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Abstract

Background: Women have more frequent and severe ischemic strokes than men, and are less likely to receive treatment for acute stroke. Primary stroke centers (PSCs) have been shown to utilize treatment more frequently. Further, as telemedicine (TM) has expanded access to acute stroke care we sought to investigate the association between PSC, TM and access to acute stroke care in the state of Texas.

Methods: Texas hospitals and resources were identified from the 2009 American Hospital Association Annual Survey. Hospitals were categorized as: (1) stand-alone PSCs not using telemedicine for acute stroke care, (2) PSCs using telemedicine for acute stroke care (PSC-TM), (3) non-PSC hospitals using telemedicine for acute stroke care, or (4) non-PSC hospitals not using telemedicine for acute stroke care. The proportion of the population who could reach a PSC within 60 minutes was determined for stand-alone PSCs, PSC-TM, and non-PSCs using TM for stroke care.

Results: Overall, women were as likely to have 60-minute access to a PSC or PSC-TM as their male counterparts (POR 1.02, 95% CI 1.02-1.03). Women were also just as likely to have access to acute stroke care via PSC or PSC-TM or TM as men (POR 1.03, 95% CI 1.02-1.04).

Discussion: Our study found no sex disparities in access to stand alone PSCs or to hospitals using TM in the state of Texas. The results of this study suggest that telemedicine can be used as part of an inclusive strategy to improve access to care equally for men and women.

Keywords

stroke; health disparities; telemedicine; acute stroke care

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ABSTRACT

Background: Women have more frequent and severe ischemic strokes than men, and are less likely to receive treatment for acute stroke. Primary stroke centers (PSCs) have been shown to utilize treatment more frequently. Further, as telemedicine (TM) has expanded access to acute stroke care we sought to investigate the association between PSC, TM and access to acute stroke care in the state of Texas.

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INTRODUCTION

Stroke is the leading cause of disability and fourth leading cause of death in the United States.(Towfighi & Saver, 2011) Stroke can be acutely treated with tissue plasminogen activator (tPA), significantly improving functional outcome when given to appropriately selected acute ischemic stroke (AIS) patients within 4.5 hours.(Hacke et al., 2008; "Tissue plasminogen activator for acute ischemic stroke. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group," 1995) However, national tPA treatment rates remain low (3-7%) despite the known benefits of treatment.(M. J. Reeves et al., 2005; Schwamm et al., 2013) Patients presenting to primary stroke centers are more likely to receive tPA and have better outcomes, but only two-thirds of Americans live within an hour of a Joint Commission Primary Stroke Center (PSC).(Albright et al., 2010; B. Carr & Branas; Lichtman et al., 2011; Prabhakaran, McNulty, O'Neill, & Ouyang, 2012)

Telemedicine has been used to improve access to care by allowing a neurologist at a remote location to interact with the patient and their family members.(Hess et al., 2006) Prior studies have shown that the use of telemedicine for treatment of AIS is not only safe and effective, but it also increases the utilization of tPA, thereby improving patient care and outcomes.(Choi et al., 2006; Meyer et al., 2008; Switzer et al., 2009) Prior research has shown that a way to increase access to acute neurological expertise is through telemedicine (TM).(Miley et al., 2009; Saler, Switzer, & Hess, 2011; Switzer & Hess, 2008) TM is the use of telecommunication technologies to provide medical information and services.(Perednia & Allen, 1995) Telemedicine uses the direct audiovisual connections between a location that does not have expert medical care and provides a remote physician, TM delivers quality health care from a distance.(Demaerschalk et al., 2009) Previous research has 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.(Adams et al., 2012; Audebert et al., 2006; Audebert et al., 2009; Choi et al., 2006; Demaerschalk et al., 2010; Meyer et al., 2008; Stewart & Switzer, 2011; Switzer et al., 2013; Switzer et al., 2009)The American Stroke Association recommends that networks of telestroke be developed to provide acute neurological expertise to locations that lack on-site resources to improve access to acute stroke care.(Higashida et al., 2013; Schwamm et al., 2009)

Stroke disproportionately impacts women, leading to a sex disparity that is increasingly being recognized in the literature.(Kapral et al., 2005) More strokes occur in women than men, partially due to the fact that women have longer lifespans than men and have historically received poorer quality care.(M. J. Reeves, Fonarow, Zhao, Smith, & Schwamm, 2009; Roger et al., 2012) Women who experience stroke are known to present with more severe neurological and functional impairments, though they are less likely to receive tPA acutely and antithrombotics on discharge.(Hachinski et al., 2010; M. Reeves, Bhatt, Jajou, Brown, & Lisabeth, 2009) These differences may explain the significant disparities in functional outcome between the sexes, as female stroke patients are known to have a worse functional outcome (modified Rankin Scale $\geq$3) at both 30 days and one year following hospitalization for a first-

time stroke.(Dougu et al., 2011; Roth et al., 2011) With the graying of America, there are more women over the age of 65 than men, because women tend to live longer than men. In addition to this, women tend to remain in the shared marital home after the passing of their spouse and therefore do not move. We believe that these factors combined increase the risk of women living in areas without access to acute stroke care. The purpose of this study is to determine whether the differences exist in access to acute stroke care for men and women and to examine the effect that telemedicine has had on eliminating disparities in access to care in this devastating, time-sensitive disease.

