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## The effects of telemedicine on racial and ethnic disparities in access to acute stroke care

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### Abstract

Racial and ethnic disparities have been previously reported in acute stroke care. We sought to determine the effect of telemedicine (TM) on access to acute stroke care for racial and ethnic minorities in the state of Texas. Data were collected from the US Census Bureau, The Joint Commission and the American Hospital Association. Access for racial and ethnic minorities was determined by summing the population that could reach a primary stroke centre (PSC) or

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#### Declaration of Conflicting Interests

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telemedicine spoke within specified time intervals using validated models. TM extended access to stroke expertise by 1.5 million residents. The odds of providing 60-minute access via TM were similar in Blacks and Whites (prevalence odds ratios (POR) 1.000, 95% CI 1.000–1.000), even after adjustment for urbanization (POR 1.000, 95% CI 1.000–1.001). The odds of providing access via TM were also similar for Hispanics and non-Hispanics (POR 1.000, 95% CI 1.000–1.000), even after adjustment for urbanization (POR 1.000, 95% CI 1.000–1.000). We found that telemedicine increased access to acute stroke care for 1.5 million Texans. While racial and ethnic disparities exist in other components of stroke care, we did not find evidence of disparities in access to the acute stroke expertise afforded by telemedicine.

## Keywords

Teleneurology; tele-stroke; healthcare access; racial minorities; ethnic minorities; telemedicine

## Introduction

Stroke is the fourth leading cause of death in the United States.<sup>1</sup> Currently, tissue plasminogen activator (tPA) is the only approved medical therapy for acute ischaemic stroke (AIS) patients.<sup>2</sup> Although some patients may be eligible to receive this therapy up to 4.5 hours from symptom onset,<sup>3</sup> tPA utilization remains below 10%.<sup>4,5</sup> Barriers to tPA usage may include limited access to acute stroke resources (neurological expertise, primary stroke centres), drug label contraindications and provider reluctance.<sup>6–8</sup> Patients evaluated at primary stroke centres (PSCs) are more likely to receive tPA and have better outcomes, yet many patients in the country do not have access to these hospitals in a time window in which thrombolysis is recommended.<sup>9–11</sup> It is estimated that only 55–66% of Americans have 60-minute ground access to a Joint Commission Primary Stroke Centre.<sup>12,13,14</sup>

Telemedicine (TM) has been proposed as a mechanism to improve access to acute stroke care. Originally developed in the 1990s, TM for stroke uses video teleconferencing to remotely examine a patient and facilitate treatment decisions.<sup>15</sup> Hospital emergency departments without on-call neurological expertise are often equipped with mobile devices that include remote control cameras and display monitors, allowing a neurologist to remotely interact with the patient and their family members.<sup>16</sup> TM for acute ischaemic stroke has been demonstrated to be safe and effective<sup>17,18</sup> and increases both tPA utilization and accuracy of treatment decisions.<sup>19,20</sup>

In the United States, racial and ethnic minorities have a higher burden of cerebrovascular disease than non-minorities.<sup>21</sup> The age adjusted incidence and prevalence of ischaemic stroke is substantially higher in non-Hispanic Black Americans compared to White Americans.<sup>22,23</sup> Hispanic Americans, the fastest growing minority group in the United States, also have a higher burden of stroke morbidity when compared to Whites.<sup>22,23</sup> Although the incidence of ischaemic stroke appears to be declining in Whites, the incidence has remained the same among Blacks.<sup>24</sup>

In addition to increased morbidity in racial and ethnic minorities, there is some evidence to suggest that disparities exist in access to acute stroke care.<sup>25,26</sup> Reasons for these disparities

are complex and are not isolated to one link in the stroke chain of survival.<sup>27</sup> In addition to reduced or delayed activation of emergency medical services,<sup>28</sup> previous studies have shown that once minority patients arrive at the hospital, they face longer wait times until initial evaluation and neurologic consultation.<sup>29,30</sup> As a consequence of this, fewer racial and ethnic minorities receive tPA.<sup>31</sup>

As PSCs expand and comprehensive stroke centres (CSCs) develop, TM is likely to play a critical role in expanding these systems of care to smaller, outlying hospitals. In addition to improving access to centres with neurological expertise, TM has the potential to narrow the racial and ethnic disparities gap in access to acute stroke care. The aim of this study was to determine if there were racial or ethnic differences in access to acute stroke care in systems with and without telemedicine. This study focuses on the state of Texas, which can serve as a model for determining if other regional differences exist.

