Title
Moving Towards Equity With Digital Health Innovations for Stroke Care

Journal
Stroke, 53(3)

ISSN
0039-2499

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Publication Date
2022-03-01

DOI
10.1161/strokeaha.121.035307

Peer reviewed

HHS Public Access
Author manuscript
Stroke. Author manuscript; available in PMC 2023 March 01.

Published in final edited form as:
Stroke. 2022 March ; 53(3): 689–697. doi:10.1161/STROKEAHA.121.035307.

Moving Towards Equity in Digital Health and Stroke Care

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Abstract

Digital Health has long been championed as a means to expanding access to health care. Now that the Coronavirus-19 disease (COVID-19) pandemic accelerated many health systems' integration of digital tools for care, digital health may provide a path towards more accessible stroke prevention and treatment, particularly for historically disadvantaged patient populations. Stroke management is composed of multiple timepoints where digital health innovations have the potential to augment health access and treatment: from primary prevention, to the time-sensitive detection of ischemic stroke, administration of thrombolytic agents and consideration for endovascular interventions, to appropriate post-acute care, rehabilitation, and lifelong secondary stroke prevention — stroke care relies on a multidisciplinary and standardized approach. However, as we discuss pointedly in this Focused Update, underrepresented individuals face multilevel digital health disparities that potentially diminish the benefits of these digital advances. As such, these multilevel needs must be discussed and accounted for as health systems seek to integrate innovative *and* equitable digital health solutions towards stroke care.

Keywords

Digital health; digital divide; stroke; health services; health disparities; telehealth; telestroke; telerehabilitation

Introduction

Disparities in stroke prevention and treatment for underserved populations in health care (racial/ethnic underrepresented groups, low income, un- or underinsured, refugee or migrant, and/or Limited English Proficient) has ignited a wave of change to better integrate and standardize stroke care for populations who have been historically and contemporaneously marginalized in health care systems. There is a large evidence base that has shown higher stroke incidence and worse outcomes for patients who experience barriers to health access and high quality of care— particularly finding that Black and Latino individuals have a greater risk for stroke, even across all socioeconomic strata (shown in the Northern

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Manhattan Stroke Study).1–11 Thus, disparities in stroke incidence and outcomes are a core issue to contextualize in parallel, when considering the prospect of stroke care innovations.

For the purposes of this Focused Update, our discussion of "digital health" encompasses modalities like mobile health (mHealth), health information technology, wearable devices, telehealth/telemedicine, and personalized medicine.12 We use clinical vignettes to describe innovative digital tools used in stroke care, with attention to how patient populations who are most at risk for stroke and poor outcomes, are potentially excluded from these innovations. We provide examples of digital health interventions from the literature in each phase of stroke management: primary prevention, acute care, rehabilitation, and secondary prevention. As summarized in Table 1, we highlight the digital divide in digital stroke health tools for each section, concluding with a call to healthcare leaders to address barriers to digital health in underserved communities when considering digital innovation developments and their implementation. The authors declare that all supportive data are available within the article and its online supplementary files.

Primary prevention

Since 75% of strokes are first-time events, primary prevention is a critical component of stroke care.[5] Patients' social determinants of health (SDOH) are drivers of stroke risk. SDOH encompass key characteristics like low socioeconomic status (SES),13 limited English proficiency,14 food insecurity and underinsurance,15–17 which are well-documented to pose challenges for stroke prevention. Other SDOH associated with increased stroke include lower education levels18, income below the poverty level19, zip code in a low-income and/or racially/linguistically segregated census tract[19–21], social isolation, [22] and poor public health infrastructure[21]. In adults less than 75 years of age, each added SDOH is associated with an increase in incident stroke risk.[23] For example, in the REGARDS trial cohort, stroke risk increased incrementally with each additional SDOH barrier (e.g., hazard ratio for one SDOH was 1.26, 2 SDOH hazard ratio was 1.38, and 3 or more SDOH hazard ratio was 1.51) [23,24] While the evidence shows that management of metabolic and cardiovascular risk factors, use of antithrombotic medications and other agents when indicated, and lifestyle modifications substantially reduce risk for stroke,[25] these are implemented less often and risk factors are less likely to be controlled in individuals from underrepresented or underserved communities. [23] Below we follow the case of Ms. S.

