Development and Initial Testing of the Stroke Rapid-Treatment Readiness Tool

DaiWai M. Olson, Margueritte Cox, Mark Constable, Gavin W. Britz, Cheryl B. Lin, Louise O. Zimmer, Gregg C. Fonarow, Lee H. Schwamm, Eric D. Peterson

ABSTRACT

No instruments are currently available to help health systems identify target areas for reducing door-to-needle times for the administration of intravenous tissue plasminogen activator to eligible patients with ischemic stroke. A 67-item Likert-scale survey was administered by telephone to stroke personnel at 252 U.S. hospitals participating in the ''Get With The Guidelines-Stroke'' quality improvement program. Factor analysis was used to refine the instrument to a four-factor 29-item instrument that can be used by hospitals to assess their readiness to administer intravenous tissue plasminogen activator within 60 minutes of patient hospital arrival.

Keywords: acute stroke therapy, intervention, reperfusion, therapy, tPA, treatment

The use of intravenous recombinant tissue plasminogen activator (IV-tPA) is recommended for patients with acute ischemic stroke (AIS) who arrive to hospital with a known onset time of ≤3.5 hours and no known contraindications (Adams et al., 2007; Jauch et al., 2013). For every minute the brain lacks blood flow, it is estimated that 1.9 million neurons die (Saver, 2006). Although fibrinolysis can reduce brain cell loss and improve clinical outcomes, the benefits of treatment decrease with increasing delays from time from stroke onset to treatment (Kwiatkowski et al., 1999; Lansberg, Schrooten, Bluhmki, Thijs, & Saver, 2009; Moser et al., 2007).

A variety of interventions aimed at reducing delays in IV-tPA administration for eligible patients with stroke have been investigated (Drescher, Spence, Rockwell, Staff, & Smally, 2011; Eissa, Krass, & Bajorek, 2012; Muller-Barna, Schwamm, & Haberl, 2012). The ''TARGET: Stroke'' initiative (American Heart Association & American Stroke Association, 2012) is a collaborative quality improvement effort aimed at improving the timeliness of IV-tPA delivery (Fonarow et al., 2011). Despite these efforts, IV-tPA within 60 minutes of arrival is not universal (Mitka, 2011). To date, no tools have been developed to help hospitals or health systems define reasons, customized to their institution, for failure to deliver timely stroke treatments and identify targets for quality improvement.

The purpose of this study was to develop a simple instrument to measure hospital readiness to rapidly treat AIS and administer IV-tPA within 60 minutes of patient arrival to the emergency department. This instrument will be essential for hospitals that wish to efficiently identify specific areas for quality improvement.

Methods

After institutional review board approval, the study team developed a comprehensive list of questions deemed relevant to understand how hospitals provide

Questions or comments about this article may be directed to DaiWai M. Olson, PhD RN CCRN, at DaiWai.Olson@UTSouthwestern.edu. He is an Associate Professor of Neurology and Neurotherapeutics at the University of Texas Southwestern Medical Center, Dallas, TX.

Margueritte Cox, MS, is a Biostatistician at Duke Clinical Research Institute, Durham, NC.

Mark Constable, RN, is a Stroke Coordinater at Duke Clinical Research Institute and Duke University, Durham, NC.

Gavin W. Britz, MD, is a Professor of Neurosurgery and the Chairman of Neurosurgery at Methodist Hospital, Houston, TX.

Cheryl B. Lin, MD, is a Medical Resident at Duke Clinical Research Institute and Duke University, Durham, NC.

Louise O. Zimmer, MPH, is a Clinical Research Coordinator at University of North Carolina at Chapel Hill, Chapel Hill, NC.

Gregg C. Fonarow, MD, is a Professor of Medicine and Associate Chief of Cardiology at University of California Los Angeles, Los Angeles, CA.

Lee H. Schwamm, MD, is a Professor of Neurology at Harvard University and Vice Chairman of Neurology at Massachusetts General Hospital, Boston, MA.

Eric D. Peterson, MD MPH, is a Professor of Medicine at Duke Clinical Research Institute and Duke University, Durham, NC.

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care to patients with AIS. This process involved several key steps. First, a qualitative study was completed to assess the domains of interest. The first step in this process has been reported (Olson et al., 2011). Briefly, "top-performing" hospitals achieving high rates of early IV-tPA were identified through a query of the "Get With The Guidelines-Stroke" (GWTG-Stroke) data set. E-mails were sent to the stroke personnel, who were identified in the GWTG-Stroke database as being the primary contact at each hospital and asked to participate in a qualitative study. Five domains (communication and teamwork, process, organizational culture, performance monitoring/feedback, and overcoming barriers) were identified (Olson et al., 2011).