## Methods

### Data sources

We obtained 2010 population data from the US Census Bureau and the Neilson Claritas Demographic Estimation Program.<sup>32</sup> Block groups, defined by the US Census Bureau as 600 to 3000 adults and not crossing county lines, were used as the primary geographic unit of analysis. A point (centroid) closest to the home address of most residents was assigned within each block group and used for point to point access calculations. The racial and ethnic composition of each block group was determined. For the purpose of this study, the population was divided into three racial groups: Caucasian/White, African American/Black, and other. Ethnicity was divided into Hispanic and non-Hispanic. Urbanization was defined according to a modification of the rural–urban continuum classification (mRUC) scheme.<sup>33–36</sup>

The details of the survey methodology have been previously described in a related study examining the impact of telemedicine for the entire population of Texas and resource allocation.<sup>37</sup> Briefly, hospitals in Texas were identified from the American Hospital Association (AHA).<sup>38</sup> Acute care facilities were defined as hospitals with emergency departments which manage adult patients. Within this group, we identified hospitals certified as stroke centres. The Texas Department of State Health Services accepts comprehensive or primary stroke centre certification issued by either The Joint Commission (TJC) or Det Norske Veritas (DNV) Healthcare to receive CSC and PSC state designation.<sup>39,40</sup> These hospitals meet guidelines set forth by the Brain Attack Coalition and American Stroke Association for acute stroke management.<sup>41</sup> For the purposes of this study, CSCs and PSCs were combined into a single category – PSC. We did not inquire about other strategies utilized to deliver tPA such as ‘drip and ship’ or translation service at each emergency department.

### Access calculations

Our primary analysis focused on calculating the population that was able to reach acute stroke care within 60 minutes. To do this, we created 60 minute travel sheds around each

hospital in Texas. We first identified each hospital and located it in space using the hospital's latitudinal and longitudinal coordinates. Next we subtracted a number of empirically derived fixed pre-hospital time intervals from the pre-determined travel shed time interval of 60 minutes, as previously described.<sup>42,43</sup> These included: (a) the time from 911 activation to ambulance dispatch (activation interval) of 1.4 and 2.9 minutes for urban and rural areas, respectively; (b) the time spent on scene stabilizing the patient and preparing for transport (on-scene time of 13.5 and 15.1 minutes for urban and rural areas, respectively).<sup>43</sup> 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 centre 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 minutes for urban and rural areas respectively to account for the time for the ambulance to travel from the depot to the 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 US Census Bureau block groups based on the 2000 census. Using the network analyst functionality in ESRI ArcMap 10.1, the shortest Euclidean (straight line) road network distances were determined between each population-weighted centroid and the nearest hospital.<sup>44,45</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.

#### Determination of telemedicine use and access

As previously described,<sup>37</sup> all acute care hospitals in Texas were contacted by telephone. Each hospital's stroke coordinator or emergency department charge nurse was interviewed using a standardized questionnaire. Interviewees were asked if their hospital was (a) an acute care hospital, (b) a TJC, DNV or the state of Texas certified stroke centre, or (c) utilizing TM to provide acute stroke care. After verification of the stroke centre status obtained from the telephone survey, hospitals were designated into four categories: stand-alone PSCs (PSCs: hospitals that were PSCs but were not using TM for acute stroke care); PSCs using TM (PSC-TM: hospitals that were PSCs and were using TM for acute stroke care); TM for stroke care (TM: hospitals that were not PSCs but were using TM for acute stroke care) or none (hospitals that were not PSCs and were not using TM for acute stroke care). We calculated the difference between the population who could reach a PSC within 60 minutes (60-minute access) and the population who could reach a TM spoke (PSC-TM or TM-only) within 60 minutes, to determine the contribution of TM to access to acute stroke care. Using census data, we were then able to determine if racial or ethnic differences exist in access to acute stroke care through TM.

