Appendix 1:
White Paper Recommendations for
Orange County Stroke-Neurology Receiving Center Program

Program Evaluation of Orange County Stroke-Neurology Receiving Center System: White Paper Recommendations

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ABSTRACT

Introduction: Despite the decreasing trends in stroke incidence, it remains the fourth most common cause of death and a leading cause of disability within an aging population. Thus, stroke care remains vitally important at the population level. The Orange County Stroke Neurology Receiving Center system, a coordinated county-level stroke triage system with nine stroke hospitals, has been in place since 2009. Initial reports of quality measures demonstrated that rates of treatment with reperfusion therapy exceeded national averages. The present analysis seeks to evaluate the continued quality of stroke care within the system, through rates of treatment with reperfusion therapy, in hospital mortality, time to treatment, and outcome measures.

Methods: Data was collected from 2013-2014 on all patients who were triaged for suspected stroke within Orange County by the county emergency medical response system. Demographic, health system, and health outcome variables were collected for each case. Univariate and bivariate analyses were performed to determine the association of these characteristics with the likelihood of receiving treatment with reperfusion therapy intravenously or through neurointerventional modalities.

Results: 1645 patients were diagnosed with ischemic stroke between January 1 2013 and October 20 2014, out of 4626 triaged (35.8%). Of these individuals, 395 (23.8%) received some form of reperfusion therapy. 301 (18.2%) received intravenous (IV) tissue Plasminogen Activator (tPA), while 14 (0.8%) received intra-arterial tPA and 80 (4/8%) received mechanical neurointerventional treatment. On bivariate analysis, treatment type was associated with younger age, neurointerventional ready hospital type, in hospital mortality, higher stroke severity, and increased time to treatment; treatment was not associated with gender or ethnicity.

Conclusions: In its fifth year, the Orange County coordinated stroke triage system has above average rates of treatment and below average treatment times for equivalent county- or regional-level stroke response systems. In the present analysis, existing health disparities in stroke care for women and minorities have not been replicated. Challenges persist with data acquisition and collection of adequate health outcomes data, including the acute stroke severity and long-term functional outcomes. Although the present process measures support the quality of care delivery, more outcomes data is necessary to ultimately evaluate the benefit of this system to the population.

INTRODUCTION

The United States has never been as obese as it is today.(Sturm, 2007; Wyatt, Winters, & Dubbert, 2006) Thus, it is no surprise that stroke represents the fourth most common cause of death, and one of the leading causes of serious disability among adults. (Koton et al., 2014) Nevertheless, several studies have characterized a steady decrease in the number of stroke hospitalizations over the past twenty years, with attendant decreases in in-hospital and 30-day mortality rates. (Fang, Coca Perraillon, Ghosh, Cutler, & Rosen, 2014; Koton et al., 2014; Krumholz, Normand, & Wang, 2014) These trends represent both a decrease in the incidence of disease as well as an improvement in treatment; management of stroke and its risk factors appears improved both in the preventive and acute settings.

However, despite the overall decrease in incidence and improved acute management, significant disparities persist. Despite the decreased incidence of stroke in the overall population, Boan et al found that the incidence actually increased in the black population younger than 65; (Boan et al., 2014) Plakht et al saw no difference in the incidence of stroke among women in a national sample. (Plakht, Pertzov, Gez, Hellerman, & Ifergane, 2014) These authors point toward specific groups needing additional attention in stroke management. Regardless, stroke remains a significant overall threat to the population, and more work is necessary to reduce this health burden.

The Orange County Stroke-Neurology Receiving Center (SNRC) system was established in 2009 to improve the quality of stroke care at the County level, leveraging the organizational capabilities of the Emergency Medical Systems (EMS) department within the Orange County Health Care Agency. The present evaluation seeks to utilize prospectively collected data through this program to determine whether the quality of stroke care in Orange County has been impacted by this intervention, five years after its implementation. Given the limitations of the database, we had several aims: first, to establish the system-level rate of reperfusion therapy received by individuals with ischemic strokes, and the timing of therapy delivered in the acute setting; and second, to determine the extent to which reperfusion therapy led to measurable outcomes in stroke severity and neurologic function.

