**Comparison of Acute Stroke Preparedness Strategies to Decrease Emergency Department Arrival Time in a Multiethnic Cohort**

The Stroke Warning Information and Faster Treatment Study

Bernadette Boden-Albala, DrPH; Joshua Stillman, MD; Eric T. Roberts, MPH; Leigh W. Quarles, MPH; M. Maria Glymour, ScD; Ji Chong, MD; Harmon Moats, MPH; Veronica Torrico, MA; Michael C. Parides, PhD

**Background and Purpose**—Less than 25% of stroke patients arrive to an emergency department within the 3-hour treatment window. Stroke Warning Information and Faster Treatment (SWIFT) compared an interactive intervention (II) with enhanced educational (EE) materials on recurrent stroke arrival times in a prospective cohort of multiethnic stroke/transient ischemic attack survivors.

**Methods**—A single-center randomized controlled trial (2005–2011) randomized participants to EE (bilingual stroke preparedness materials) or II (EE plus in-hospital sessions). We assessed differences by randomization in the proportion arriving to emergency department <3 hours, prepost intervention arrival <3 hours, incidence rate ratio for total events, and stroke knowledge and preparedness capacity.

**Results**—SWIFT randomized 1193 participants (592 EE, 601 II): mean age 63 years; 50% female, 17% black, 51% Hispanic, 26% white. At baseline, 28% arrived to emergency department <3 hours. Over 5 years, first recurrent stroke (n=133), transient ischemic attacks (n=54), or stroke mimics (n=37) were documented in 224 participants. Incidence rate ratio=1.31 (95% confidence interval=1.05–1.63; II to EE). Among II, 40% arrived <3 hours versus 46% EE (P=0.33).

In prepost analysis, there was a 49% increase in the proportion arriving <3 hours (P=0.001), greatest among Hispanics (63%, P<0.003). II had greater stroke knowledge at 1 month (odds ratio=1.63; 1.23–2.15). II had higher preparedness capacity at 1 month (odds ratio=3.36; 1.86, 6.10) and 12 months (odds ratio=7.64; 2.49, 23.49).

**Conclusions**—There was no difference in arrival <3 hours overall between II and EE; the proportion arriving <3 hours increased in both groups and in race-ethnic minorities.

**Clinical Trial Registration**—URL: http://www.clinicaltrials.gov. Unique identifier: NCT00415389.

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**Key Words:** acute stroke ■ health literacy ■ patient-centered outcomes research ■ patient education ■ preparedness

**Stroke** is a public health problem in the United States and globally. Although prevention of stroke is the ultimate goal, prevention strategies remain suboptimal. Emphasis on early stroke treatment remains an important opportunity to reduce stroke morbidity and mortality. Less than 25% of eligible stroke patients arrive to an emergency department (ED) within the 3-hour treatment window, indicating lay communities are not prepared to take action during an acute stroke. Reasons for poor stroke preparedness include inadequate lay knowledge and limited preparedness competency to respond to stroke as an emergency and recognize symptoms. To date, no study has demonstrated that stroke preparedness interventions lead to a greater proportion of acute stroke arrivals to the ED under 3 hours. Finally, it is unclear what modality (eg, culturally appropriate materials, interactive platform, reinforcement) is optimal for dissemination of stroke preparedness information.
The Stroke Warning Information and Faster Treatment (SWIFT) compares the effect of an interactive intervention (II) with enhanced educational (EE) materials on recurrent stroke arrival times in a multiethnic prospective cohort of mild/moderate stroke and transient ischemic attacks (TIA) survivors. As a secondary aim, we tested whether the incidence of identified stroke events was higher among patients randomized to II versus EE because increased preparedness may increase the chances that patients identify symptoms and seek care.

Methods

Study Population
SWIFT prospectively enrolled patients at Columbia University Medical Center (CUMC) with an initial diagnosis of ischemic stroke or TIA. Eligibility for SWIFT included ischemic stroke or TIA diagnosis, over 18 years of age, and living in a household with a telephone. Patients were excluded if they were unable to give informed consent; discharged to long-term nursing care; had severe aphasia limiting comprehension; had a prestoke dementia history, or end-stage disease resulting in probable mortality ≤1 year. Subjects were either an English or Spanish speaker; further details are published elsewhere.

Study Protocol and Design
SWIFT was approved by CUMC Institutional Review Board and written informed consent obtained. Eligible patients were randomized into either II or EE. An 8-cell randomization scheme with stratification by language (English versus Spanish) was used.