#### Statistics

Given the proportion with access to a stand-alone PSC was greater than 20% in all groups, we elected to use modified Poisson regression to produce prevalence odds ratios (POR) to illustrate the association between race and ethnicity and access to acute stroke care.<sup>46</sup> This decision was made in an attempt to prevent the overestimation often seen when using logistic regression (odds ratios) in situations with prevalent outcomes.<sup>46</sup> In addition to crude models, models were adjusted for urbanization.

## Results

In 2009, the population of Texas was 23.8 million residents.<sup>32</sup> Of these patients, 17 million were Caucasian/ White, 2.7 million were African American/Black and 4 million were classified as other (Figure 1A–D). The most common races included in the other category were American Indian, Asian, and Native Hawaiian. Nearly 8.6 million (36%) residents were Hispanic.

We identified 578 Texas hospitals in the AHA database, of which 96% (556/578) participated in the survey. Of the 22 hospitals who did not participate, seven could not be reached by phone (no answer, automated line), four declined participation and 11 had an inactive phone number. Of the participating hospitals, 395 identified themselves as acute care facilities (71%). Over 26% of acute care facilities (103/395) identified themselves as PSCs. While the majority of PSCs reported not using TM for acute stroke care, 21% (22/103) were using TM to deliver acute stroke care (PSC-TM). Only 9% (26/292) of non-PSCs were using TM for acute stroke care (TM).

We found that 18 million (75%) of the Texas population had 60-minute access to a stand-alone PSC (PSC). By including PSC-TM, 60-minute access increased to 19.5 Million (82%; Figure 1E–F). An additional 478,000 patients (2%) could access a hospital which has TM capabilities but that has not been PSC designated (TM). Nearly 4 million Texans (16%) do not have 60-minute access to acute stroke care.

Broken down by racial groups, Blacks had similar odds of having 60-minute access to acute stroke care when compared to Whites (POR 0.998, 95% CI 0.998–0.999). This finding remained after adjustment for urbanization (POR 0.997, 95% CI 0.995–0.998). We found that 83% of Black patients had 60 minute access to a stand-alone PSC compared to 73% of Whites (Table 1). Including PSC-TM expanded this access to an additional 5% of Blacks and nearly 7% of Whites for a combined total of 88% and 80% respectively. Residents of other racial background had access similar to Black residents (Table 1). TM hospitals provided 60-minute access for an additional 1.3% of Black residents and an additional 2.3% of White residents. The odds of providing 60-minute access to acute stroke care via existing TM sites were similar in Blacks and Whites (POR 1.000, 95% CI 1.000–1.000), even after adjustment for urbanization (POR 1.000, 1.000–1.001).

Access to acute stroke care for Hispanic residents did not differ from non-Hispanic residents (Table 2). Nearly 75% of Hispanics could access a stand-alone PSC within 60 minutes compared to 76% of non-Hispanics. PSC-TM expanded this access by an additional 10% in Hispanics and 5% in non-Hispanics. Overall, Hispanics had similar odds of having 60-minute access to acute stroke care when compared to non-Hispanics (POR 1.000, 95% CI 1.000–1.000). This finding remained even adjusting for urbanization (POR 1.000, 95% CI 1.000–1.001). TM hospitals provided additional access to 1.1% of Hispanics and 2.5% of non-Hispanics. The odds of providing access to acute stroke care via TM were similar for Hispanics and their non-Hispanic counterparts (POR 1.000, 95% CI 1.000–1.000), even after adjustment for urbanization (POR 1.000, 95% CI 1.000–1.000).

