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ORIGINAL RESEARCH

A Community-Engaged Stroke Preparedness Intervention in Chicago

Shyam Prabhakaran, MD, MS; Christopher T. Richards, MD, MS; Soyang Kwon, PhD; Erin Wymore, MS; Sarah Song, MD, MPH; Amy Eisenstein, PhD; Jen Brown, MPH; Namratha R. Kandula, MD, MPH; Maryann Mason, PhD; Heather Beckstrom; Knitasha V. Washington, DHA; Neelum T. Aggarwal, MD

BACKGROUND: We evaluated a community-engaged stroke preparedness intervention that aimed to increase early hospital arrival and emergency medical services (EMS) utilization among patients with stroke in the South Side of Chicago, Illinois.

METHODS AND RESULTS: We compared change in early hospital arrival (<3 hours from symptom onset) and EMS utilization before and after our intervention among patients with confirmed ischemic stroke at an intervention hospital on the South Side of Chicago with concurrent data from 6 hospitals in nonintervention communities on the North Side of Chicago and 17 hospitals in St Louis, Missouri. We assessed EMS utilization for suspected stroke secondarily, using geospatial information systems analysis of Chicago ambulance transports before and after our intervention. Among 21 497 patients with confirmed ischemic stroke across all sites, early arrival rates at the intervention hospital increased by 0.5% per month (95% CI, −0.2% to 1.2%) after intervention compared with the preintervention period but were not different from North Side Chicago hospitals (difference of −0.3% per month [95% CI, −0.12% to 0.06%]) or St Louis hospitals (difference of 0.7% per month [95% CI, −0.1% to 1.4%]). EMS utilization at the intervention hospital decreased by 0.8% per month (95% CI, −1.7% to 0.2%) but was not different from North Side Chicago hospitals (difference of 0.004% per month [95% CI, −1.1% to 1.1%]) or St Louis hospitals (difference of −0.7% per month [95% CI, −1.7% to 0.3%]). EMS utilization for suspected stroke increased in the areas surrounding the intervention hospital (odds ratio [OR], 1.4; 95% CI, 1.2–1.6) and in the South Side (OR, 1.2; 95% CI, 1.1–1.3), but not in the North Side (OR, 1.0; 95% CI, 0.9–1.1).

CONCLUSIONS: Following a community stroke preparedness intervention, early hospital arrival and EMS utilization for confirmed ischemic stroke did not increase. However, ambulance transports for suspected stroke increased in the intervention community compared with other regions.

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Key Words: acute stroke ■ education campaigns ■ emergency medical services

Early hospital arrival increases the likelihood of receiving proven acute stroke treatments.[1,2] However, delayed arrival of a patient to the hospital remains the primary reason for low rates of tissue plasminogen activator treatment.[3] An important predictor of early hospital arrival is the use of emergency medical services (EMS).[4] In the United States, less than two-thirds of patients with stroke are transported by EMS.[5]

Increasing early arrival and EMS utilization in the community remain important goals of stroke education efforts. These efforts have focused largely on improving public knowledge, using slogans such as FAST (face, arm, speech, time).[6–10] However, mass media public education campaigns have not resulted in meaningful changes in early arrival or EMS utilization after stroke.[11–13] Perceptions, attitudes, cultural and social norms, and self-efficacy, in addition to knowledge,

Correspondence to: Shyam Prabhakaran, MD, MS, 5841 S. Maryland Ave., MC 2030, S-237, Chicago, IL 60637. E-mail: shyam1@uchicago.edu

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CLINICAL PERSPECTIVE

What Is New?

- Following a community-engaged stroke preparedness intervention in the South Side of Chicago, there was no increase in early hospital arrival or emergency medical services utilization for patients with confirmed ischemic stroke.
- However, emergency medical services utilization for suspected stroke increased in a graded manner with the greatest effect size in areas of the greatest intervention penetration.

What Are the Clinical Implications?

- Our approach and findings should inform future study designs of community-engaged stroke preparedness interventions.

Nonstandard Abbreviations and Acronyms

CEERIAS	Community Engagement for Early Recognition and Immediate Action in Stroke
EMS	emergency medical services
FAST	face, arm, speech, time
GWTG	Get With The Guidelines

may determine behavioral intent and precede behaviors or actions. As a result, community-engaged and community-participatory approaches[14] have been recommended to address these decisional factors.

We applied a community-engaged approach to develop a novel face-to-face stroke preparedness intervention in the South Side of Chicago, where stroke incidence and mortality rates were high and EMS utilization was low. We hypothesized that a community-engaged and -delivered stroke preparedness intervention would increase early arrival and EMS utilization after stroke symptom onset.

METHODS

Study Overview

The CEERIAS (Community Engagement for Early Recognition and Immediate Action in Stroke) study was funded by the Patient-Centered Outcomes Research Institute (ClinicalTrials.gov identifier NCT02301299). The ethics boards at all participating hospitals granted approval. The study principal investigators had full access to all data and take responsibility for its integrity and for the data analysis. The data that support the findings of this study are available from the corresponding author on reasonable request.

Study Setting and Population

The city of Chicago has a population of 2.7 million and an area of 247 square miles. A single municipal fire-based EMS agency, the Chicago Fire Department, responds to all 9-1-1 calls. EMS system protocols require paramedics to screen patients with suspected stroke using the Cincinnati Prehospital Stroke Scale and to transport to the closest stroke center hospital. The South Side of Chicago has a population of nearly 800 000 residents and is predominantly (>93%) Black. During the study period, there were 16 stroke centers in Chicago but only 2 primary stroke centers and 1 comprehensive stroke center in the South Side.

We targeted an urban underserved setting surrounding the 2 primary stroke centers on the South Side of Chicago for the intervention, based on baseline data on stroke incidence and EMS use, field observations, and community town halls facilitated by the research team. We selected concurrent comparison hospitals in the North Side of Chicago (n=6) and St Louis, Missouri (n=17), to provide contemporaneous reference data to data from the intervention hospitals and to account for potential unintended diffusion of the intervention. We selected St Louis because it is another Midwestern city with a diverse urban population and outside the Chicago media market. We are unaware of any local, regional, and national stroke awareness campaigns that were active in the North Side of Chicago or St Louis during the study period.

Changes to Study Protocol

We excluded data from one of the South Side intervention hospitals based on data-quality assessments in 2015 that suggested data sampling and incomplete and inaccurate reporting of EMS mode of arrival into the Get With The Guidelines–Stroke (GWTG-Stroke; Quintiles Real World and Late Phase Research) database. A replacement hospital was not available because these 2 hospitals are the only primary stroke centers in the South Side of Chicago. Because suspected patients with stroke who activate EMS are transported to primary stroke centers per regional policy, non–stroke center hospitals would not have been appropriate replacement hospitals.

Stroke Preparedness Intervention

We integrated 2 pilot stroke awareness programs using focus groups and key informant interviews, as previously published,[15] to create a community-engaged stroke preparedness intervention. A central

concept of the intervention was the "Pact to Act FAST," a pledge that community members signed attesting that they would call 9-1-1 if they witnessed someone having a stroke. The other key standardized components of the intervention were as follows: (1) a rigorous training program for stroke promoters recruited from the community that included didactic material, a hospital tour, workshops, and role-playing sessions; (2) the use of educational materials (eg, cards, magnets) provided by the CEERIAS team; (3) the use of strategies and activities gleaned from the training sessions to overcome specific barriers encountered (eg, mistrust in hospitals); (4) the use of the CEERIAS website to log activities and pacts online and to discuss successes and failures with other stroke promoters; and (5) regular contact between the study team and stroke promoters for 6 months following training. We performed no specific additional education for paramedics or hospital staff beyond the routine annual training they receive regarding prehospital stroke care.

