

## RESEARCH PAPER

# Impact of telemedicine on access to acute stroke care in the state of Texas

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## Abstract

**Background:** To examine the impact of telemedicine (TM) on access to acute stroke care and expertise in the state of Texas. **Methods:** Texas hospitals were surveyed using a standard questionnaire and categorized as: (1) stand-alone Primary Stroke Centers (PSC) not using TM for acute stroke care, (2) PSC using TM for acute stroke care, (3) non-PSC hospitals using TM for acute stroke care, or (4) non-PSC hospitals not using TM for acute stroke care. Population data were obtained from the U.S. Census Bureau and the Neilson Claritas Demographic Estimation Program. Access within 60 min to a designated facility was calculated at the block group level. **Results:** Over 75% of Texans had 60-min access to a stand-alone PSC. Including PSC using TM increased access by 6.5%. Adding non-PSC that use TM for acute stroke care provided 60-min access for an additional 2% of Texans, leaving 16% of Texans without 60-min access to acute stroke care. Approximately 62% of Texans had 60-min access to more than one type of facility that provided acute stroke care. **Conclusion:** The use of TM in the state of Texas brought 60-min access to >2 million Texans who otherwise would not have had access to acute stroke expertise. Our findings demonstrate that using TM for acute stroke has the ability to provide neurologically underserved areas access to acute stroke care.

## Introduction

Despite the substantiated benefit of intravenous (IV) tissue plasminogen activator (t-PA) for patients with acute ischemic stroke, it is estimated that only 2–5% of patients receive this treatment.<sup>1,2</sup> The main reason that stroke patients are not treated with IV t-PA is arrival to hospitals outside the treatment time window.<sup>3</sup> Arrival at hospitals lacking on-site neurological expertise represents an additional barrier to IV t-PA administration.<sup>3</sup> Patients living in rural, underserved areas must rely on local community hospitals which may be uncomfortable for taking care of acute ischemic stroke patients or for initiating treatment with confidence.<sup>4–6</sup>

A potential solution to increase access to acute neurological expertise is telemedicine (TM).<sup>7–9</sup> TM is the use of telecommunication technologies to provide medical information and services.<sup>10</sup> By establishing direct audiovisual connections between a location that lacks expert medical care and a remote physician, TM allows for delivery of quality health care from afar.<sup>11</sup> Many studies have shown that acute stroke care provided through audio/video TM is safe with acceptable clinical outcomes and, in many instances, can improve utilization of IV t-PA.<sup>12–20</sup> The American Stroke Association has recommended that telestroke networks be developed to provide acute neurological expertise to facilities that lack on-site resources to enhance access to acute stroke care.<sup>21,22</sup> The

success of this type of network is demonstrated by the REACH–MUSC network, where their TM network doubled access to stroke care in South Carolina.<sup>23</sup>

While 55% of Americans have access to a Joint Commission Primary Stroke Center (PSC) within 60 min, access to care in states across the U.S. is variable and access to care is strongly correlated with state urbanicity.<sup>24</sup> Texas is the third most populous state in the U.S., with 14% of the state's population living in rural areas.<sup>25,26</sup> Second only to Alaska in size and California in population, Texas ranks in the top 10 states with the largest rural population.<sup>25,26</sup> Despite the fact that Texas has a high incidence of stroke and stroke mortality, only 49% of Texans have access to a Joint Commission PSC within 60 min.<sup>21,24,27</sup> The purpose of this study was to examine the impact of TM on access to acute stroke expertise in Texas and to describe the current landscape of PSC vis-a-vis TM allocation. In addition, we sought to highlight duplication of resources to manage acute ischemic stroke and to provide data that may lead to more efficient allocation of acute stroke care in the future.

## Methods

### Data sources

Population data were obtained from the U.S. Census Bureau and the Neilson Claritas Demographic Estimation Program.<sup>27</sup> The primary geographic units of analysis were census block groups, clusters of blocks within the same census tract generally consisting of 600–3000 people.<sup>28</sup> Hospitals in Texas were identified through publicly available data from the American Hospital Association (AHA).<sup>29</sup> Acute Care Facilities were defined as registered facilities with emergency departments capable of managing adult patients. Within this group, hospitals certified as stroke centers within the state of Texas were identified.<sup>30</sup> The Texas Department of State Health Services accepts Comprehensive or Primary Stroke certification issued by either The Joint Commission (TJC) or Det Norske Veritas (DNV) Healthcare to receive Comprehensive Stroke Center and PSC state designation.<sup>31,32</sup> These centers meet guidelines set forth by the Brain Attack Coalition and American Stroke Association and demonstrate appropriate patient management and outcomes in stroke care.<sup>33,34</sup> For the purposes of this study, Comprehensive Stroke Centers and PSC were combined into a single category – PSC.