## Discussion

Our study is one of the first to investigate the impact of TM for stroke on racial and ethnic minorities. Our previous work has found that the addition of PSC-TM to traditional face-to-face neurologic consultation (PSC) provided an additional 1.5 million Texans access to the acute stroke expertise.<sup>37</sup> Further, there were no significant differences in access to acute stroke care via PSC, PSC-TM, or TM among racial and ethnic minority groups. This is critical since these populations carry a higher burden of cerebrovascular disease. While disparities have been reported in other components of stroke care (differences in disease awareness and differences in attitudes, beliefs and compliance),<sup>27</sup> our observations suggest that TM systems do not widen the disparity gap.

Over the last decade, stroke systems of care in the United States have focused on the establishment and certification of PSCs. Despite this, many people still do not have timely access to PSCs.<sup>13</sup> Although systems of care are being developed to improve delivery of tPA, becoming a PSC does not require a certificate of need and as a result many PSCs are found in urban areas, leaving a substantial population underserved.<sup>47</sup> In addition, many PSCs are geographically clustered, in part as a result of competitive market forces, creating what may be redundancy in the system. TM has emerged as a potential bridge in the system to help expand access to stroke care by virtually delivering sub-specialty expertise to hospitals, particularly those in rural areas. It seems, however, that only a small percentage of non-PSC hospitals are using this technology. Policy initiatives encouraging the incorporation of TM into regional planning for stroke could serve to advance population access to stroke care.<sup>48</sup>

Currently, racial and ethnic disparities exist in stroke prevalence, acute stroke care, and stroke related mortality.<sup>27</sup> Our study provides reassurance that implementation of a TM system does not adversely impact access to care for racial and ethnic minorities. It has been well established that Black and Hispanic Americans have a disproportionately higher incidence of stroke<sup>22</sup> and have delays at several points in the chain of survival for acute stroke care.<sup>27</sup> One component of this is delayed evaluation in the emergency department and delayed neurological consultation.<sup>29,30</sup> Equipping hospitals with TM capabilities can potentially improve this element of the disparity. While hospitals and city centres are clearly fixed, TM allows for innovated systems to be designed that are not constrained by traditional geographic limits.

Our study has several limitations. First, drive times calculations are based on data from trauma systems.<sup>43</sup> While these are reasonable approximations, some data suggest that drive times for stroke patients may be six to 11 minutes longer.<sup>49,50</sup> These calculations also do not account for geographic boundaries such as mountains, rivers and weather, nor do they account for traffic. Second, our analysis did not allow for patients to be transported across state lines. Third, our estimates are based on where people live, not necessarily where their strokes occur. We do know, however, that most strokes occur at home.<sup>51</sup> Fourth, while our definition of a stand-alone PSC included both PSCs and CSCs certified by TJC, DNV, and the state of Texas, centres certified by national quality improvement projects were not included in this definition.<sup>52</sup> Further, PSC credentialing is a dynamic process, and thus our inventory may underestimate the current number of credentialed centres.<sup>39,40</sup> Fifth, our



study only accounts for access to thrombolysis at PSCs, PSC-TM, or TM facilities and does not account for each individual hospital's capability and/ or comfort in delivering tPA or employing other strategies such as 'drip and ship'.<sup>53,54</sup> This study is population based and does not account for the role that language barriers may play in individual treatment decisions using TM. Our study does not look at how the additional access provided by TM affects outcomes in racial and ethnic minorities. Finally, this is an ecological study. Observations at the aggregate level do not necessarily represent associations at the individual level.

Current access to in-person neurological expertise for acute stroke care is limited throughout the country and may disproportionately affect minority groups. Our findings suggest that the use of TM coupled with free standing PSCs can be used as part of a comprehensive strategy to address disparities in access to care. Although there are still barriers to the use of TM (reimbursement, privacy laws, fear of malpractice), the benefits of this model can be seen in all races and ethnicities without leading to any increases in the existing disparities in stroke care.