METHODS

Study Population

Data from the US Census Bureau and the 2010 Neilson Claritas Demographic Estimation Program were used to obtain population demographic information and geographic locations.(USCensusBureau, 2010) The primary unit of analysis was the block group; a small unit of geographic analysis that is contained within the boundaries of a census tract and comprised of a population of 600-3000 adults. Calculations were conducted from the block group centroid, a point closest to the most residents within each block group. Sex composition of each block group was determined.

Hospital Survey

The details of the survey methodology have been previously described. (Wu et al., 2014) Briefly, hospitals in Texas were identified through publicly available data from the American Hospital Association (AHA).(Association) 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.(Services, 2013) 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 Primary Stroke Center state designation.(TJC, 2013; Veritas, 2013) 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.(Alberts et al., 2000; Services, 2009) For the purposes of this study, state designated Comprehensive Stroke Centers and Primary Stroke Centers were combined into a single category—Primary Stroke Centers.

Using a standardized questionnaire, a three question telephone survey was administered to the emergency department coordinator or charge nurse in 556 hospitals to determine if each hospital was (1) an acute care hospital, (2) a TJC, DNV or the state of Texas certified Primary Stroke Center, or (3) utilizing telemedicine (TM) to provide acute stroke care. The questions asked during the telephone survey were (1) Is your hospital an acute care hospital?, (2) Is your hospital a primary stroke center?, and (3) Does your hospital use telemedicine for stroke?. After verification of the information obtained from the telephone survey, hospitals were designated into 4 categories: stand-alone Primary Stroke Centers (**stand-alone PSC**: hospitals that were Primary Stroke Centers and were not using telemedicine for acute stroke care), Primary Stroke Centers using telemedicine (**PSC-TM**: hospitals that were Primary Stroke Centers and were using telemedicine for acute stroke care), telemedicine for stroke care (**TM-only**: hospitals that

were not Primary Stroke Centers but were using telemedicine for acute stroke care) or **none** (hospitals that were not Primary Stroke Centers and were not using telemedicine for acute stroke care).

Access to Care Calculations

Each block group was classified as having access within 60 minutes to either a stand-alone PSC, a PSC-TM, or a TM-only facility. Time estimates for each block group were calculated using the distance from the block group centroid to the closest hospital of each type (i.e., stand-alone PSC, PSC-TM, TM-only), with the addition of validated ambulance prehospital time intervals. The population of the block groups within these catchment areas was summed to determine total population with 60-minute access. Calculations were restricted to only consider the population and facilities residing within Texas state borders.

The Network Analyst functionality in ESRI ArcMap 10.1 was used to determine the shortest road distance between each centroid and the nearest hospital.(Love & Morris, 1979; Love & Wesolowsky, 1988) Each block group was linked exclusively with one hospital of each type and no block group was counted more than once. Transport times were calculated based on posted speed limits with 10 mph added to the speed limit for the roads in each path to the linked hospital. Key pre-hospital ambulance time intervals, adjusted based on rurality, were added to the transport time to estimate the total prehospital travel time. The 911 activation to ambulance dispatch interval was estimated as 1.4, 1.4 and 2.9 minutes for urban, suburban and rural areas, respectively.(B. G. Carr, Caplan, Pryor, & Branas, 2006) The time from ambulance dispatch until arrival at the scene was determined by multiplying the drive time from the scene to the hospital (as described above) by 1.6, 1.5 and 1.4 for urban, suburban and rural drives, respectively.(B. G. Carr et al., 2006) Lastly, 13.5, 13.5 and 15.1 minutes were added to account for time spent by emergency medical services (EMS) on the scene prior to transport.(Branas et al., 2005; B. G. Carr, Branas, Metlay, Sullivan, & Camargo, 2009) 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 sex 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 sex and access to acute stroke care.(Zou, 2004) This decision was made in an attempt to prevent the overestimation often seen when using logistic regression (odds ratios) in situations with prevalent outcomes. (Zou, 2004) In addition to crude models, models were adjusted for urbanization.

RESULTS

In 2009 the population of Texas was 23.8 million residents. Of these, approximately 50% were women. A total of 578 Texas hospitals were identified in the American Hospital Association database, of which 96% (556/578) completed the survey. There were 22 hospitals who did not participate (18 could not be reached by phone). Of the 556 hospitals completing the survey, 395 (71%) were identified as acute care facilities. One hundred and three (26%) acute

care facilities were identified as stroke centers; the minority of these were PSC-TMs (21%, 22/103).

Over 75% (18 million) of the Texas population had 60-minute in-state ground access to a stand-alone PSC. Sixty-minute access increased to 82% with an additional 478,000 (2%) people being served by PSC-TMs. Although PSC-TMs increased access to acute stroke care, nearly 4 million Texans still do not have 60-minute access.