Training and Implementation

We implemented the intervention in December 2015 and monitored its reach, penetration, and adoption until November 2016. First, we identified and recruited laypeople and community members from the South Side to serve as stroke education promoters (heretofore referrred to as "stroke promoters") and to undergo training. Each 4-hour structured training session included lectures, didactic material on stroke statistics relevant to South Side communities, hospital-based tours of the "stroke patient journey," case examples, multimedia aids, role-playing activities, and storytelling of shared experiences and feelings to enhance the learning process. We then tasked each trained stroke promoter with disseminating the educational materials to his or her constituents (eg, parishioners, school-aged children, and customers) and presenting the program at least twice a month for 6 months following the training. We required stroke promoters to obtain pacts in person, with zip-code verification of the individual making the pledge, and provided training and tools for tracking the pacts and event activities on the study website. We evaluated other aspects of the intervention using the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework.[16] See Data S1 and Figures S1 through S3 for further details of intervention development and implementation.

Primary Outcomes

The 2 primary outcomes were (1) monthly early hospital arrival rate and (2) monthly EMS utilization rate among confirmed ischemic patients with stroke. We defined early hospital arrival as a confirmed ischemic stroke patient arriving at a hospital within 3 hours of symptom onset (or last known well if symptom onset time was unknown), and EMS utilization as a confirmed ischemic stroke patient arriving at the hospital emergency department by Chicago Fire Department ambulance rather than by private transport, taxi, or other form of transportation.

Secondary Outcome

The secondary outcome was the frequency of ambulance transports for paramedic-suspected strokes. We defined a suspected stroke as any EMS patient encounter with paramedic documentation in the prehospital electronic patient care record of "suspected stroke" or "rule-out stroke" or transport to a primary stroke center bypassing non–stroke centers.

Data Collection and Variables

We collected hospital data using the GWTG-Stroke registry, including demographic, clinical, and hospital outcome data.[3] All stroke center hospitals in Chicago and St Louis used this registry for data collection. With a waiver of informed consent under the common rule for data collected for quality improvement, we accessed and downloaded anonymized GWTG-Stroke records from all participating hospitals between January 1, 2013, and December 31, 2017, for review and analysis.

We included records with ischemic stroke type and arrival mode by EMS, private transport, taxi, other means of transportation, or walk-in. Records with elective or direct admission, unknown or interhospital transfer arrival mode, and stroke occurrence after admission were excluded. Hemorrhagic stroke was not included in the analyses because (1) the primary stroke center hospitals in the intervention community did not routinely collect data on this subset of patients with stroke; (2) these patients are often transferred emergently from a primary stroke center to comprehensive stroke centers; and (3) unlike ischemic stroke, no proven, specific, time-dependent intervention exists for hemorrhagic stroke. Extracted data included demographics (age, sex, race, and ethnicity), mode of hospital arrival, and times of symptom onset and hospital arrival. Race and ethnicity were categorized into 4 groups for analysis: non-Hispanic White, non-Hispanic Black, Hispanic, and Other, which included Asian, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, UTD (unable to determine), and other mixed races.

We created an early arrival variable by subtracting the symptom onset time from the hospital arrival time. When symptom onset time was unknown or missing, we used the last known well time as symptom onset

time, consistent with the convention in stroke care and research. When both symptom onset time and last known well time were unknown or missing, we treated that admission as a late arrival (>3 hours from onset).

For the secondary outcome, we obtained deidentified EMS records from the Chicago Fire Department's electronic medical-record system (SafetyPAD; ESO Solutions). EMS records included the paramedics' clinical impression, the destination hospital and reason, and the location of patient contact.

Statistical Analysis

We conducted all primary outcome analyses using SAS 9.4 (SAS Institute). First, we performed frequency analysis for the number of admissions by years and months and descriptive analysis of patient's characteristics, such as age, sex, and race and ethnicity. We conducted a seasonally adjusted interrupted time series analysis for the intervention hospital to examine the effects of the intervention on early arrival and EMS utilization rates.[17] We specified an impact model before the analysis, based on our hypothesis that the change in the outcome (eg, rate of early arrival or EMS use) would be both a gradual change in the slope over time with an abrupt change in the level after the intervention. In addition, we assumed that there would be a change in the slope before intervention and that there would be autocorrelation between consecutive observations. The early arrival and EMS utilization variables were aggregated by month (total of 60 months) to create monthly early arrival rates and monthly EMS utilization rates for time series analysis. We excluded the outcome data during the 4-month period from December 2015 to March 2016 from time series analysis because this was the implementation period over which more than half of pacts were obtained. These resulted in 35 preintervention-month points and 21 postintervention months.

To correct for autocorrelation, we used a backstep approach that initially fitted a high-order model with 12 autoregressive lags and then sequentially eliminated autoregressive parameters until all remaining autoregressive parameters had significant *t* tests. The regression models of the interrupted time series data included the following 4 terms: intercept (ie, monthly EMS utilization rate at the first month [January 2013]), time point in months (0–60 months), level change after intervention (ie, change in a monthly EMS utilization rate immediately after the intervention month), and slope change after intervention (ie, change in a monthly EMS utilization rate over time after the intervention). A maximum likelihood method was used to estimate parameters.

Because interrupted time-series analysis may not completely account for background temporal trends unrelated to the intervention, we sought to compare the primary outcomes at the South Side Chicago intervention hospitals with those from concurrent nonintervention hospitals in the North Side of Chicago and St Louis. A series of 3 interrupted time series analyses were conducted for 3 different samples: (1) the intervention hospital alone, (2) the intervention hospital and 6 North Side Chicago nonintervention hospitals, and (3) the intervention hospital and 17 St Louis nonintervention hospitals.

We did not match hospitals by demographics or other features or adjust for differences between the groups. Instead, we conducted subgroup analyses by age group (<66 versus ≥66 years), sex (male versus female), and race/ethnicity (Black versus non-Black) to examine whether the results differed by the subgroups. Because we conducted 10 statistical tests in prespecified subgroup analyses (2 outcomes by 5 subgroups [age <66 years, age ≥66 years, men, women, and Black patients]), we conservatively considered $P<0.005$ to be significant in subgroup analyses using the Bonferroni method.