Interactive Group Intervention
Grounded in social cognitive theory, SWIFT included community input on the development of culturally tailored intervention materials. The II group included in-hospital interactive group sessions consisting of a community placed preparedness PowerPoint presentation; a stroke survivor preparedness narrative video; and the use of role-playing techniques to describe stroke symptoms (eg, interacting with ED staff). Details of the intervention are described elsewhere. Both II and EE groups received a standardized packet of preparedness-focused education materials and received a medical alert bracelet, identifying them to medical professionals as a SWIFT participant.

Baseline Survey Data
We administered questionnaires on vascular risk, medical/family history, demographics, and psychosocial factors. The stroke knowledge (SK) survey was verbally administered at baseline, 1 and 12 months, and scored from 0 to 29. SK consists of 3 sections: multiple choice questions on symptoms, risk factors, and acute stroke treatment; hypothetical scenarios on action during an acute stroke; and end-stage disease resulting in probable mortality ≤1 year. Subjects were either an English or Spanish speaker; further details are published elsewhere.

Follow-Up and Ascertainment of Outcome Events
Participants were followed at 1 and 12 months post stroke/TIA and annually for outcome events. Participants received the same amount and type of educational reinforcement at follow-up. Research assistants blinded to intervention status responded to any remaining participant questions following SK assessment and reported that most participants asked for correct answers to the SK survey.

At follow-up, participants (or family members) were asked to report hospitalizations since last contact to capture outcomes, and participants were administered a stroke screening instrument. We conducted an in-service with clinical staff at local hospitals serving notifying them of the 24-hour hotline. Additionally, CUMC’s daily hospital-based stroke surveillance system identified SWIFT outcome events. We have confidence in this surveillance methodology; over 80% of the community used CUMC for all care.

We conducted a full chart review on all possible events to verify outcomes and document acute stroke data, including date, time, type, symptoms of recurrent event, date/time to ED. Participants and family members, when applicable, were asked to report on the time symptoms began or the time last known well. When timing was difficult to establish, we used a sequence of questions to determine time of symptom onset, described previously. Stroke mimics were defined as presentation to ED with the presence of stroke symptoms where a neurovascular pathogenesis was not found and a final diagnosis other than stroke/TIA was given. We captured stroke mimics because the behaviors associated with time of arrival to the ED on experiencing stroke (or stroke-like) symptoms are the same. We collected a range of events to capture stroke mimics, including migraine, seizure, and vertigo. All stroke/TIA and stroke mimic events were adjudicated by a team of stroke neurologists.

Dependent Measures
SWIFT primary outcomes include a comparison of the proportion of patients arriving to the ED within 3 hours of a recurrent event (stroke, TIA, stroke mimic) in II versus EE; a comparison of prepost intervention differences in baseline and recurrent stroke arrival times; a comparison of SK and PC at 1 and 12 months; and incidence rate ratio (IRR) for recurrent events overall and by race-ethnicity. The outcome measure was defined as the time from symptom onset to triage in the ED. We also assessed arrival times at 2 hours and 4.5 hours.

Statistical Analysis
Chi square and analysis of variance statistics were used, as applicable, to describe the distribution of demographics, vascular risk factors, socioeconomic status, social support, and baseline stroke characteristics of the SWIFT sample by randomization. Differences in the proportion of participants experiencing stroke/TIA/mimic by intervention group were assessed using the χ² test. The primary analysis invokes the intent-to-treat principle. Only the first recurrent event was considered, and the proportion of participants by intervention status that arrived to the ED within 3 hours was assessed. In-hospital events were assessed as arriving within the designated time window because they could be appropriately treated. All other events were considered failures to arrive on time. The χ² test of general association determined whether the proportion of participants arriving to the ED within 3 hours differed by intervention group. ED arrival for early (<30 days) versus later (>30 days) events was also examined. McNemar’s Test determined whether the proportion of participants arriving to the ED within 3 hours differed pre- and postintervention overall and by race-ethnicity.

An IRR tested whether there were differences in number of recurrent events by randomization. We preformed this calculation varying our assumptions regarding the distribution of the outcome using both logit-linear models for high SK and PC using generalized estimating equations. A priori, we dichotomized the 29-item SK scale into high SK (≥23 correct) and low SK (<23 correct) to reflect an 80% knowledge cut-point. The PC competency assessment was based on a complete recounting of 3 key preparedness skills (stroke, symptoms, time). We dichotomized to reflect full competency. All analyses were performed using SAS software.