Ms. S, a previously healthy 38-year-old Black woman, presented to a federally qualified healthcare center (FQHC) with complaints of polyuria. Vitals were significant for a blood pressure of 150/80 mmHg, point of care hemoglobin A1c of 11%, and an electrocardiogram (ECG) indicating a likely prior inferior MI. She was started on indicated medications for coronary artery disease, diabetes, and hypertension and then referred to a cardiologist. She was started on insulin, but an SGLT-2 inhibitor could not be initiated due to its prohibitive cost. The first available cardiology appointment was scheduled 6 weeks out due to the limitations of cardiology availability in this FQHC.

The COVID-19 pandemic arrived and her primary care clinic cancelled her follow-up appointment, and she was told to call in a few weeks to reschedule. During this time, *Ms. S lost her job. She did not refill her medications to save on cost while unemployed. She was not aware of the long-term effects of diabetes and hypertension, and in particular, the consequences of stopping her medications. She began smoking cigarettes to alleviate the stress of hearing the news and discussion on TV about current events highlighting societal racism and financial losses from the pandemic. She did not follow up with any doctor for many months. She was not sure about how to conduct a phone or video visit with her primary care physician (although she had heard that this was an option). A family member passed away from a stroke. After this, she attempted to learn about stroke warning signs, but had trouble understanding information that she found on the Internet. She did not know who to talk to about her concerns and questions about her personal risk for stroke*.

Digital tools that focus on stroke risk stratification or education can directly offer patients who experience access barriers to clinical encounters an additional option to increase health literacy and knowledge of stroke risk factors. Increased use of Smartphones and Internet-connected devices (even among low-income populations) has opened up the world of mobile health, or mHealth, as a way to connect with patients outside of the clinical setting (e.g., Smartphone applications (app), Short-Message-Service (SMS) text interventions, and social media outreach).

Some of these mHealth innovations have been evaluated through validation studies and clinical trials. [26,27] One systematic review examining the role of mHealth for cardiovascular prevention found improvements in glycemic control and smoking cessation via apps for self-monitoring, educational programs using short text/video messages, and interval text message reminders. [27] However, the data on the efficacy of the interventions in stroke is limited. A scoping review that evaluated mHealth for all phases of stroke care found that most studies were underpowered and/or were pilot and feasibility studies and case series (with no mHealth studies using stroke as a primary outcome).[27,28]

The Stroke Riskometer is one of the few digital apps that has been scientifically evaluated and is endorsed by the World Stroke Organization and World Federation of Neurology.[29] The Stroke Riskometer derives from the Framingham stroke prediction algorithm with additional risk factors based on the INTERSTROKE study (e.g., diet, non-Caucasian race, stress level, and alcohol consumption).[30] Although, there is no data of yet that a tool like the Riskometer reduces stroke risk,[31] the app provides absolute and relative estimates of personal stroke risk in the subsequent 5 and 10 years for its users.[29] It is meant to be used on a Smartphone or Internet-connected tablet/device and encourages laypeople to identify their relative risk of a stroke to motivate individuals to address their personal risk factors. The app includes an educational section on stroke warning signs and symptoms, and what to do if these should occur.[24] One limitation of the app is the inability to send this data to the user's medical team, which could theoretically deliver patient-generated information to the provider and/or alert them to patient concern regarding stroke risk. This feature is being developed and validated for other apps and wearable devices[32] and involves challenges around protecting patient health information and managing big data analytics. On the provider side, commonly used web-based calculators for stroke prevention are related to predicting stroke risk with atrial fibrillation (e.g., CHA_2DS_2-VASc), mean arterial pressure measurement, and computation of the National Institute of Health Stroke Scale (NIHSS) score. While studies on electronic medical record-embedded clinical decision tools are limited in the primary prevention of stroke[34,35], computerized clinical decision pathways have demonstrated utility in other disease processes[36] and secondary stroke prevention[37] and hold promise on improving adherence to guideline-based practice.