Because we aggregated individual patient data on a monthly basis and the model regressed monthly early arrival rates and monthly EMS arrival rates on time in months, the sample unit of the regression model was a time point (month), not patients. Therefore, the sample size was the number of months and not the number of patients per month or the number of hospitals in the analysis. For power calculation, we assumed that the postintervention period would be at least one-third of the total months of data available from the hospitals, which we achieved with 35 months of preintervention data (January 2013–November 2015) and 21 months of postintervention data (April 2016–December 2017). The effect size was defined as the sum of the expected slope change and the expected level change over the standard deviation in monthly early hospital arrival rates or monthly EMS use rates. Assuming an autocorrelation level of 0.3, an effect size of 0.5 (which would translate to a 4% level change and a 1% change/month with a 10% SD in early arrival or EMS use) would be detectable at 90% power at a significance level of 0.05. Such an effect size would mean an absolute increase in either primary outcome by >10% over 1 year of postintervention observation, which would be considered meaningful.[18]

For the secondary outcome, we used ArcGIS and ArcGIS Pro (ESRI) for geographic information system analysis. We geolocated ambulance transport locations using addresses provided in the records for a period before the CEERIAS intervention and compared these with an equal period after the intervention. HotSpot Analysis was used to analyze all ambulance transports, regardless of incident type or paramedic impression, applying a false discovery rate correction

to account for multiple comparisons. Using Getis-Ord Gi* analysis, we identified hot spots for paramedic-suspected stroke transports. Statistical hot and cold spots were defined as areas where there is <1% likelihood that case clusters occur by chance alone. We used χ^2 tests to compare the proportion of EMS utilization for suspected stroke versus overall EMS utilization in the pre- and postintervention periods in specific geographic locations in Chicago: (1) a 3.5-mile radius around the intervention hospitals, (2) the South Side (defined as south of Interstate 290), and (3) the North Side (defined as north of Interstate 290). A standardized 3.5-mile radius was chosen to include the historic catchment areas for the hospitals and visual inspection of the maps.

RESULTS

We identified 297 potential stroke promoters; 55 (18.5%) declined to participate or did not return multiple attempts of phone contact. In total, we conducted 21 training sessions for 242 community promoters (81 Black men, 133 Black women, 4 Hispanic men, 5 Hispanic women, 3 non-Hispanic White men, and 16 non-Hispanic White women) between October 2015

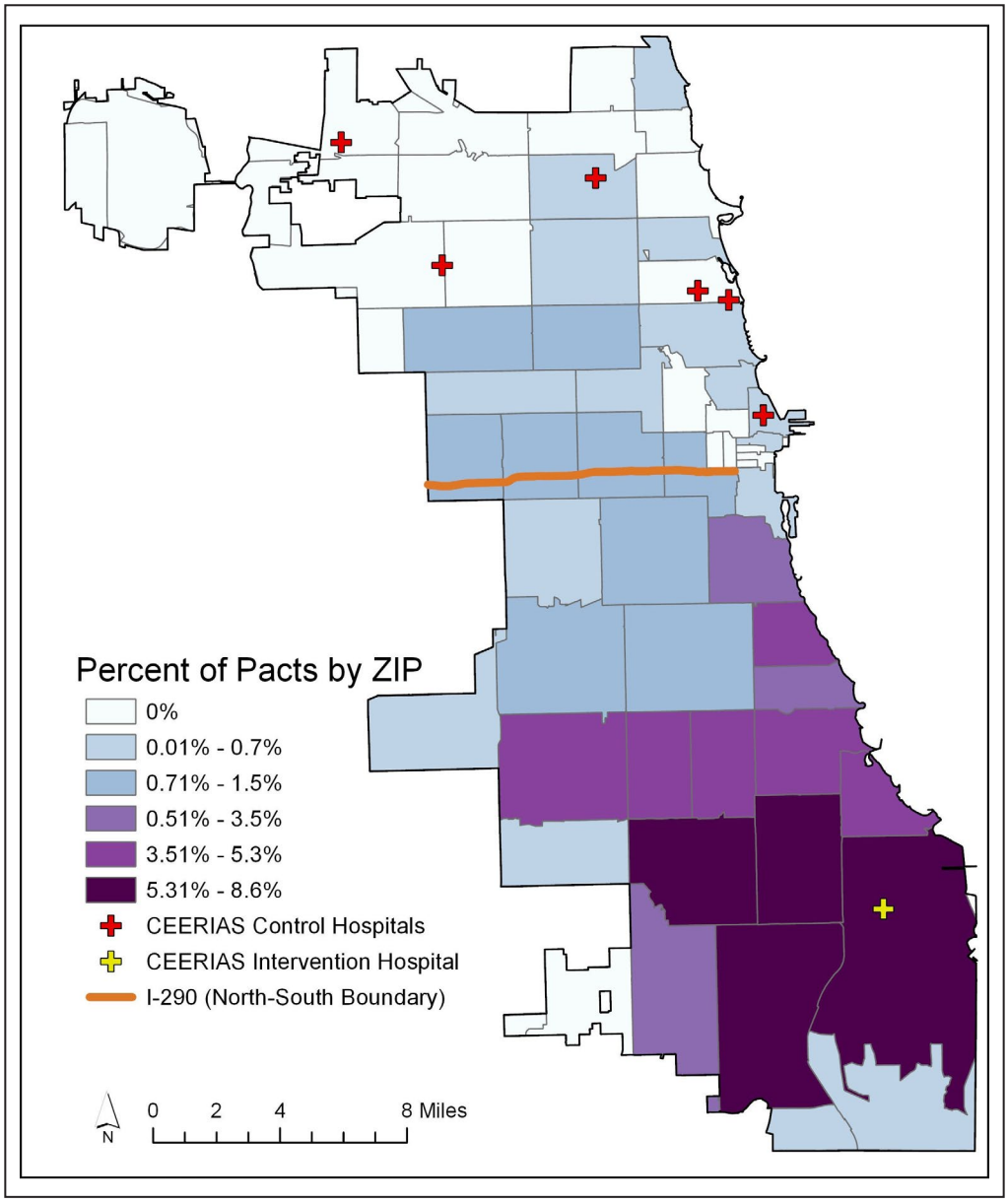

Figure 1. Pacts received by Chicago zip-code.
CEERIAS indicates Community Engagement for Early Recognition and Immediate Action in Stroke.

Table 1. Patient Characteristics at the Intervention, North Side, and St Louis Hospitals, n (%)

	Intervention Hospital (n=1)			North Side Hospitals (n=6)			St Louis Hospitals (n=17)		
	Total	Pre	Post	Total	Pre	Post	Total	Pre	Post
Total	1322 (100)	865 (100)	457 (100)	3566 (100)	1894 (100)	1672 (100)	16 609 (100)	8401 (100)	8208 (100)
Aged <66 y	550 (41.6)	355 (41.0)	195 (42.7)	1415 (39.8)	742 (39.3)	673 (40.3)	5627 (36.7)	3174 (37.8)	2453 (35.5)
Male	571 (43.2)	364 (42.1)	207 (45.3)	1868 (52.4)	997 (52.6)	871 (52.1)	7934 (47.8)	3993 (47.5)	3941 (48.0)
Hispanic	87 (6.6)	49 (5.7)	38 (8.3)	474 (13.3)	229 (12.1)	245 (14.7)	76 (0.5)	31 (0.4)	45 (0.5)
Black	1176 (89.0)	777 (89.8)	399 (87.3)	689 (19.3)	407 (21.5)	282 (16.9)	4420 (26.6)	2266 (27.0)	2154 (26.2)
White	43 (3.3)	28 (3.2)	15 (3.3)	1673 (46.9)	966 (51.0)	707 (42.3)	11 767 (70.8)	5915 (70.4)	5852 (71.3)
Other (including Asian, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, UTD, and other mixed races	16 (1.2)	11 (1.3)	5 (1.1)	729 (20.4)	292 (15.4)	437 (26.2)	346 (2.1)	189 (2.2)	157 (1.9)

UTD indicates unable to determine.

and May 2016. Of these stroke promoters, 87 (40.0%) were self-employed, 63 (26.0%) were from faith-based organizations, 28 (11.6%) were from healthcare organizations, 24 (9.9%) were from schools, and 40 (16.5%) were from other community advocacy groups and local businesses. Stroke promoters distributed >110 000 educational materials including FAST cards and magnets and participated in at least 167 large-scale community events. A total of 39 795 Pact to Act FAST pledges were registered between December 2015 and November 2016; of those, 80.3% were registered at South Side zip-codes (Figure 1). The intervention's penetration in the excluded intervention hospital's geographic service area was lower than the penetration for the included intervention hospital (an estimated 4.3% penetration of 140 855 households versus 19.4% penetration of 58 427 households using 2010 census data).