There was no difference in the proportion of men and women with 60-minute access to stand-alone PSCs, PSC-TMs, and TM-only (Table 1). Approximately 16% of Texas had did not have 60-minute access to acute stroke care (16.2% men, 15.9% women). Overall, women were equally likely to have 60-minute access to acute stroke care at a stand-alone PSC or PSC-TM (POR 1.02, 95% CI 1.02- 1.03) when compared to their male counterparts. Women remained just as likely to have 60-minute access to acute stroke care at a stand-alone PSC or PSC-TM or TM-only as men (POR 1.03, 95% CI 1.02-1.04).

Table 1: Current Access to Acute Stroke Care in Texas by Sex

	Men (n= 11,871,925)	Women (n= 11,929,515)
Stand-alone PSC	8,950,514 (75.4%)	9,003,888 (75.5%)
PSC-TM	755,100 (6.4%)	792,268 (6.6%)
TM-only	237,974 (2.0%)	240,674 (2.0%)
None	1,928,337 (16.2%)	1,892,685 (15.9%)

Discussion

Stroke is an unplanned time-sensitive critical illness and, as such, requires rapid access to hospitals prepared to treat acute stroke. Delayed presentation on the part of women has been thought to play a role in the 30% lower likelihood of women receiving acute stroke treatment (i.e., tPA) when compared to men.(Dougu et al., 2011; M. Reeves et al., 2009) This lack of acute treatment has been thought to contribute to the worse functional outcome seen in women following a stroke.(Dougu et al., 2011; M. Reeves et al., 2009) While it has been previously demonstrated that telemedicine increases both access to acute stroke care and tPA utilization, no study has investigated the association between sex and access to acute stroke care—with and without the use of telemedicine. We found no sex disparities in access to stand-alone PSCs, PSCs utilizing telemedicine, or hospitals using telemedicine for acute stroke care in the state of Texas. Our findings do not explain the delayed presentation and low tPA treatment rates that have been reported in women with acute stroke.(Hachinski et al., 2010; M. Reeves et al., 2009)

Telemedicine has the potential to increase access to PSCs and has been shown to increase use of tPA.(Choi et al., 2006),(Mullen, Kasner, et al., 2013) If our findings for Texas are generalizable nationally, then this raises the question of whether potential access to acute stroke care for women translates to realized access.(Andersen & Aday, 1978; Sibley & Weiner, 2011)

Our study examined potential access (i.e., availability, accessibility) via travel time from place of residence to the nearest acute stroke care facility. In contrast, Mullen et al. examined where patients were actually treated for their acute stroke (i.e., realized access) using a national cohort study.(Mullen, Judd, et al., 2013) Our divergent findings raise important questions about acute stroke care for women. Are there other variables that facilitate or impede women in receiving acute stroke care at PSCs?(Andersen & Aday, 1978; Sibley & Weiner, 2011) What is the role of Emergency Medical Services (EMS) in selecting the hospital to which a patient will be transported?(Grotta, Savitz, & Persse, 2013) While longer EMS transport times have been reported for women with suspected acute coronary syndrome, reasons for this delay are understudied and not well understood.(Concannon et al., 2009; Ornato, 2009)

Our study is not without limitations. Our design does not account for patients who are transported across state lines. Additionally, our analysis was based on where people live, which may not be where every patient experiences stroke symptoms, although previous research has demonstrated that most strokes occur at home.(Kelly-Hayes et al., 1995) The drive times used in this study are calculated from trauma systems; stroke patients may have drive times that are 6 to 11 minutes longer.(Ramanujam et al., 2009; Wojner-Alexandrov, Alexandrov, Rodriguez, Persse, & Grotta, 2005) The drive time calculations do not account for traffic or geographic boundaries. Our definition of a stand-alone PSC included both primary stroke centers and comprehensive stroke centers certified by TJC, DNV, and the state of Texas, centers certified national quality improvement projects were not included in this definition.(Gropen et al., 2009) This study only accounts for access to PSCs or telemedicine facilities. It does not account for each individual hospital's ability to safely deliver tPA or employ other acute care strategies through existing transfer agreements (i.e., drip and ship).(Kleindorfer et al., 2009; Qureshi et al., 2012) Finally, this is an ecological study. Observations at the aggregate level do not necessarily represent associations at the individual level. This study is limited by its ecological nature and thus we are only able to report on two of the five domains of access to care: availability and accessibility. We acknowledge that accommodation, affordability, and accessibility are equally as important domains of access to care, but this data was not readily available.(Penchansky & Thomas, 1981)

Although women have more frequent and more severe strokes, they are less often treated with tPA which may result in the higher levels of poor functional outcomes seen in women after stroke. Our study found that men and women have equal potential access to all three types of hospitals that reported providing acute stroke care. While increasing access to stroke care has been an important public health endeavor with a focus on increasing access for groups that have historically been underserved, our study failed to show a sex disparity in potential access to acute stroke care. Further the results of this study suggest that telemedicine can be used as part of an inclusive strategy to improve access to care equally for men and women.

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