A glaring drawback of these risk stratification apps is that they do not fully incorporate the social determinants of health (SDOH) related to stroke risk. As an example, the Stroke Riskometer app scored poorly in predicting stroke risk when compared to 3 large cohorts of diverse patients (Auckland Regional Community Stroke or ARCOS IV, Rotterdam, and Russian Cohort Studies).[29] One consideration is that the app is based on data from the Framingham Study which mostly included US White men over the age of 55. [29,38] Additionally, the Stroke Riskometer validation analysis did not compare differences in stroke prediction rates across race/ethnicity; this could have provided better insight on the groups of people whose risk do not correlate with the application's prediction algorithms.

In any discussion of stroke mHealth, we must also consider the US digital divide that will affect equitable implementation of the technology. Technology-specific challenges of available mHealth tools include access to Internet-connected personal devices and broadband Internet at home [39], limited phone minutes and/or data plans, ability to use Internet-connect devices (electronic health literacy)[40], and lack of user-centered design limitations of most mHealth stroke platforms (e.g., high levels of literacy and numeracy required to navigate, email registrations, sensitive information required to register, English-only)[41]. Although the digital divide is "shrinking" over time when it comes to Internet access via phones or other mobile devices, those who live in households earning less than $30,000 and/or those with a high school diploma or less are still less likely to own a Smartphone.[42](despite some improved access to Internet-connected phones for low-income individuals via the Lifeline program[43]). Additionally, only 60% of adults older than 65 years own a Smartphone. [42]These structural barriers lead to inequitable mHealth adoption (younger age, more education, and higher income associated with mHealth use).[44,45] The data shows that patients like Ms. S are much less likely to access mHealth tools that improve stroke prevention, when potentially, they stand to benefit most from health care/information that is delivered outside of the traditional mechanisms. Bridging these structural barriers necessitates a two-prong solution: providing the basic equipment (eg, phones, universal broadband) as well as training on digital health literacy. In a recent commentary, Sieck et. al. highlights this need for "digital inclusive strategies" and advocates for digital skill training, particularly for recent adopters of technology or those who may have devices with limited.[46]

Finally, while mHealth interventions that focus on lifestyle changes are important, they are not a panacea for solving access barriers, especially as current products fail to address, or even acknowledge underlying health care barriers outside of the patient's locus of control. Consequently, the optics of these advancements mostly place the responsibility of disease prevention on the individual, rather than push digital health innovations that focus on population health and public policy. Another important note is that many patient-facing mHealth products have not been extensively studied or validated in clinical trials. These consumer-operating products are not regulated by the Food and Drug Administration (FDA) unless they are categorized as medical devices. As a result, there are no regulations or quality control on usability, language, or cultural appropriateness.[47] Now more than ever, the COVID-19 pandemic has fueled an unprecedented impetus for the development of culturally sensitive mHealth worldwide.[48] This is the time to address these challenges, otherwise, the aforementioned health disparities will continue to disproportionately widen.

Acute Care

Physicians are distributed unequally across America. From 2010 to 2017, the median physician density per 100,000 persons was 125 physicians in large urban counties and 60 physicians in rural counties.[49] Additionally, in rural communities, there is a high physician turnover rate, which weakens therapeutic rapport and contributes to vulnerability of people with chronic diseases.[50,51] As seen in our case, Ms. S, living in an under-resourced setting and without robust medical support, will experience fragmented care leading to suboptimal outcomes after a stroke.

At the age of 45, Ms. S developed sudden-onset vertigo and blurry vision. She called 911 and was taken to her local rural community hospital, a setting with no in-house neurologist or protocol for acute stroke management, including thrombolysis. A head CT was performed which ruled out acute intracranial hemorrhage and the staff physician transferred her to the regional academic center by ambulance. By the time she was evaluated by a neurologist, the patient was out of the window for consideration of thrombolysis. She remained at the hospital to evaluate cause of ischemic stroke and determine further management.

Telestroke is defined as telemedicine-enabled stroke consultation and remote stroke service, and is a well-developed example of a scalable digital health intervention to expand expert level care in the acute stroke setting. [52] Various approaches to stroke management have been made possible by telestroke; most notably, stroke patients may be treated in their local community hospital with treatment by an on-site physician with remote consultation by a specialist (who can provide recommendations regarding thrombolysis and need for endovascular intervention). The patient can receive IV thrombolysis at the hospital and if they are a candidate for endovascular intervention, they can then be transferred out to a comprehensive stroke center (referred to as the “drip and ship” model).[53] Initially met with political hurdles and inconsistent payment models, the Furthering Access to Stroke Telemedicine (FAST) Act of 2018 expanded telestroke reimbursement and coverage for Medicare beneficiaries to all hospitals (versus only to rural hospitals). The use of telestroke is now a Class I recommendation by the American Heart Association (AHA).[52,54]