METHODS

Stroke-Neurology Receiving Center System Overview

The Orange County Stroke-Neurology Receiving Center (SNRC) system has been previously described in detail. (Cramer et al., 2012) Briefly, nine hospitals volunteered to serve as SNRC hub hospitals, which would receive all eligible potential stroke victims. Six of these hospitals had neurointerventional radiologists available 24 hours a day; these were designated spoke SNRC hospitals, to receive transfers from other hospitals for patients needing higher-acuity care. Eligible victims included all patients suspected of stroke <5 hours duration, defined as weakness (hemiplegia, hemiparesis, pronator drift, or facial paresis), capillary glucose >80 mg/dl, no seizure prior to or during EMS arrival, and Glasgow Coma Scale score >10.

Data Collection

SNRC planners developed and validated a standardized data collection sheet to be completed for each patient initially by EMS units, and subsequently by SNRC hub hospital stroke coordinators, who submit this information to Orange County EMS. This data forms the foundation of the prospective database underlying the present evaluation.

Data was included for the present evaluation for all patients triaged by EMS for suspected stroke within Orange County between January 1, 2013 and October 20, 2014. The database included those with ischemic stroke, hemorrhagic stroke, transient ischemic attack, as well as those inappropriately triaged for their stroke-like symptoms. The present analysis was limited to those diagnosed with ischemic stroke following formal medical evaluation.

Variable Selection

Variables were selected in order to have a representative sample of demographic, health systems and processes, and health outcomes; this would allow for the best possible understanding of the stroke system functioning. Demographic variables included age, gender, and ethnicity. Age was converted from a continuous variable to a categorical variable with ages ≤60, 61-70, 71-80, 81-90, >90. Ethnicity was coded as Caucasian, Asian American, Latino, Black, or Other.

Health systems and processes variables included hospital type, time to treatment, and treatment type. Hospital type was based upon the two levels of hospitals included in the stroke system, with 6 neurointerventional-ready spoke hospitals, and 3 non-neurointerventional-ready hub hospitals incorporated into a two-level categorical variable. Time to treatment was categorized as a four-level categorical variable based upon the present and historical recommended ideal time limits for treatment with reperfusion therapy, with ≤60 minutes, 61-90 minutes, 91-270 minutes, and >270 minutes.(Adams et al., 2007; Jauch et al., 2013) Treatment type examined the rates of reperfusion therapy for acute stroke, and was characterized as a categorical variable with no treatment or unknown treatment, intravenous (IV) tissue plasminogen activator (tPA), intraarterial (IA) tPA, mechanical clot retrieval (using stents, baskets, or other neurointerventional devices), or if patients were ineligible for treatment (due to unknown onset, contraindication, or other factors).

Health outcomes variables included the admission NIH Stroke Scale (NIHSS) score and an NIHSS change score, in which NIHSS at the time of hospital discharge was subtracted from NIHSS at hospital admission. NIHSS is a validated measure of stroke severity, and is ranked on a scale of 0-42. We report these data as a categorical variable, where 0=no stroke, 1-4=mild stroke, 5-15=moderate stroke, 16-20=moderate/severe stroke, and 21-42=severe stroke.(Tziomalos et al., 2014)

Data Analysis

Data was analyzed using computer statistical software to tally the number and percentage of patients with each of the described variables. Independent variables included: the demographic variables of age, gender, and ethnicity; the health systems and processes variables of hospital type and time to treatment; and the health outcomes variables of admission NIHSS and NIHSS change score. The dependent variable of interest was the treatment type.

Bivariate analyses were conducted to examine the associations of patient and health systems factors with treatment for acute stroke within the Orange County stroke system. Chi-square analyses were performed for treatment type with all categorical predictor variables (age, gender, ethnicity, hospital type, NIHSS admission, and time to treatment). P-values for each chi-square were calculated to determine whether the association reached significance. For the single continuous predictor variable, NIHSS change score, we calculated median change score values and interquartile range values for each treatment type.

All statistical analyses were performed using Stata statistical software, version 13.1. (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP.)

RESULTS

There were 4626 cases of stroke triaged by emergency medical response between the dates January 1, 2013 and October 20, 2014. Of these, 1654 (35.8%) were classified as ischemic stroke upon further medical evaluation. (Table 1) These individuals formed the study population. Of this group, the majority were aged 71-90 (71-80 years, 23.2%; 81-90 years, 29.8%), although there was a broad age distribution. A slim majority was female (51.5%), while a large majority was of Caucasian ethnicity (71.6%), with Asian Americans (11.6%) and Latinos (10.8%) representing the largest minority groups.