### Determination of TM use

Using a standard questionnaire, a three question telephone survey of emergency room staff at 556 hospitals was administered to the emergency department coordina-

tor or charge nurse in an effort to determine if each hospital was (1) an acute care hospital, (2) a TJC, DNV or the state of Texas certified PSC, or (3) utilizing TM to provide acute stroke care. After verification of the information obtained from the telephone survey, hospitals were designated into four categories: stand-alone PSC (PSCs: hospitals that were PSC but were not using TM for acute stroke care), PSC using TM (PSC-TM: hospitals that were PSC and were using TM for acute stroke care), TM for stroke care (TM: hospitals that were not PSC but were using TM for acute stroke care) or none (hospitals that were not PSC and were not using TM for acute stroke care).

### Calculating access to stroke care

Our primary analysis focused on calculating the population that was able to reach stroke care within 60 min. To calculate estimates of population access to care, we estimated the proportion of the population that could access 911, have an ambulance dispatched to their location, be stabilized and prepared for transport by prehospital providers, and then be transported to the closest PSC or TM-capable hospital. To do this, we created 60-min travel sheds around each hospital in Texas. We first identified each hospital and sited that facility in space using the latitude and longitude of the hospital. We next subtracted a number of empirically derived fixed prehospital time intervals from the predetermined travel shed time interval of 60 min, as previously described.<sup>35,36</sup> These included: (1) the time from 911 activation to ambulance dispatch (activation interval) of 1.4 and 2.9 min for urban and rural areas, respectively; (2) the time spent on scene stabilizing the patient and preparing for transport (on-scene time of 13.5 and 15.1 min for urban and rural areas, respectively). We then used the road travel network and the posted drive speeds to determine which block groups were able to travel to the hospital within the remaining time. A block group was considered to have access to care if the block group's population-weighted center point (centroid) was within the travel shed. As this travel time only represents the second half of the journey (from the patient's home to the hospital), we added 5.28 and 7.86 min for urban and rural areas, respectively, to account for the time for the ambulance to travel from depot to patient. Finally, we summed the population of all block groups that could reach each hospital in the specified travel time. For calculations to determine distances to each hospital, we used U.S. Census Bureau block groups based on the 2000 Census. Using the Network Analyst functionality in ESRI (Environmental Systems Research Institute) ArcMap 10.1 (Redlands, CA), the shortest Euclidean (straight line) road network distances

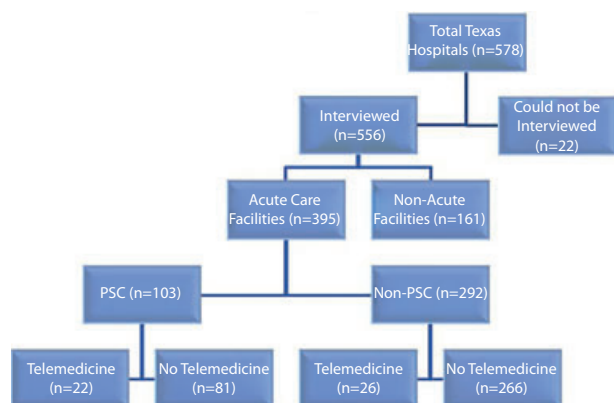
were determined between each population-weighted centroid and the nearest hospital.<sup>37,38</sup> Each block group was linked exclusively to the nearest hospital and no group was counted more than once. We did not allow for crossing of state lines.

Population access to stroke centers was determined by summing the population who could reach a PSC within 60 min. We then summed the population who could reach a PSC, PSC-TM site or TM site within 60 min. The difference between the sum of three groups and stand-alone PSC represents the additional population with access to stroke care afforded by TM. Duplication of coverage was defined by the population that had access to two of the three hospital designations (PSC, PSC-TM, or TM) within 60 min.