Primary Outcomes

We analyzed 21 497 patients with confirmed ischemic stroke across all sites (Table 1). Compared with the nonintervention hospitals, patients at the intervention hospital were more likely to be women, Black, and slightly younger. Monthly stroke admissions and patient characteristics were stable between pre- and postintervention periods, except that the proportions of Black and White patients at North Side hospitals declined from the pre- to postintervention period.

For early arrival rates and EMS utilization rates for confirmed ischemic stroke (Table 2), we observed no level or slope change in early arrival at the intervention hospital. Slope change did not differ between the intervention hospital and the North Side hospitals or St Louis hospitals for either primary outcome. Subgroup analyses by age group (<66 versus ≥66 years), sex

Table 2. Interrupted Time Series Regression Model for the Primary Outcomes at the Intervention South Side Chicago Hospital and Comparison to North Side Chicago Hospitals and St Louis Hospitals

	Intervention Hospital		Comparison With North Side Chicago Hospitals		Comparison With St Louis Hospitals	
	β	95% CI	β	95% CI	β	95% CI
Early arrival (<3 h from symptom onset)						
Intercept	0.287	0.227, 0.348	−0.152	−0.231, −0.072	0.032	−0.030, 0.094
Time	−0.002	−0.005, 0.001	0.005	−0.001, 0.009	−0.003	−0.006, 0.0001
Level change	−0.001	−0.106, 0.103	−0.043	−0.181, 0.094	0.035	−0.072, 0.142
Slope change	0.005	−0.002, 0.012	−0.003	−0.012, 0.006	0.007	−0.001, 0.014
EMS arrival						
Intercept	0.587	0.513, 0.661	0.028	−0.055, 0.111	0.013	−0.062, 0.088
Time	−0.001	−0.004, 0.004	0.003	−0.001, 0.007	−0.0002	−0.004, 0.004
Level change	0.056	−0.100, 0.211	−0.092	−0.267, 0.083	0.043	−0.116, 0.202
Slope change	−0.008	−0.017, 0.002	<0.001	−0.011, 0.011	−0.007	−0.017, 0.003

A level change is an abrupt change right after intervention implementation. A slope change is the change per month over time after intervention implementation. EMS indicates emergency medical services.

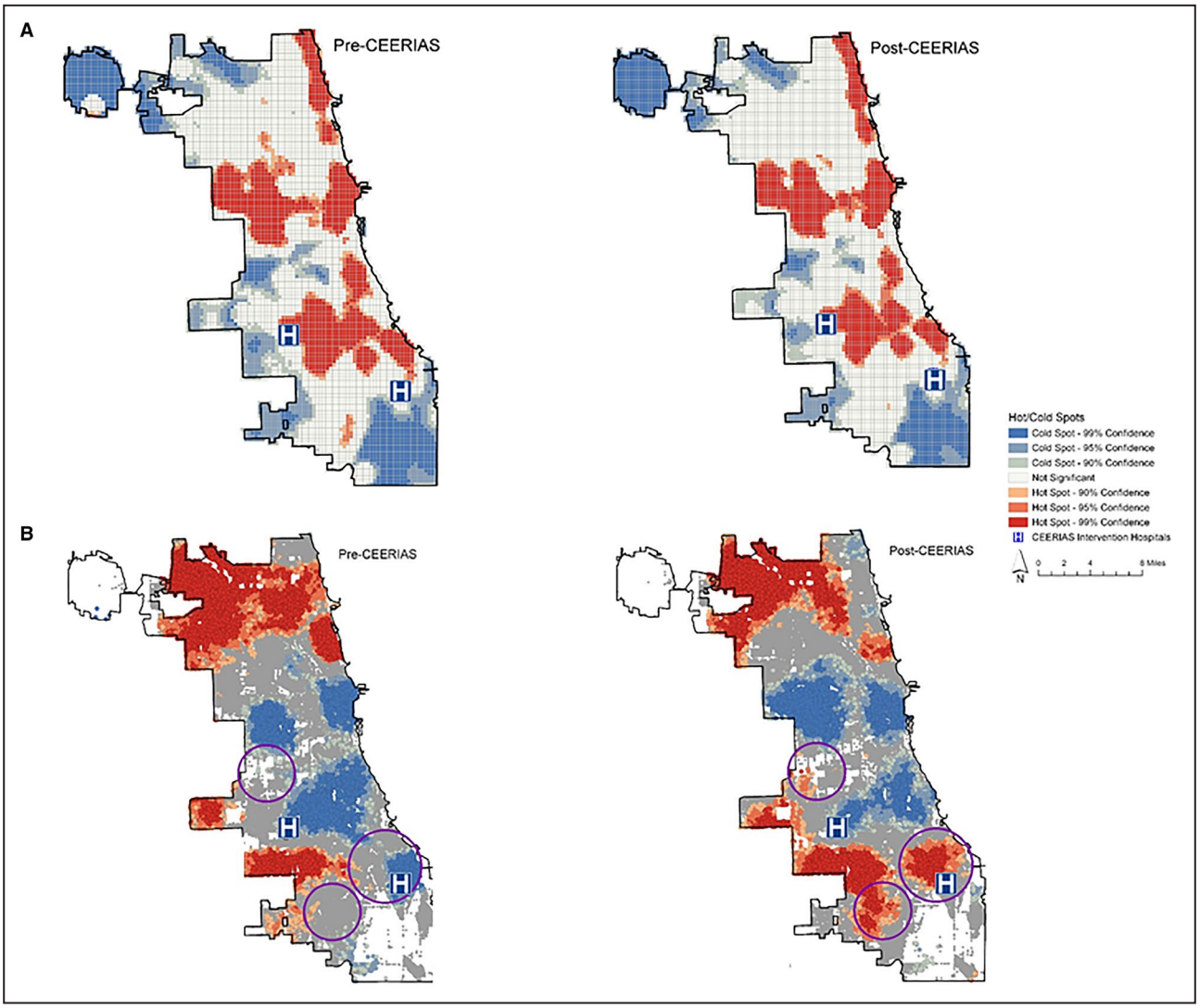

Figure 2. Geographic information system analysis of effect of intervention on secondary outcomes in Chicago before and after intervention; statistical hot and cold spots are defined as areas where there is <1% likelihood that case clusters occur by chance alone.
A, Overall EMS utilization; **B**, EMS utilization for suspected stroke (purple circles indicate geocoded regions where cold spots became hot spots after the intervention). CEERIAS indicates Community Engagement for Early Recognition and Immediate Action in Stroke.