In its 2017 policy statement, while the AHA recommended telestroke as a cost-effective approach to increase access and quality in underserved areas, the group also warned the public that the same technology has the potential to introduce a new form of disparity in access to care by replacing geographic isolation with “digital isolation.” The authors stated, “communities and patients who are not technologically engaged, who live on the other side of the digital divide, and who have limited capital to invest in telehealth infrastructure, at the community or patient level, may face challenges to access care as telehealth offerings are increasingly used to reduce cost and increase access.”[54] On this note, one study by Zhang et. al assessed trends in telestroke from 2008 to 2015 and found that the highest proportion of such services were provided for non-Hispanic White males under 65 years.[55] Other telestroke studies have observed that Medicaid access to telestroke (for patients under age 65 years) is lower compared to commercially insured and Medicare patients in some states.[56] On the other hand, a large retrospective review evaluating telestroke services held more promise when it found that no significant disparities in telestroke consult time, utilization of thrombolysis, and time to thrombolysis. The authors hypothesized that standardized stroke protocols in telestroke could contribute to more frequent utilization of guideline-based stroke therapies—which bodes well for some alleviation of these disparities.[57]

With the implementation of the FAST Act and the expansion of telestroke networks in both rural and urban regions, further studies will be needed to fully evaluate the impact of telestroke on access and quality of care for all.[54] Such studies will be especially important given the ongoing failures in equity that are fundamentally driven by structural barriers, like systemic racism. While telestroke improves emergency access to specialist hyper-acute stroke care in remote locations and has been correlated with shorter door to treatment times[58,59], one must remember that Black and Latino patients still face substantial delays in care from the outset: longer Emergency Department wait times, door-to-computed tomography time[60], door to needle time[61], and time to neurologic consultation compared to White patients.[60] Multiple large studies have shown that even after adjustment for patient- and hospital-level variables, Black patients have lower odds of receiving evidence-based therapies like intravenous thrombolysis, cardiac monitoring, dysphagia screening, antithrombotic medications on discharge, anticoagulants for atrial fibrillation, and appropriate lipid therapy.[62–64] Additionally, Black and Latino patients have higher odds of exceeding the median length of hospital stay relative to Whites.[64] Thus, while telestroke holds promise to increase access, such strategies for acute stroke care will only be equitable if an anti-racist lens is central to its development and implementation.

Post-stroke rehabilitation

While fewer people are dying of stroke today, it remains the leading cause of disability in the United States.[65] Physical, occupational, and speech-language therapy are the standard of care for post-stroke disability. Upon hospital discharge after stroke, rehabilitation may be one of the only spaces for long-term monitoring and care, particularly for patients who lack robust outpatient follow-up and home care due to socioeconomic factors. Studies also suggest that there are important socioeconomic differences and underuse of post-stroke rehabilitation services in certain subgroups.[66–68] One Los Angeles study of community-dwelling post-stroke patients found that physical and occupational therapy services were less frequently utilized among older patients and individuals with less than college education.[66] Disparities in rehabilitation access and use are likely driven by the complex interrelationships of demographic and socioeconomic factors—including age, sex/gender, race/ethnicity, income, insurance, geography, social support, housing stability— as well as patient cultural preferences/norms which all coincide to affect an individual's likelihood of receiving consistent patient-centered stroke rehabilitation and recovery.[66,67] We follow the barriers faced by Ms. S and her medical team below.