## Results

We identified a total of 578 hospitals in the state of Texas, 96% (556/578) of which participated in the phone interview. Of the 22 hospitals that did not participate, seven could not be reached by phone (no answer, automated line), four declined participation due to time constraints, and 11 had an inactive phone line. Of the hospitals that completed the interview, 395 identified themselves as acute care facilities (Fig. 1). In total, 26% of acute care facilities (103/395) were designated PSC with 21% of these facilities (22/103) utilizing TM technology to deliver local acute stroke care. Only 9% (26/292) of non-PSC used TM technology for acute stroke care.

The total population of Texas during this time period was 23,791,370 residents (Fig. 2C). Our analysis found that 75.4% of the population (17,944,332 Texans) had access to a stand-alone PSC within 60 min (Fig. 2A), using ground ambulance transport. The marginal benefit in access to care within 60 min gained by including PSC that use TM increased this number by 6.5% of the popu-



**Figure 1.** Flow diagram.

lation (1,547,368 Texans). An additional 2.0% of the population had access to acute stroke care (478,648 Texans) served by hospitals that use TM but that were not designated as PSC (Fig. 2B). Approximately 16.1% of Texans (3,821,022) currently did not have 60-min access to acute stroke care. We estimated that 15 million Texans (62% of the Texas population) had access within 60 min to more than one type of facility (PSC, PSC-TM, or TM) that can provide acute stroke care (Fig. 2D). Figure 3 compares population with 60-min ground transport to in-state stand-alone certified stroke centers that reported not using TM for acute stroke care to population with 60-min ground transport to in-state centers that reported using TM for acute stroke care.

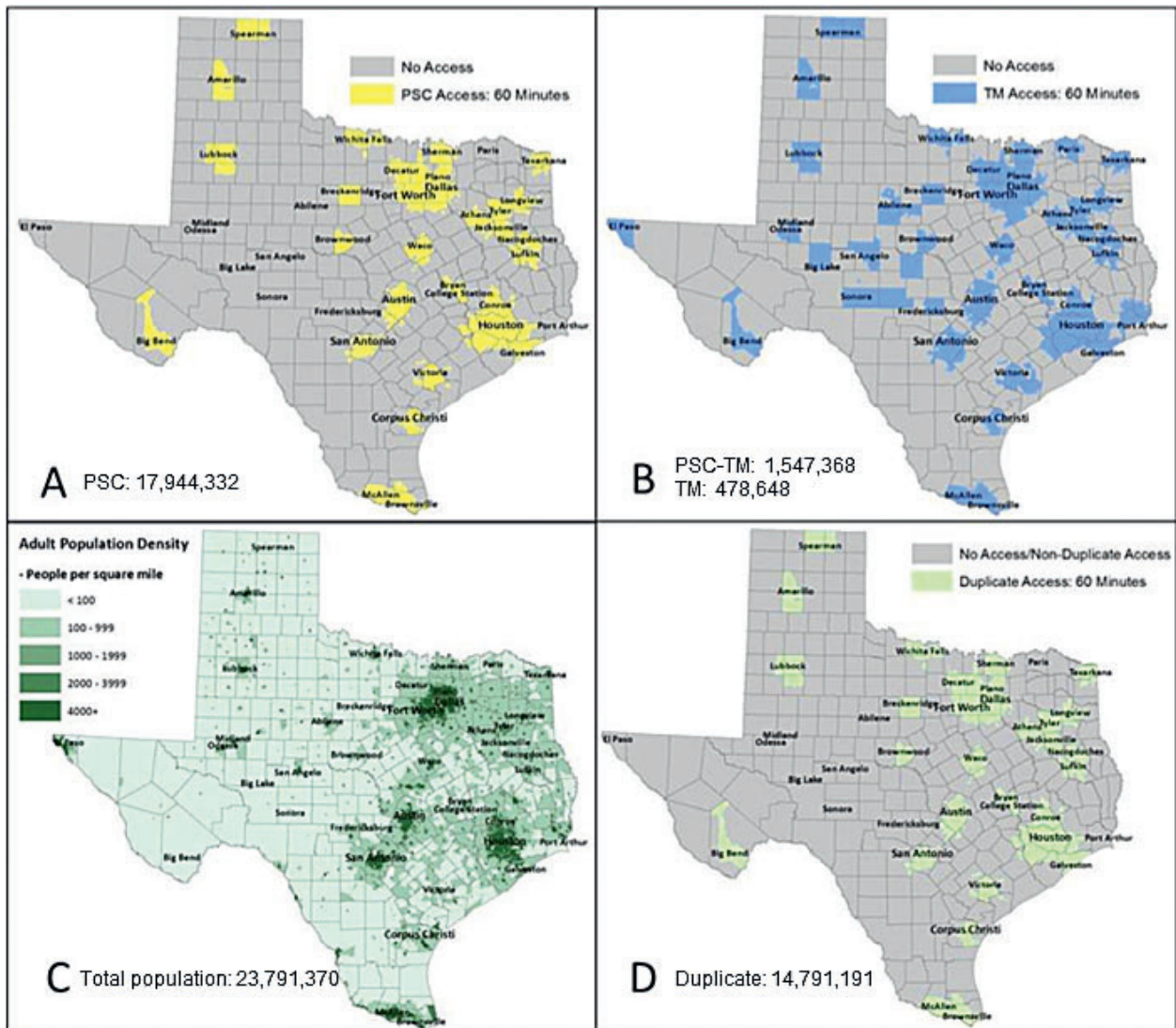
When analyzing where PSC and TM sites are deployed, we found that TM sites have been placed in large cities that already had PSC available, creating overlap and potential duplication of resources. In fact, overlap of access was found in each of the five most populous cities in the state (i.e., Houston, San Antonio, Dallas, Austin, Fort Worth). Overall, nearly 15 million, or 60% of Texans, had overlap of acute stroke care coverage. Furthermore, 21 out of the 22 PSC-TM hospitals were located in a city ranking in the top 100 in terms of population. In comparison, 10 out of 26 TM sites were located in cities where the population was less than 29,000.