(male versus female), and race and ethnicity (Black versus non-Black) showed that the slope for early arrival increased after the intervention for patients who were <66 years old (increase of 0.8% per month [95% CI, 0.06%–1.6%]; *P*=0.036), among men (increase of 1.2% per month [95% CI, 0.1%–2.3%]; *P*=0.026), and among Black patients (increase of 0.9% per month [95% CI, 0.05%–1.7%]; *P*=0.037). However, none reached

Table 3. EMS Utilization for Suspected Stroke in Specific Regions of Chicago Before and After Intervention

	Preintervention, Suspected Stroke/Total EMS Calls, n (%)	Postintervention, Suspected Stroke/Total EMS Calls, n (%)	OR (95% CI)	*P* Value
Area centered around included intervention hospital (3.5-mile circular radius)	440/48 150 (0.91)	603/47 714 (1.26)	1.4 (1.2–1.6)	<0.001
Area centered around excluded intervention hospital (3.5-mile circular radius)	684/69 949 (0.98)	846/69 547 (1.22)	1.2 (1.1–1.4)	<0.001
South Side (south of interstate 290)	2342/260 388 (0.90)	2897/267 479 (1.08)	1.2 (1.1–1.3)	<0.001
North Side (north of interstate 290)	1904/158 408 (1.20)	1978/162 947 (1.21)	1.0 (0.9–1.1)	0.757

EMS indicates emergency medical services; and OR, odds ratio.

statistical significance using the Bonferroni correction method.

Secondary Outcome

We successfully geolocated 418 796 (98%) EMS transports in a 20-month period before the CEERIAS intervention (April 2014–November 2015) and 430 426 (97%) in a 20-month period after the CEERIAS intervention (April 2016–November 2017). The distributions of overall EMS utilization were unchanged citywide and in the areas adjacent to the intervention hospitals (Figure 2A). However, the frequency of ambulance transports for suspected strokes changed from a cold spot to a hot spot relative to other Chicago areas in 3 geographic areas near the intervention hospitals (Figure 2B). EMS utilization for suspected stroke increased (Table 3) in the areas surrounding the intervention hospital (odds ratio [OR], 1.4; 95% CI, 1.2–1.6) and in the South Side (OR, 1.2; 95% CI, 1.1–1.3) but not in the North Side (OR, 1.0; 95% CI, 0.9–1.1).

DISCUSSION

Implementation of a community-based stroke preparedness intervention in the South Side of Chicago did not increase early arrival or EMS utilization for confirmed ischemic stroke at the hospital level. However, EMS utilization for suspected strokes increased in the areas of greatest intervention penetration and in the South Side overall, suggesting a potential intervention effect. These conflicting findings may be due to an overrepresentation of false-positive strokes (eg, EMS-suspected stroke but final hospital diagnosis was not stroke), transient ischemic attacks, or hemorrhagic strokes that were not included in the primary outcome measures.

A recent systematic review of stroke preparedness interventions found that 10 of 13 studies decreased prehospital delay, but only 1 study was a prospective cluster randomized clinical trial.[13] This trial showed a reduction in prehospital delay in Berlin, Germany, among women but not men.[19] Although some observational studies have noted an effect of stroke preparedness interventions on arrival time or tissue plasminogen activator utilization for stroke,[6,20,21] these have included both public and professional (eg, physicians, nurses, and paramedics) education, limiting causal inference. Others have introduced community-engaged approaches including youth-based programs such as the hip-hop stroke program in Harlem, New York, although they have not yet evaluated the effects on behavioral outcomes (eg, calling 9-1-1).[22–26]

Our study may be informative for future stroke preparedness interventions. First, using a community-engaged approach enabled us to develop potential solutions to address culturally bound barriers and perceptions and to deliver messaging using trained nonmedical stroke promoters from the intervention community. Unlike most prior interventions, CEERIAS focused on key decisional factors (eg, perceptions about stroke severity, mistrust, or the costs and benefits of calling 9-1-1) in addition to knowledge of stroke symptoms. Second, we applied behavioral change theories to develop solutions that were the most acceptable in the community in the forms of a "social contract" approach (pacts) and a culturally representative stroke promoter training program as part of the community-partnered intervention. Third, we used geographic information system analysis of EMS utilization for suspected strokes, a potential primary outcome in future stroke preparedness intervention trials because it captures the intended behavior at the community level without the limitations imposed by data collection and analysis of confirmed strokes at the hospital level.

Our study had several limitations. Although we achieved nearly 20% penetration of our intervention in targeted neighborhoods, successful interventions may require even higher community penetration than we achieved to observe significant behavioral changes.[27] Although our results are likely generalizable to other urban settings with high proportions of Black residents or people at a socioeconomic disadvantage,[28,29] comparison and translation to other populations, including Hispanic communities, is uncertain. Cities without established community networks may also find reproducing our intervention challenging. As with other community-engaged stroke preparedness programs, the significant effort required to conduct training sessions and face-to-face workshops and to monitor events may limit sustainability and broad dissemination.[24,30,31] Detailed assessment of every promoter activity, especially informal and small-group sessions, was not feasible and, therefore, not done; this limited our ability to completely verify the fidelity of the intervention's adoption. Furthermore, although the complex and nonstandardized nature of our intervention had the advantage of being pragmatic in its approach, it may limit generalizability, replication, and application elsewhere.

Because we did not match hospitals, imbalances in baseline characteristics between comparison groups may have also affected our results. A cluster randomized trial would be an ideal design to account for hospital- and region-level imbalances and confounding but was beyond the scope of this project. The loss of the planned second intervention hospital could have increased the random sampling variability and thus reduced statistical power. However, because our unit of analysis was months, not patients, and because we had sufficient data from the other intervention hospital,

excluding one of 2 planned intervention hospitals had a minimal impact on power. Nevertheless, patients in the service area of the included intervention hospital may have been transported to or arrived at the excluded hospital, biasing our results toward the null. It is also possible that the excluded hospital found no effect or an opposite effect on early arrival from the included hospital. We also did not collect hospital data beyond 1 year after intervention; therefore, long-term effects of our intervention cannot be assessed. Last, although we trained stroke promoters on addressing the cost of EMS care, which is also disproportionately levied on minority communities, patients may have been disincentivized to call 9-1-1 for suspected stroke because of financial concerns.

In summary, we did not observe a significant effect of a community-engaged stroke preparedness intervention on early arrival or EMS use for confirmed ischemic stroke in the South Side of Chicago. In secondary geographic information system analyses of EMS data, the observed increase in EMS use for suspected stroke in areas with the greatest message penetration with no discernable (unintended) effect on EMS use for other medical conditions suggests a possible intervention benefit. Our approach and findings should inform future study designs of community-engaged stroke preparedness interventions.

ARTICLE INFORMATION

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Affiliations

From the Department of Neurology, University of Chicago, IL (S.P.); University of Cincinnati, College of Medicine, Cincinnati, OH (C.T.R.); Northwestern University, Feinberg School of Medicine, Chicago, IL (S.K., E.W., J.B., N.R.K., M.M.); Lurie Children's Hospital of Chicago (S.K., M.M.); Rush University Medical Center, Chicago, IL (S.S.); The Retirement Research Foundation, Chicago, IL (A.E., N.T.A.); MetroSouth Hospital, Blue Island, IL (H.B.); Governor's State University, University Park, IL (K.V.W.); and Rush Alzheimer's Disease Center, Chicago, IL (N.T.A.).