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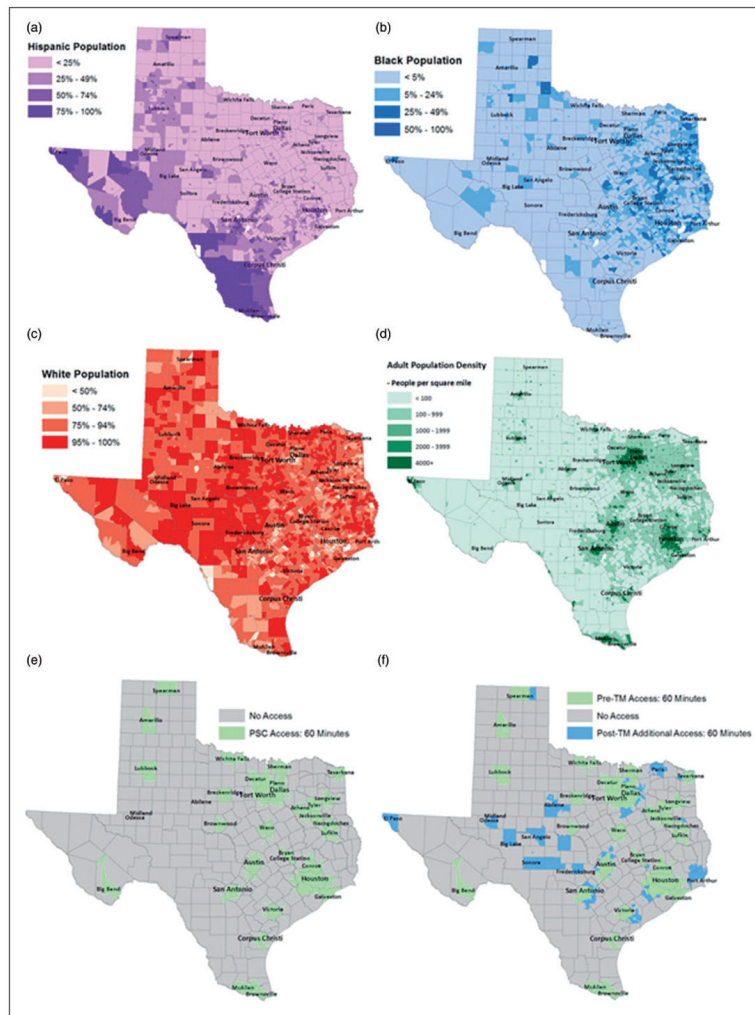
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**Figure 1.**  
 The effects of telemedicine on primary stroke centre access in Texas.  
 A: Hispanic population  
 B: Black population  
 C: White population  
 D: Adult population density  
 E: 60 minute primary stroke centre access  
 F: 60 minute access afforded by telemedicine  
 PSC: primary stroke centre; TM: telemedicine  
 Maps were generated using ESRI ArcMap 10.1.

**Table 1**

Current access to acute stroke care in Texas by race.

	<b>Race</b>		
	<b>White (n =17,096,097)</b>	<b>Black (n =2,738,429)</b>	<b>Other (n =3,966,914)</b>
PSC	12,431,953 (72.7%)	2,270,715 (82.9%)	3,251,664 (82.0%)
PSC-TM	1,169,987 (6.8%)	135,951 (5.0%)	241,430 (6.1%)
TM	397,961 (2.3%)	35,789 (1.3%)	44,898 (1.1%)
Non-PSC/No TM	3,096,126 (18.1%)	295,974 (10.8%)	428,922 (10.8%)

PSC: primary stroke centre; PSC-TM: primary stroke centre using telemedicine; TM: telemedicine.

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**Table 2**

Current access to acute stroke care in Texas by ethnicity.

	<b>Ethnicity</b>	
	<b>Hispanic (n =8,550,214)</b>	<b>Non-Hispanic (n =15,251,226)</b>
PSC	6,402,169 (74.9%)	11,552,233 (75.7%)
PSC-TM	835,549 (9.8%)	711,819 (4.7%)
TM	95,972 (1.1%)	382,676 (2.5%)
Non-PSC/No TM	1,216,524 (14.2%)	2,604,498 (17.1%)

PSC: primary stroke centre; PSC-TM: primary stroke centre using telemedicine; TM: telemedicine.

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