The second step was to develop a comprehensive list of statements to be included in the instrument. A set of 56 individual statements were developed based upon the domains identified in the qualitative analysis. Concurrent to the qualitative analysis, a 24-question survey was developed by members of the "TARGET: Stroke" team. Hospitals participating in the "TARGET: Stroke" initiative were instructed to complete the survey electronically. The 24 questions from the online survey were reconstructed as statements and added to the instrument. After removing duplicate statements (17) and eliminating a free-text response question, the instrument containing 67 questions was reviewed for content by four expert clinicians in stroke research.

Each of the statements were then refined, and Likert responses were added for each statement. Scoring for each item is based on the following: 5 = *strongly agree*, 4 = *somewhat agree*, 3 = *neutral*, 2 = *somewhat disagree*, and 1 = *strongly disagree*. Four of the items (25, 35, 36, and 56) should be scored inversely (e.g., strongly disagree is scored "5" instead of "1") as they are negatively correlated with early IV-tPA. This tool was sent to stroke neurologists (n = 4) and stroke coordinators or advanced practice nurses (n = 6) who were considered experts in the field. After incorporating their comments, the survey was field tested in a telephone interview format with community hospital medical and nursing staff. After additional refinements for clarity, the 67-item survey questionnaire was finalized.

Population and Sampling Method

Using GWTG-Stroke performance data, a sample of 300 hospitals were selected according to their ranking in percent of eligible patients receiving IV-tPA within 60 minutes of hospital arrival (including 100 hospitals with the highest percentage, 100 midrange performers, and 100 of the lowest performers). Contact information for the stroke coordinator or stroke program manager was obtained from the American Heart Association, and

Although a number of strategies targeted at reducing delays in administering IV-tPA to eligible patients have been described, no single tool had been created to date that would help clinicians identify the reasons that underpin treatment delays. These authors describe the development and use of such a tool.

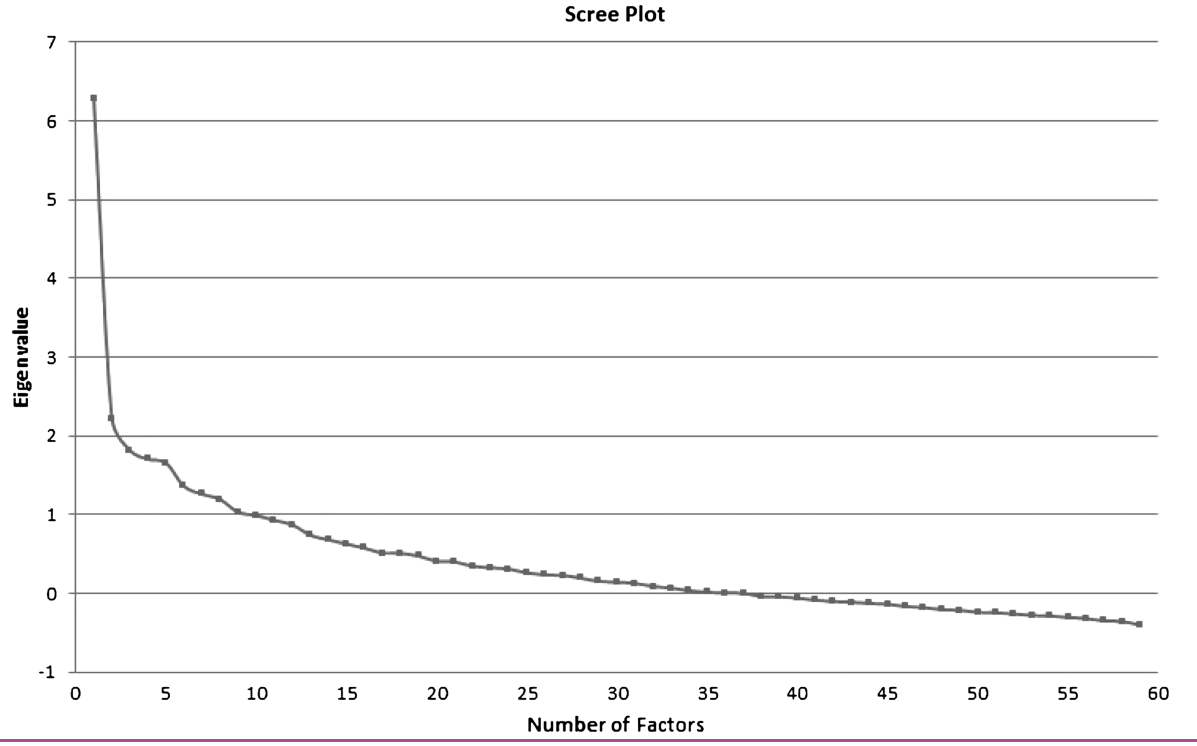
hospitals were contacted first by E-mail and, second, by follow-up telephone call to request participation. Each hospital could elect to have the telephone questionnaire completed by any member of the stroke team with adequate knowledge of emergency care at that hospital. Given that the sample covered the entire United States, telephone interviewing was selected for survey response based on the ease of use and high agreement with face-to-face sampling techniques (Lee et al., 2010; Weisberg, 2005). For hospitals that opted out or never responded to the E-mail request for participation, a replacement hospital was selected as the next highest/lowest/median performing site.