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Disclosures

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Supplementary Materials

Data S1
Figures S1–S3

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SUPPLEMENTAL MATERIAL

Data S1.

Supplemental Methods

Intervention Development

We developed and adapted our community stroke preparedness intervention based on the theory of planned behavior,[8] Bandura's theoretical self-efficacy model as a framework to promote decision-making capacity in stroke bystanders, and Kolb's experiential learning theory as the framework that guided the interactive stroke promoter training program.[28,29] We thereby combined 2 prototypes we had previously developed into a prototype intervention for CEERIAS: (1) the PSC Mini-Internship Program (MIP), which was piloted at five Chicago PSCs in 2011–2012, and (2) the Pact to Act FAST program, which was developed in 2011 for rural Illinois communities.

The MIP used a hands-on experiential training approach including hospital emergency room tours and direct interactions with patients and health care professionals, we educated and trained community stroke promoters on the barriers to and benefits of early action after stroke symptom onset. This program not only emphasized the benefits of calling 9-1-1 but also visually demonstrated the resources and treatments available at the PSC. At the conclusion of the MIP program, participants received stroke information packet of educational materials, services, and community events. The Pact to Act FAST program sought to increase self-efficacy in two ways: (1) by developing an action plan before witnessing a stroke and (2) by developing a social contract ("Pact") that required a pledge or pact from individuals in a community to act on the behalf of loved ones, neighbors, and coworkers if they witness a possible stroke. This program developed materials for schools, churches, and community events, which we included in the final prototype of the CEERIAS intervention.

Stroke Promoter Recruitment, Selection, and Retention

We identified and recruited lay persons and trusted community members to serve as "stroke promoters." The CEERIAS study maintained a broad range of community partnerships with large multi-ethnic outreach potential and drew upon five core community groups: (1) faith-based organizations, (2) hospitals and clinics, (3) public and private schools, (4) local businesses, and (5) advocacy groups. These groups were present in all targeted areas of the intervention and had prior experience in community health initiatives. Stroke promoters were identified by partner community organizations, the Community Principal Investigator, subsequent stroke promoter referrals, and interested participants who contacted research team members at community events. Stroke promoters were required to be adults older than 18 years who had strong connections in the target areas of Chicago's South Side based on the review of their roles, prior activities, and organizational contacts. Based on interest and community outreach potential, the research team and CAB members selected final candidates for training. We recruited stroke promoters concurrently in a total of 21 sessions for training and remunerated them for their time ($732 total per promoter). We explicitly asked stroke promoters to incorporate stroke preparedness discussions in their regularly planned community activities over a period 6 months from the date of their training.

Promoter Training

We trained the recruited stroke promoters on the adapted MIP-Pact program and provided them tools to be used for tracking activity in the community, event planning, and logging of obtained Pacts (Figure S1). We held the MIP-Pact training program at the 2 intervention hospitals; each session lasted approximately 4 hours and was facilitated by study team members and the local stroke coordinator. We provided stroke promoters with (1) training regarding the benefits of early recognition and EMS use for stroke (e.g., stroke centers, tPA), (2) culturally-adapted solutions to current barriers (e.g., misperceptions about vulnerability, severity, mistrust, costs), and (3) cues to aid in stroke recognition and immediate action. Stroke promoters engaged in interactive discussions with community leaders and health care professionals regarding strategies to enhance patient and bystander self-efficacy and increase public knowledge about stroke warning signs, treatments, and expected outcomes.

The training program included lectures, a mix of didactic material on stroke statistics relevant to South Side communities, hospital-based tours of the "stroke patient journey," case examples, multi-media aids, role playing activities, and storytelling of shared experiences and feelings to enhance the learning process. We distributed training manuals and presented slides on stroke demographics, disparities, and local data from the hospitals on EMS use, arrival times, treatment rates, and outcomes. Following the didactic portion, we conducted the hospital-based tours at the 2 planned intervention hospitals on Chicago's South Side with assistance from the local stroke program coordinator to minimize disruption in the clinical setting. We encouraged stroke promoters to ask questions throughout the training regarding patient throughput, physician-patient discussions on risks and benefits of administering tPA, and required tests in the emergency department. Following the tour, we discussed barriers to early arrival and EMS use and solicited and provided solutions using role-playing and small group workshops. The groups also discussed approaches incorporating their experiences and techniques learned during the training for use in their interactions with their constituents in the home, school, and workplace. At the completion of training, we provided every stroke promoter website login and instructions, and distribution materials including magnets, bookmarks, Pact to Act FAST cards, and suggested community educational activities (Figure S2).

Intervention Implementation

We tasked each trained stroke promoter with disseminating the educational materials to their constituents (e.g., parishioners, school-aged children, and customers) over a 6-month period. We asked them to present the program at least twice monthly for 6 months as part of their interactions in the community and document activities using the CEERIAS website (www.ceerias.com). We required stroke promoters to obtain Pacts in person, with ZIP code verification of the individual making the pledge, and log the Pacts into website. We defined the number of Pacts collected as the objective measure of total individuals whose behavioral intent to call 9-1-1 for stroke could be verified. If Pacts were collected on paper, we required these be either later entered online or faxed to our central coordinating office at Northwestern University for manual entry on the website.

Concurrent comparison settings performed stroke education activities in a non-prescribed way and provided, therefore, contemporaneous comparisons to the intervention community. These approaches included ongoing community education led by regional hospitals and their staff members in the form of health fairs, distribution of materials to patients and families in the

hospitals and clinics, and local news media interviews and stories about stroke occurred at both intervention and non-intervention settings. None of the North Side Chicago and St. Louis comparison hospitals or their regional partners participated in a stroke promoter training or similar community health worker programs to improve stroke recognition and early EMS activation after stroke onset.

Monitoring and Evaluating Intervention Implementation

We evaluated the intervention using the RE-AIM framework. We assessed reach based on the collected number of Pacts as the objective measure of total individuals whose behavioral intent to call 911 for a stroke could be verified. We used hospital and prehospital data to evaluate the effectiveness of the intervention in an interrupted time-series design. We assessed adoption by trained stroke promoters though surveys and direct contact by our Community Navigator and Community Principal Investigator. We assessed the fidelity of implementation in the community setting through weekly webinars and phone conferences with stroke promoters and attendance at stroke promoter events. We facilitated maintenance through regular contact by Community Navigator and Principal Investigator with stroke promoters during the 6-month post-training period.

In partnership with EdgeOne Medical (Chicago, Illinois), we created online forms using the ceerias.com website for stroke promoters to log their activities, document Pacts recorded, and communicate with fellow stroke promoters using chat rooms and forums. Figure S3 shows representative online calendars, forms, and chat forums. EdgeOne Medical staff pilot tested the website's functionality among five stroke promoters from the first training session, deployed it to subsequent stroke promoters, and maintained the website throughout the study period.