The majority of cases were handled at neurointerventional ready stroke hospitals (73.9%). (Table 1) Few died in the hospital (5.6%), and most were diagnosed with minor or moderate strokes on admission (NIHSS 1-4, 34.5%; NIHSS 5-15, 34.6%) and treated within 60 minutes of hospital arrival (42.4%). Almost all patients were treated within 270 minutes of arrival (98.9%). Median NIHSS change scores increased with stroke severity; patients admitted with moderate/severe or severe strokes (NIHSS 16-42) experienced a median NIHSS decrease of 5 points between admission and discharge. Among these groups, interquartile ranges also demonstrated an increased variability in change scores (IQR 0,12) with increased stroke severity upon admission.

Treatment data demonstrated that 18.2% received IV TPA, while 5.6% received intra-arterial therapy, with 0.8% receiving IA TPA and 4.8% receiving mechanical therapy. (Table 1) Treatment was contraindicated for 7.3% of patients. Thus, 68.7% received no treatment or had treatment that was not reported.

Bivariate analyses demonstrated the associations of patient and health system characteristics with the likelihood of acute treatment. (Table 2) Age, hospital type, in-hospital mortality, NIHSS Admission, and Time to treatment demonstrated significant associations with the treatment outcome, while Gender ($p=0.671$) and Ethnicity ($p=0.407$) were not associated with treatment. Patients >90 years old were less likely to receive intraarterial or mechanical therapy, though no trend of increased mechanical therapy was evident for the younger age groups. Neurointerventional ready accounted for nearly all intraarterial and mechanical treatment, while the rates of IV TPA were similar between the two hospital types. In hospital mortality was highest for patients who received mechanical therapy, while patients receiving any treatment were more likely to have higher NIHSS scores on admission. Among those treated, time to treatment increased for more complex intraarterial and mechanical therapies.

DISCUSSION

The present analysis has three main implications for stroke care in Orange County and nationally. First, we have found that approximately 25% of individuals who are found to have ischemic stroke subsequently receive treatment with reperfusion therapy. These rates of treatment five years into the program are slightly increased compared to those found in the first year of the program.(Cramer et al., 2012) When compared to other city and regional-level triage systems, however, these rates of treatment are equivalent or higher, though they do not achieve the rates of treatment found within consortia of high-acuity, tertiary centers. (Albright et al., 2012; Cha et al., 2014; Gladstone et al., 2009; Kapral et al., 2013; LaMonte et al., 2009; Prabhakaran, O'Neill, Stein-Spencer, Walter, & Alberts, 2013) At the same time, in hospital mortality rates appear to be equivalent or better than those previously reported, despite the

considerable risks of intravascular hemorrhage following reperfusion therapy; in this population, these risks appear to have been minimized.(Khatri, Wechsler, & Broderick, 2007; Krumholz et al., 2014) This seems to buttress the success of the coordinated response model and the centralization of high-acuity care for stroke at the county level.

Second, the present analysis demonstrates that nearly complete compliance with treatment measures is plausible on a systems level, with over 40% receiving reperfusion treatment within 60 minutes, and 99% receiving treatment within the 4.5 hour window limit recommended by 2013 AHA guidelines.(Adams et al., 2007; Jauch et al., 2013) This is an improvement from our initial 2012 report of the program, where we found that only 25% of patients received treatment within the 60-minute window—and it outperforms many other settings, which our earlier rates matched.(Cramer et al., 2012; Jauch et al., 2013) It demonstrates that as providers become more comfortable implementing specific goal measures for improved quality of care, these can be achieved, at least as a process outcome.

Third, although recent reports have continued to demonstrate disparities in stroke care for women and minority groups, these associations have not been replicated in the current analysis. (Boan et al., 2014; Plakht et al., 2014) This might reflect a benefit of the systematized nature of emergency response at the county level, as the disparities in diagnosis or treatment of stroke care have been apparently eliminated by the triage process. Intuitively, the protocolization of stroke care may limit the implicit biases that patients and providers bring to the clinical encounter, thus democratizing health care delivery in the acute setting. Alternatively, this finding could also reflect the relatively small black population in Orange County, since blacks have been the minority previously shown to have the greatest health disparity in stroke incidence and outcomes nationally. Still, the gender gap has not been replicated here, despite the fact that more women than men were treated in our system.