Results

Study Participant Baseline Characteristics
SWIFT randomized 1193 stroke participants: mean age 63 years +15; 50% female; 17% black, 51% Hispanic, 26%...
white, 6% other. This was a mild stroke/TIA cohort with over 84% scoring <7 on National Institute of Health Stroke Scale. Figure 1 provides the patient recruitment, attrition, and retention schematic; 1.5% of participants were lost to follow-up, which did not differ by treatment arm. At baseline, 27% arrived to the ED within 3 hours of symptom onset (28% white, 26% black, 27% Hispanic), 36% arrived via ambulance, and 4.3% were treated with tissue-type plasminogen activator (Table). Approximately 43% did not complete high school, and close to 60% reported public health insurance, including Medicare (38%) or Medicaid (28%). Baseline vascular risk factors were prevalent as shown in Table. Baseline mean SK score was 71% (21 out of 29; SD=3.98) and only 36% displayed full stroke PC. Of the 1193, 592 were randomized to EE and 601 to the II group. The 2 groups did not differ at baseline, except those in EE were more likely to arrive by ambulance at baseline ($P=0.05$).

### Recurrent Events

SWIFT captured 599 outcomes in 377 participants: 325 strokes/TIA/stroke mimics, 104 deaths, 21 MIs, and 149 other events. A first recurrent stroke, TIA, or stroke mimic was documented in 224 participants: 133 strokes, 54 TIs, and 37 stroke mimics. There appeared to be an excess number of total strokes/TIA/stroke mimics in the II compared with the EE group (187 versus 138), which was not driven by stroke mimics. To test this hypothesis, we tabulated the number of events and the person time at risk in each arm. The significance, however, of this estimate was sensitive to the distributional assumption; assuming a Poisson distribution, IRR=1.31 (1.05, 1.63). Assuming a zero-inflated negative binomial distribution, IRR=1.18 (0.69, 2.03). Therefore, we cannot conclude that the incident rate ratio is truly statistically significantly different between study arms.

### ED Presentation

Of the 224 participants experiencing a recurrent stroke, TIA, or stroke mimic, 124 were in II and 100 in EE. Approximately 4% received tissue-type plasminogen activator with no differences by intervention arm. Overall, among the II group, 40% arrived within 3 hours compared with 46% of the EE group ($P<0.33$; Figure 2) with similar results for stroke/TIA only: 43% II and 45% EE ($P<0.5$). We report that 46/224 events occurred within the first 30 days and 83/224 events occurred within the first 90 days. For recurrent outcomes in the first 30 days, 58% of II arrived under 3 hours compared with 40% EE, but that pattern attenuated after 30 days. All results are similar for 2 and 4.5 hour arrival. Of the 104 patients who died during the study, we have information for death classification on 71 out of 104 deaths, and 66% of those were related to vascular causes. There were no significant differences in deaths by intervention arm.

Figure 3 compares the proportion of participants arriving under 3 hours at baseline with the proportion arriving under 3 hours for a recurrent event. Among participants experiencing a recurrent stroke, TIA, or mimic, 28% presented to the ED within 3 hours at baseline, whereas 42% presented within 3 hours for a recurrent event, a 49% increase ($P$ value=0.001). Stratified by race-ethnicity, we report increases (prepost relative increase; post absolute percent) in arrival under 3 hours among whites (33; 37%; $P$ value=0.40), blacks (36; 35%; $P$ value=0.50), and a large and significant increase among...
Hispanics (63; 45%; P value <0.004). The respective figures in the group experiencing a stroke or TIA are overall (63; 44%; P value <0.01), whites (29; 38%; P value=0.50), blacks (56; 37%; P value=0.33), and Hispanics (90; 48%; P value<0.001).

Educational Reinforcement
We observed no difference between intervention groups at baseline in SK (odds ratio [OR]=1.10; 95% confidence interval 0.86–1.41) or PC (OR=1.41; 0.67–2.95). We observed, however, II had 1.63 (95% confidence interval 1.23–2.15)
times greater odds of SK proficiency compared with EE at 1 month, but at 12 months, EE caught up to II (OR=1.21; 0.87, 1.67). For the open-ended PC competency measure, II maintained significantly greater odds of high PC at 1 month (OR=3.36; 1.86–6.10) and 12 months (OR=7.64; 2.49–23.49) compared with EE.