Immediately following the training, stroke promoters completed surveys on the content, speakers, hospital-based tour, and distribution materials. In addition, the Community Principal Investigator and Community Navigator contacted each stroke promoter to monitor activity, reinforce performance goals, provide post-training advice on high-yield activities and events, give successful tips and strategies for overcoming resistance, and continue follow-up on a regular basis to ensure ongoing community engagement and intervention implementation. In addition to forums created on the website to generate conversations among stroke promoters, we held webinars and phone conferences with stroke promoters to evaluate adoption of the tools and strategies discussed in training. Members of the research team attended some stroke promoter events to ensure that high-fidelity adoption of the intended intervention was taking place. For example, we assessed whether stroke promoters were utilizing materials as instructed, engaging in face-to-face discussions with a goal of overcoming resistance and barriers, and obtaining Pacts from attendees. We also boosted and maintained the intervention through ongoing presentations by research team members at community fairs and events, local radio interviews, and community newsletters in the South Side of Chicago. Other than tallying the number of Pacts signed, we did not systematically track the delivery of stroke prevention/treatment knowledge in the target community.

Intervention Monitoring and Maintenance

Post-training, we conducted 1 webinar to demonstrate the use of the website and 12 conference calls for stroke promoters to provide feedback, describe successes, and discuss ongoing

community challenges post-training. We assessed promoters' experiences including successes and challenges in their outreach activities; interventions conducted at health fairs and church events were the most positively received and had the highest number of attendees.

Using Google Analytics from the ceerias.com website, we observed a total of 6,256 login sessions onto the website by stroke promoters, of which more than 1,710 sessions were on activity logging, calendar, and chat forum pages. Stroke promoters distributed more than 110,000 educational materials including FAST cards and magnets and participated in at least 167 large-scale community events. To boost the intervention, CEERIAS team members participated in three Chicago local radio interviews during the implementation phase, describing the study purpose and answering public questions related to stroke. In addition, the CEERIAS team distributed 18 newsletters to members of partner organizations for wider distribution.

Figure S1. Intervention development and implementation from pilot projects (orange), the adapted MIP-Pact program and training of stroke promoters (red), and promoter activities (blue)

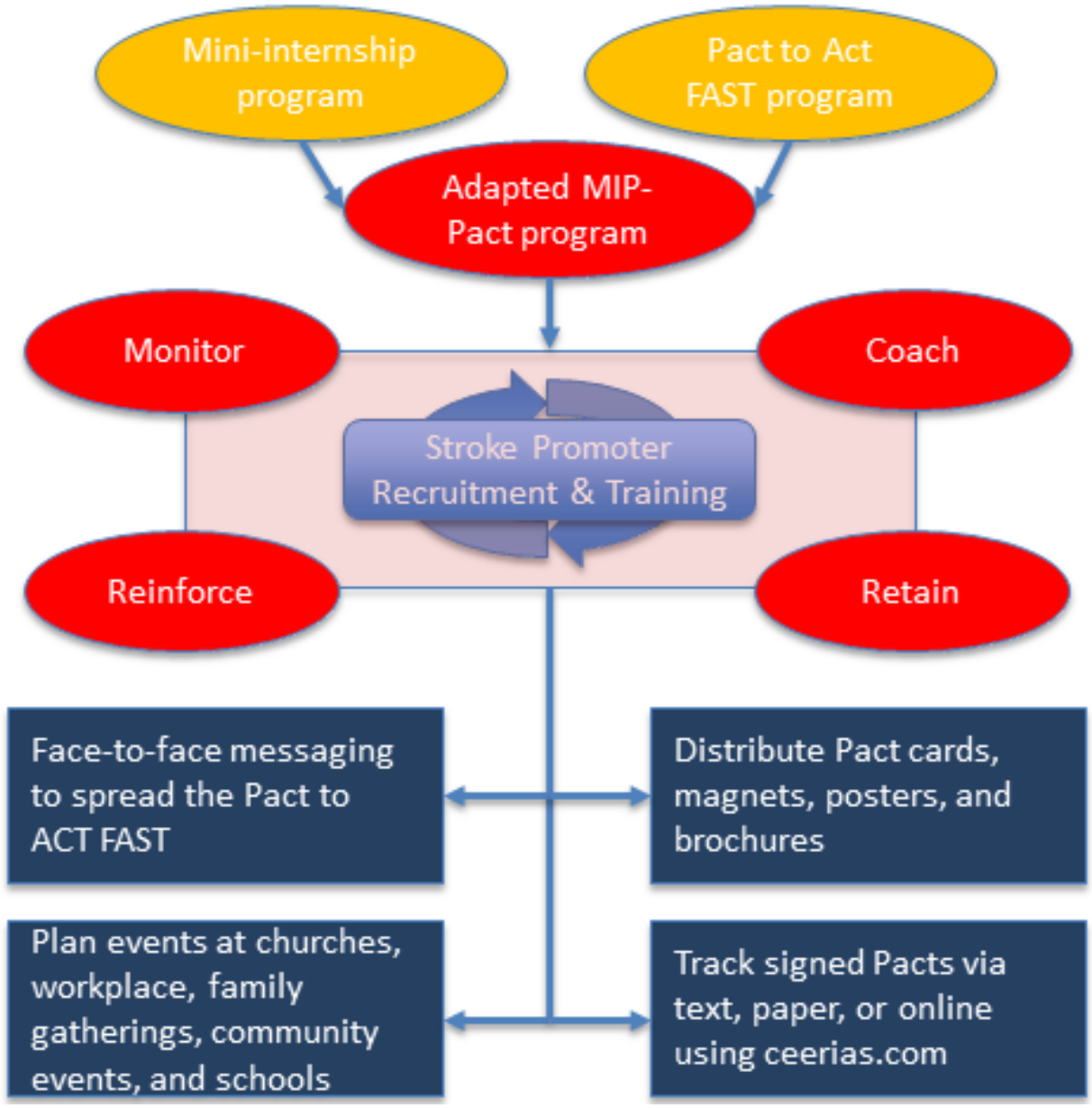
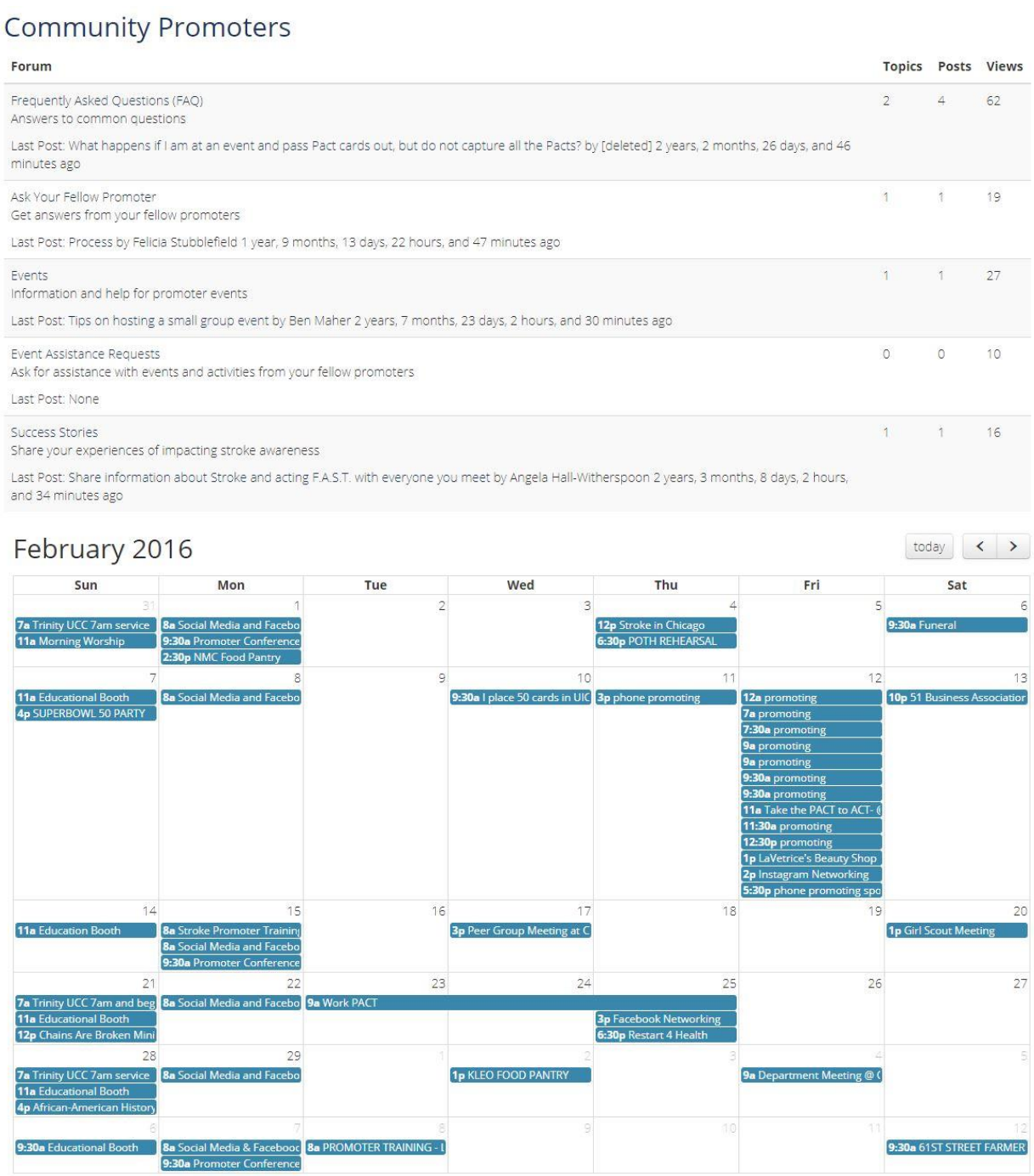