The strength of these conclusions is subject to several limitations. First, stroke care is largely evaluated using process measures or inadequate outcomes measures; our study is no exception. While the NIHSS is an accurate and validated measure for evaluation of stroke severity in the acute setting, its use as a proxy for long-term outcome is of limited value, as it does not measure disability or functional status.(Kasner, 2006; Weimar et al., 2004) However, the modified Rankin Scale (mRS), though better at evaluating long-term functional outcomes, is more difficult to record, especially to achieve 30-day post-stroke evaluation.(Banks & Marotta, 2007) This is reflected in the poor data collection for mRS in the current program; although SNRC planners designed the data collection sheet to included the mRS, only 48% of patients in the present cohort had recorded mRS values. Second, the inconsistency in data reporting may undermine the quality of this data. For example, of the 1135 patients who were not documented to have received any reperfusion treatment, only 22% were noted as such; the fate of the true treatment for the remaining 78% is unknown. Of the 22% with documentation, there was inconsistency in the documented reasons for the lack of therapy; ASA was a commonly documented contraindication, though this is not supported by the literature.

If we are to make any conclusions regarding the health outcomes of patients treated within the stroke system, we must strengthen the quality of our data acquisition and reporting. In addition to the absence of granularity among those not receiving reperfusion therapy, even fewer patients had documented time to treatment: only 23% of cases could be documented by this metric. While the data for treatment was incomplete, the health outcomes data was even more faulty, and thus challenging to interpret. For example, although we found a positive association between initial stroke severity and NIHSS change score, this was accompanied by a significant

increase in variance, such that any differences were impossible to determine. Second, the challenge in obtaining data regarding the modified Rankin Scale is manifest in the underreporting found within our database; more administrative support is necessary to flesh out these vital outcomes data at the systems level.

Despite these limitations, this analysis supports the continued quality of stroke care delivered in Orange County under the Stroke-Neurology Receiving Center system. Rates of treatment with reperfusion therapy, continually supported by AHA stroke guidelines, match or exceed those delivered in other analogous systems, while time to treatment exceeds the most ideal projections of care within a large, county-level health system. Finally, the documented disparities in stroke care delivery to women and minorities were not found in Orange County despite its diverse population and the plurality of female patients treated within the stroke system, suggesting that stroke systems may offer one solution to reduce the disparities in stroke care nationally.

CONCLUSION

In its fifth year, the Orange County coordinated stroke triage system has above average rates of treatment and below average treatment times for equivalent county- or regional-level stroke response systems. In the present analysis, existing health disparities in stroke care for women and minorities have not been replicated. Challenges persist with data acquisition and collection of adequate health outcomes data, including the acute stroke severity and long-term functional outcomes. Although the present process measures support the quality of care delivery, more outcomes data is necessary to ultimately evaluate the benefit of this system to the population.

REFERENCES

Adams, H. P., del Zoppo, G., Alberts, M. J., Bhatt, D. L., Brass, L., Furlan, A., . . . Group, Q. o. C. O. i. R. I. W. (2007). Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research Interdisciplinary Working Groups: The American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists. *Circulation, 115*(20), e478-534. doi: 10.1161/CIRCULATIONAHA.107.181486

Albright, K. C., Savitz, S. I., Raman, R., Martin-Schild, S., Broderick, J., Ernstrom, K., . . . Meyer, B. C. (2012). Comprehensive stroke centers and the 'weekend effect': the SPOTRIAS experience. *Cerebrovasc Dis, 34*(5-6), 424-429. doi: 000345077

Banks, J. L., & Marotta, C. A. (2007). Outcomes validity and reliability of the modified Rankin scale: implications for stroke clinical trials: a literature review and synthesis. *Stroke, 38*(3), 1091-1096. doi: 10.1161/01.STR.0000258355.23810.c6

Boan, A. D., Feng, W. W., Ovbiagele, B., Bachman, D. L., Ellis, C., Adams, R. J., . . . Lackland, D. T. (2014). Persistent racial disparity in stroke hospitalization and economic impact in young adults in the buckle of stroke belt. *Stroke, 45*(7), 1932-1938. doi: 10.1161/STROKEAHA.114.004853

Cha, J. K., Nah, H. W., Kang, M. J., Kim, D. H., Park, H. S., Kim, S. B., . . . Huh, J. T. (2014). Outcomes after tissue plasminogen activator administration under the drip and ship paradigm may differ according to the regional stroke care system. *J Stroke Cerebrovasc Dis, 23*(1), 160-163. doi: 10.1016/j.jstrokecerebrovasdis.2013.07.032

Cramer, S. C., Stradling, D., Brown, D. M., Carrillo-Nunez, I. M., Ciabarra, A., Cummings, M., . . . Stratton, S. J. (2012). Organization of a United States county system for comprehensive acute stroke care. *Stroke, 43*(4), 1089-1093. doi: 10.1161/STROKEAHA.111.635334