Nearing discharge, the patient's symptoms improved, but she continued to have blurry vision and intermittent vertigo which limited ambulation. Ms. S lived with a roommate, *but otherwise did not have family close by. She was anxious that her symptoms would return in severity when she returned to work as a domestic worker and limit her ability to function independently at home. The medical team recommended that the patient be discharged home with outpatient occupational, physical, and vestibular therapy. Ms. S was discharged home. She had to return to work and was not able to take time off work to go to her therapy appointments. Additionally, she had no car or family to take her to appointments and there were no public transportation options to the outpatient rehabilitation center. She was discharged on new medications for secondary stroke prevention, but there had been no discussion about these changes and/or the medical and lifestyle risk factors for stroke that she could recall.*

Digital rehabilitation, or telerehabilitation delivered via robotic, virtual reality, commercial gaming devices, and communication tools (e.g., video conferences, telephoning and smartphone apps) has the potential to increase access to post-stroke therapy that is crucial to optimal recovery.[54] This approach to rehabilitation offers early access to treatment, reduces cost, enables the patient to play a more active role in treatment through interactive play, and allows for adapting the treatment to the individual's home routine.[69,70] One study evaluating speech-language tele-rehabilitation found that older adults were as engaged in using tablets and/or Smartphones for remote rehabilitation therapy when compared to younger patients. Those who lived in a rural location participated in a higher number of therapeutic sessions compared to their urban or suburban counterparts.[68] According to the 2020 Cochrane review on telerehabilitation for stroke, there is a "moderate-level" of evidence that telerehabilitation is more effective or similarly effective to usual care.[71] Telerehabilitation could be a promising solution to reduce the delays that come with traditional face-to-face rehabilitation or augment the scope of in-person therapy services.

One major equity limitation to this innovation is that, like mHealth interventions, there are concerns around technological adoption for individuals limited by digital access (e.g., Wifi, Internet-connected devices), digital literacy, unstable housing, and social support. One qualitative study found that telerehabilitation participants noted the importance of technical support, physical environment at home, and family member support as key factors to sustaining their rehabilitation progress.[72] In the trials included in the Cochrane telerehabilitation review, it is important to note that most patients were under 70 years of age, and race or other socioeconomic factors were not included.[71] The only two studies specifically evaluating telerehabilitation in a low-resource setting have been conducted *outside* the United States.[71,73] To date, there is a paucity of data on the differing impact of tele-rehabilitation based on socioeconomic and environmental factors.

Secondary prevention

In the first 5 years post stroke, about 10–25% patients will have a recurrent event.[74] While the rate of recurrent stroke initially decreased with new evidence-based medical therapies, it has plateaued since the mid 2000s.[75] Individuals with stroke account for a disproportionate share of health care resources given their complex needs, including disability, multiple medical comorbidities, and concomitant mental health diagnoses.[76]

Upon discharge, Ms. S returned to the FQHC to see her primary care physician. Unfortunately, her doctor was unavailable for an appointment due to a full clinic schedule during COVID-19, so the patient saw a different physician for the discharge follow-up. Since the FQHC was not affiliated with the hospital where the patient was admitted, the clinic did not have medical records from the hospitalization at the time of the patient's appointment.

Ms. S shared that she was confused about her hospital stay. She recalled that she did not have bleeding in the brain, but she did not know that she had a stroke. She did not know what her medications on discharge were for and thought they were to help relieve the symptoms of dizziness. On further discussion, Ms. S did not know what a stroke was. She admitted that she avoided asking too many questions at the hospital because she did not want to be "difficult" as she observed that this had negatively impacted the hospital care of family and friends that had been hospitalized in the past.

The primary care physician spent extra time with the patient educating her on the definition of a stroke, risk factors, and signs and symptoms of recurrent stroke. She stressed the importance of diet, exercise, and medication adherence to reduce risk of a recurrent stroke. However, the physician was running behind schedule in clinic and could not address everything at this visit. The physician sensed that Ms. S had no one to speak to about her recent medical events. Ms. S felt dejected and was tearful. Although the physician suspected that Ms. S was depressed, there was no time to discuss the topic during this clinic appointment.

After adjustment for both patient- and hospital-level variables, Black patients relative to White patients have lower odds of receiving guideline-based secondary stroke prevention interventions (antithrombotics, anticoagulation for atrial fibrillation, counseling on smoking cessation and lipid-lowering therapy)[77] or having their risk factors controlled.[4,78] Differences between Latino and White patients are less drastic but remain significant for antithrombotic at discharge and smoking cessation.[64] Post-stroke depression is prevalent and studies show that there are ethnic disparities,[79] which are partially explained by sociodemographic and health factors, like low educational attainment.[80]