Figure S2. Examples of FAST pledge cards and magnets used by CEERIAS promoters.

Plan with your family:

Agree today to call 911 when stroke signs occur even if the patient objects at the time: Make a Pact to Act FAST

Figure S3. Examples of online tools used by CEERIAS promoters.



Community Promoters

Forum	Topics	Posts	Views
Frequently Asked Questions (FAQ) Answers to common questions Last Post: What happens if I am at an event and pass Pact cards out, but do not capture all the Pacts? by [deleted] 2 years, 2 months, 26 days, and 46 minutes ago	2	4	62
Ask Your Fellow Promoter Get answers from your fellow promoters Last Post: Process by Felicia Stubblefield 1 year, 9 months, 13 days, 22 hours, and 47 minutes ago	1	1	19
Events Information and help for promoter events Last Post: Tips on hosting a small group event by Ben Maher 2 years, 7 months, 23 days, 2 hours, and 30 minutes ago	1	1	27
Event Assistance Requests Ask for assistance with events and activities from your fellow promoters Last Post: None	0	0	10
Success Stories Share your experiences of impacting stroke awareness Last Post: Share information about Stroke and acting F.A.S.T. with everyone you meet by Angela Hall-Witherspoon 2 years, 3 months, 8 days, 2 hours, and 34 minutes ago	1	1	16

February 2016

today

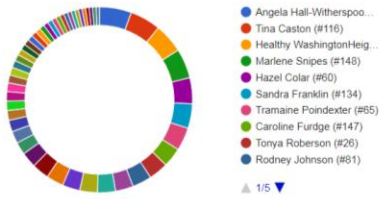
Sun	Mon	Tue	Wed	Thu	Fri	Sat
31 7a Trinity UCC 7am service 11a Morning Worship	1 8a Social Media and Facebo 9:30a Promoter Conference 2:30p NMC Food Pantry	2	3	4 12p Stroke in Chicago 6:30p POTH REHEARSAL	5	6 9:30a Funeral
7 11a Educational Booth 4p SUPERBOWL 50 PARTY	8 8a Social Media and Facebo	9	10 9:30a I place 50 cards in UIC	11 3p phone promoting	12 12a promoting 7a promoting 7:30a promoting 9a promoting 9a promoting 9:30a promoting 9:30a promoting 11a Take the PACT to ACT- (11:30a promoting 12:30p promoting 1p LaVetrice's Beauty Shop 2p Instagram Networking 5:30p phone promoting spo	13 10p 51 Business Association
14 11a Education Booth	15 8a Stroke Promoter Training 8a Social Media and Facebo 9:30a Promoter Conference	16	17 3p Peer Group Meeting at C	18	19	20 1p Girl Scout Meeting
21 7a Trinity UCC 7am and beg 11a Educational Booth 12p Chains Are Broken Mini	22 8a Social Media and Facebo	23 9a Work PACT	24	25 3p Facebook Networking 6:30p Restart 4 Health	26	27
28 7a Trinity UCC 7am service 11a Educational Booth 4p African-American History	29 8a Social Media and Facebo	1	2 1p KLEO FOOD PANTRY	3	4 9a Department Meeting @ (	5
6 9:30a Educational Booth	7 8a Social Media & Faceboo 9:30a Promoter Conference	8 8a PROMOTER TRAINING - I	9	10	11	12 9:30a 61ST STREET FARMER

CEERIAS analytics on

Dashboard | Leaderboard | Forums | Make an Impact | About | Shyam Prabhakaran

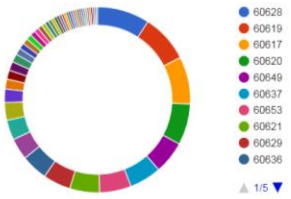
Pact to Act FAST Results

Leaderboard



Rank	Name	Pacts	% of Pacts
	Total	**39795**	**100%**
1	Angela Hall-Witherspoon (#142)	1845	4.6%
2	Tina Caston (#116)	1770	4.4%
3	Healthy WashingtonHeights (#80)	1706	4.3%
4	Marlene Snipes (#148)	1701	4.3%
5	Hazel Colar (#60)	1500	3.8%

Pacts to Act FAST by Zip Code



Rank	Zip Code	Pacts	% of Pacts
	Total	**39795**	**100%**
1	60628	3286	8.3%
2	60619	3012	7.6%
3	60617	2974	7.5%
4	60620	2575	6.5%
5	60649	2038	5.1%

CEERIAS analytics on

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Sign the Pact to Act FAST

I agree to Act Fast when I see someone with the sudden signs of stroke.

As a bystander, I will call 911 immediately even if the stroke victim objects because I know

***Time* lost is *Brain* lost.**

* Zip code (required)

This pact will be registered to the following Community Promoter:

Shyam Prabhakaran

Promoter number: 750