Fang, M. C., Coca Perraillon, M., Ghosh, K., Cutler, D. M., & Rosen, A. B. (2014). Trends in stroke rates, risk, and outcomes in the United States, 1988 to 2008. *Am J Med, 127*(7), 608-615. doi: 10.1016/j.amjmed.2014.03.017

Gladstone, D. J., Rodan, L. H., Sahlas, D. J., Lee, L., Murray, B. J., Ween, J. E., . . . Black, S. E. (2009). A citywide prehospital protocol increases access to stroke thrombolysis in Toronto. *Stroke, 40*(12), 3841-3844. doi: 10.1161/STROKEAHA.108.540377

Jauch, E. C., Saver, J. L., Adams, H. P., Bruno, A., Connors, J. J., Demaerschalk, B. M., . . . Cardiology, C. o. C. (2013). Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke, 44*(3), 870-947. doi: 10.1161/STR.0b013e318284056a

Kapral, M. K., Fang, J., Silver, F. L., Hall, R., Stamplecoski, M., O'Callaghan, C., & Tu, J. V. (2013). Effect of a provincial system of stroke care delivery on stroke care and outcomes. *CMAJ, 185*(10), E483-491. doi: 10.1503/cmaj.121418

Kasner, S. E. (2006). Clinical interpretation and use of stroke scales. *Lancet Neurol, 5*(7), 603-612. doi: 10.1016/S1474-4422(06)70495-1

Khatri, P., Wechsler, L. R., & Broderick, J. P. (2007). Intracranial hemorrhage associated with revascularization therapies. *Stroke, 38*(2), 431-440. doi: 10.1161/01.STR.0000254524.23708.c9

Koton, S., Schneider, A. L., Rosamond, W. D., Shahar, E., Sang, Y., Gottesman, R. F., & Coresh, J. (2014). Stroke incidence and mortality trends in US communities, 1987 to 2011. *JAMA, 312*(3), 259-268. doi: 10.1001/jama.2014.7692

Krumholz, H. M., Normand, S. L., & Wang, Y. (2014). Trends in hospitalizations and outcomes for acute cardiovascular disease and stroke, 1999-2011. *Circulation, 130*(12), 966-975. doi: 10.1161/CIRCULATIONAHA.113.007787

LaMonte, M. P., Bahouth, M. N., Magder, L. S., Alcorta, R. L., Bass, R. R., Browne, B. J., . . . Center, E. M. N. o. t. M. B. A. (2009). A regional system of stroke care provides thrombolytic outcomes comparable with the NINDS stroke trial. *Ann Emerg Med, 54*(3), 319-327. doi: 10.1016/j.annemergmed.2008.09.022

Plakht, Y., Pertzov, B., Gez, H., Hellerman, M., & Ifergane, G. (2014). Stroke hospitalizations over three decades: lower for men, unchanged for women. A population-based study. *J Womens Health (Larchmt), 23*(4), 296-301. doi: 10.1089/jwh.2013.4591

Prabhakaran, S., O'Neill, K., Stein-Spencer, L., Walter, J., & Alberts, M. J. (2013). Prehospital triage to primary stroke centers and rate of stroke thrombolysis. *JAMA Neurol, 70*(9), 1126-1132. doi: 10.1001/jamaneurol.2013.293

Sturm, R. (2007). Increases in morbid obesity in the USA: 2000-2005. *Public Health, 121*(7), 492-496. doi: 10.1016/j.puhe.2007.01.006

Tziomalos, K., Bouziana, S. D., Spanou, M., Giampatzis, V., Papadopoulou, M., Kazantzidou, P., . . . Hatzitolios, A. I. (2014). Increased augmentation index is paradoxically associated with lower in-hospital mortality in patients with acute ischemic stroke. *Atherosclerosis, 236*(1), 150-153. doi: 10.1016/j.atherosclerosis.2014.06.028

Weimar, C., König, I. R., Kraywinkel, K., Ziegler, A., Diener, H. C., & Collaboration, G. S. S. (2004). Age and National Institutes of Health Stroke Scale Score within 6 hours after onset are accurate predictors of outcome after cerebral ischemia: development and external validation of prognostic models. *Stroke, 35*(1), 158-162. doi: 10.1161/01.STR.0000106761.94985.8B

Wyatt, S. B., Winters, K. P., & Dubbert, P. M. (2006). Overweight and obesity: prevalence, consequences, and causes of a growing public health problem. *Am J Med Sci, 331*(4), 166-174.