underserved patient populations, especially those residing in rural areas.
4. For certain medical conditions, telemedicine has demonstrated improved health outcomes with associated reductions in cost.
5. Policy changes for fair reimbursement of telemedicine services would be necessary to promote widespread implementation and further improve access to care.

### DISCLOSURE STATEMENT

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