There are some mobile-based applications and telephone-based programs to support patient education and medication adherence after a stroke. One meta-analysis concluded that mHealth using telephone and SMS text reminders contributed to a significant reduction in systolic blood pressure among stroke survivors.[81] Given the risk of elevated blood pressure and recurrent ischemic events in stroke patients[82], there are additional studies evaluating the feasibility and clinical significance of using mHealth through patient reminders and remote blood pressure monitoring for secondary prevention[83]. However, none of these integrate the culturally and/or linguistically tailored approaches used in in-person studies that have been shown to work in stroke prevention among communities of color and those with limited English proficiency. [84–86]

Several studies have shown that community healthcare workers (CHWs), care navigators, and health educators are important allies in helping patients navigate the complex healthcare system. A multidisciplinary team including CHWs[76], pharmacists, and nurses[87] in the delivery of chronic disease care and cardiovascular health has led to significant improvements in health literacy, risk factor control, self-management behaviors, lifestyle habits, clinical outcomes, and a decrease in inappropriate health care utilization. [76,88–90] One way forward could be integrating effective culturally-tailored approaches, such as those implemented in the Secondary stroke prevention by Uniting Community and Chronic care model teams Early to End Disparities (SUCCEED) trial,[76] with telemedicine approaches. In fact, one of the limitations of SUCCEED was that most intervention participants did not receive the minimum number of touches with the healthcare team (i.e., 3 clinic visit, 3 home visits, and completion of the Chronic Disease Self-Management Program). If a telehealth component had been implemented, the healthcare team would have been able to see more patients, and the patients may have had fewer barriers to participation. The World Health Organization (WHO) recommends the use of telemedicine to complement, rather than replace, the delivery of health services.[91] In other words, high tech and high touch solutions are not mutually exclusive, but rather technology can expand high quality and high touch solutions, paving the way for novel, sustainable, and standardized strategies to equitable care.[92]

Conclusions

This Focused Update outlines major digital health interventions for each phase of stroke care- while delineating key themes contributing to the digital divide. The digital divide could prevent the most underrepresented groups from benefitting from potential improvements in stroke care via digital tools and can exacerbate health care disparities, conferring “further advantages to the already advantaged” as stated in the inverse care law.[41] It is critical to intentionally tailor digital innovations to address specific gaps by centering developments around communities who typically “fall through the cracks.” Key considerations for successful digital stroke innovations will encompass: 1) increasing digital access/literacy of populations, 2) the prioritization of culturally and linguistically relevant content for underserved patients, and 3) the integration of the social determinants of health and structural barriers to quality health care at each key phase of stroke prevention and treatment.

Acknowledgments

Disclosures

Dr. Towfighi reports grants from National Heart, Lung, and Blood Institute and grants from American Heart Association.

Non-standard Abbreviations and Acronyms

App	Application
Covid-19	Coronavirus 19
mHealth	Mobile health
SDOH	Social determinants of health

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Table 1:

Digital health Innovations in Stroke Care - Potential Benefits and Persistent Barriers to Equity

Type of care	Potential benefits	Persistent barriers to equity
Primary prevention		
Health promotion apps	Improve lifestyle factors to improve cardiovascular health	Digital access (eg, broadband, Internet-enabled devices) Digital literacy
Wearable devices and biosensors	Highlights abnormal vital signs such as atrial fibrillation	Cost Health literacy Requires user engagement with physician
Stroke awareness apps	Directly educate consumers on stroke signs and symptoms	Low educational attainment Limited English proficiency Usability of interface Cultural appropriateness
Risk stratification apps	Inform users of their individual risk	No evidence of better clinical outcomes Poor generalizability
Acute stroke care		
Telestroke	Provide real-time neurology and radiology input for hospitals without expert personnel or teams	Persistent sociodemographic discrimination leading to worse stroke outcomes
Post-stroke rehabilitation		
In-home tele-rehab	May bypass barriers of high cost, transportation to rehab facilities, shortage of regional rehab care	Digital access (eg, broadband, Internet-enabled devices) Digital literacy Unstable housing Social support
Robotic devices, virtual reality, and gaming devices	Increase patient engagement	Insurance coverage and out-of-pocket cost
Secondary prevention		
Remote monitoring devices	Address stroke risk factors (e.g., ambulatory blood pressure and glucose monitoring)	Health literacy Requires user engagement with medical team
EMR-based quality improvement	Identify and address systemic disparities to stroke care using clinical informatics	Time Cost