Discussion

SWIFT is the first randomized controlled trial to evaluate 2 different stroke preparedness educational strategies in decreasing time from symptom onset to ED arrival among stroke/TIA survivors. In both groups, we report an unprecedented 40% to 50% arrival to the ED <3 hours from symptom onset. In SWIFT, post randomization, the proportion arriving within 3 hours in both study arms is considerably greater than any stroke ED arrival trends currently reported across the United States (5% to 28% arriving <3 hours).2,14–16 Among Get with the Guidelines participating hospitals, on average, 26% arrived under 3 hours in 2003, 28% in 2006, and 25% in 2009.16 Both SWIFT educational arms resulted in a significant increase in the proportion of participants arriving within the critical 3-hour time window, but were not significantly different from each other in symptom onset to triage time at recurrent event. Although underpowered, there may be some effect on earlier arrival times in the II group for early recurrent events (<30 days). This is further supported by significant early knowledge and preparedness capacity differences between II and EE. We report no change in tissue-type plasminogen activator utilization, which may be because of limited indication among a secondary stroke population or may reflect continued inefficiencies in other components of the acute stroke triage system. Historically, the delay to ED may be even more reduced in underserved race-ethnic populations.17 SWIFT's findings of a large and significant increase in arrival <3 hours among Hispanics and trending among blacks demonstrates that message accessibility may lead to uptake of preparedness actions. SWIFT is one of the first stroke interventions demonstrating capacity to decrease race-ethnic disparities in arrival times.

In the United States, continued low rates of arrival to ED under 3 hours for acute stroke suggests that as a stroke community nationwide, we may not be effectively disseminating existing materials on stroke preparedness. Our findings suggest that at minimum clear, simple, preparedness-focused messages, predischarge (and possibly follow-up reinforcement) results in greater proportion of early ED arrivals. SWIFT data support evidence for brain attack coalition, Get with the Guidelines, and state-level certification programs that emphasize the critical role of continued education of...
community.\textsuperscript{5,15,16,18–20} None, however, specify what the educational efforts must be or when those efforts may be used most effectively. SWIFT demonstrates that although the II group has significantly greater SK one-month post intervention, the EE group caught up at 1 year. This catch up suggests that our follow-up could be considered post discharge reinforcement. In practice, the window of opportunity does not close merely because the patient is discharged without education, but that reinforcement of basic stroke preparedness education can be administered by phone within a month after the stroke and yield similar results to an intensive education in-hospital.

An unexpected finding was the increased IRR 1.3 for the II versus EE group. The increased number of detected stroke events in the II group is suggestive of increased awareness and better symptom recognition. We posit that the II group recognized symptoms that may remain undetected in the EE group. This result is consistent with evidence on the prevalence of undiagnosed cerebrovascular accidents in healthy older adults and suggests a similarly high prevalence among survivors of a prior stroke.

Evaluating PC, we found the II group more proficient in the ability to describe critical preparedness actions. Significantly better PC may have been facilitated by the group dynamic provided in the II group. This focused on problem solving techniques, including flexible open conversations, allowing participants to feel more secure in their environment and increasing receptivity toward disease recognition, which may be associated with the increased number of strokes detected.

Although II seems to increase detection of stroke cases, it was not associated with better arrival times than EE overall. One theory is that during an acute stroke, individuals may not be able to take action themselves, and need people around them (social networks) to respond. We have previously reported that living with a spouse/partner was associated with decreased time to ED after acute stroke,\textsuperscript{22} and we highlight findings from these data (separate analysis not shown) that living with a spouse/partner is associated with 3.5-fold increased likelihood of presenting under 3 hours, regardless of randomization ($P<0.07$).

**Study Limitations**

One limitation is that there is no true placebo arm for comparison because the control group reflects the most enhanced standard of usual care available. Another limitation is the generalizability of results from a mild stroke and TIA population to the larger nonstroke community. There are sparse data for comparison on time of arrival behaviors among prevalent stroke survivors. Most ED arrival data constitutes a mix of incidence/prevalence cases from registries like Get with the Guidelines. We have previously reported no difference between incidence and prevalent stroke in terms of ED arrival times.\textsuperscript{21} Finally, we are limited as to whether these results reflect trends in city, state, or national data. It is possible that some other educational campaign or trend is responsible for the significant shift in decreased arrival times; however, no other local New York City, state, or national trend report rates over 30% during this time period.

**Conclusions**

SWIFT results suggest that an intensive intervention may impact early arrival, detection of events, preparedness capacity, and greater SK within the first 30 days post discharge. Results from EE group suggests that even modest educational efforts can significantly and realistically increase awareness and action, so that almost half of recurrent stroke and TIA patients should be expected to arrive to ED in time to be eligible for acute stroke treatments, regardless of race-ethnic background. Further, SWIFT is one of the first stroke interventions demonstrating capacity to decrease race-ethnic disparities in arrival times.

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**Disclosures**

None.

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