## Discussion

While prior reports have provided examples of select telestroke programs, this is the first study to comprehensively describe the impact of TM on access to acute stroke expertise for an entire state.<sup>21</sup> We found that 12% of acute care hospitals were using TM for acute stroke care in Texas. Without the use of TM, 75% of Texans had 60-min access to acute stroke care. With the help of TM, this percentage increased to 84%.

While TM in Texas provided timely access to acute stroke care for an additional 2 million Texans, this study did not find that TM doubled population access to acute stroke care like that of the REACH-MUSC study.<sup>23</sup> The REACH-MUSC TM network was created explicitly with the goal of increasing access to stroke care for the residents of South Carolina while the TM networks in Texas appear to have evolved independently, underscoring the importance of public health care planning.<sup>14</sup> It also highlights that the maturity of stroke networks in various states may range significantly in their development, allowing some states to see a more significant increase in access by utilizing methods already adopted in other states.

In addition, this study found significant overlap of coverage, with TM sites placed in proximity to existing PSC. One has to wonder if these resources were redistributed



**Figure 2.** Population with 60-min ground transport access to in-state acute stroke care in Texas. (A) Displays access to stand-alone certified stroke centers that reported not using telemedicine for acute stroke care (PSCs). (B) Shows the increased access provided when centers that reported using telemedicine for acute stroke care were included. (C) Depicts the population density for Texas. (D) Illustrates areas of duplicate access.

on a basis of need (e.g., certificate of need, department of health approval), if they could provide improved access for the 4 million, or 16% of Texans that currently lack 60-min access to acute stroke care.<sup>39</sup> Ideally, telestroke networks would be designed from a population health care planning perspective, targeting geographic areas without stroke care – perhaps even areas with the highest proportion of the population affected by stroke. Unfortunately, that is not the case. Over 30 years ago, the National Heart, Lung, and Blood Institute recognized that the age-adjusted stroke mortality rates in Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia were 10% higher than the U.S. average, dubbing

them the Stroke Belt states.<sup>40</sup> Despite the high incidence of stroke and high stroke mortality of the Stroke Belt states, a recent study by Mullen et al.<sup>27</sup> found that patients in the Stroke Belt were less likely to be evaluated at a certified stroke center.

TM has the potential to increase population access to acute stroke care. Regional or state level planning with respect to the placement of TM cameras is in keeping with the Healthy People 2020 objective to “reduce the proportion of persons who are unable to obtain or delay in obtaining necessary medical care”.<sup>41</sup> Proponents of the public health approach would argue that establishing TM or seeking PSC designation at a particular hospital should be based on clinical need and not on market forces, with





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