Between March and December 2011, hospital representatives at the 252 selected GWTG-Stroke hospitals across the United States completed the telephone survey. The data from the survey were converted to SAS v. 9.2 for statistical analysis. A quality check of the data entry process into Access was performed on 10% of the records and resulted in an error rate of <0.03%.

Analysis

Exploratory factor analysis was used to explore the 67-item instrument. Eight items were removed before the factor analysis because they had no variation (five items) or less than 2.5% variation (three items) in response. An unweighted least squares factor analysis with orthogonal rotation was performed on the remaining 59 questions. Estimates of communalities were calculated using the squared multiple correlation between variables. A scree plot was created to determine the number of factors to retain (Figure 1). After the number of factors was determined, the rotated factoring results were used to sort questions into factors, and questions with loadings greater than .30 (or less than −.30) were

FIGURE 1 Scree Plot for Factor Analysis of the Original 67 Items



deemed important. Finally, Cronbach's alpha was explored to further reduce the number of items.

Results

Thus, 252 of the 300 (84%) telephone surveys were completed between August and December 2012. Surveys in which there were >10% of responses missing (n = 5) were excluded leaving 247 hospitals in our final analysis populations (Table 1). The factor analysis identified four factors and 33 items; checking Cronbach's alpha eliminated an additional four items. The final instrument is 29 items (Cronbach's alpha = .818)

TABLE 1. Characteristics of Participants' Hospitals

Variable	Level	*n* (%)
Hospital type	Nonacademic	91 (36.1)
	Academic	137 (54.4)
	Missing	24 (9.5)
Number of beds	Median	220
	25th IQR	273.5
	75th IQR	504
Number of stroke discharges/year	>300	86 (34.1)
	101–300	103 (40.9)
	0–100	22 (8.7)
	Missing	41 (16.3)
TJC Primary Stroke Center	Yes	130 (51.6)
	No	122 (48.4)
IV-tPA within 60 minutes of arrival for eligible patients	Median	20.4%
25th IQR	11.1%	
75th IQR	37.5%	
Lowest performer	0%	
Highest performed	92.3%	

TABLE 2. Factors and Loadings

Item	Descriptor	Factor Loading
Factor 1: "Stability"		
24	There is adequate professional stroke education for all the stroke team members.	.5551
19	Our institution has routine meetings to provide timely performance feedback to the stroke team.	.4957
18	Our institution has structured reports for providing timely performance feedback to the stroke team.	.4769
31	For every stroke code, the role of each stroke team member is well defined.	.4567
27	Our stroke team works well together.	.4209
21	When reviewing stroke care, instead of assigning blame, our hospital uses ''mistakes'' to identify areas for improvement.	.3835
40	When something goes wrong during a stroke code, we have a backup plan.	.3754
47	Every potential patient with stroke is immediately seen by a physician.	.3505
46	In our ED, every potential patient with stroke is immediately seen by a nurse other than a triage nurse.	.3299
25	The members of our stroke team do not receive regular reeducation about stroke care.	−.4977
Factor2: "Shared Goals"		
14	At our hospital, early tPA administration to every eligible patient is the goal recognized by the entire team.	.6045
60	During the stroke code, team members track how long the patient has been in our facility.	.5512
63	For each stroke code, there is one person who remains with the patient at all times.	.5204
15	At our hospital, DTN ≤ 60 minutes is the goal recognized by the entire team.	.4861
6	We have a designated method to keep track of time for each stroke code.	.4797
23	Our stroke team feels a strong sense of institutional support.	.4118
61	We have a debriefing or a review of our stroke codes.	.3774
57	In our ED, when tPA is ordered, it is readily available.	.3669
52	Stroke code documentation includes a record of when blood samples were obtained and sent to the laboratory.	.3034
Factor 3: "Preparedness"		
2	When EMS notifies our hospital of a potential patient with stroke, the team begins to take action, even if the patient has not yet arrived.	.6076
3	Prearrival EMS notification at our hospital helps reduce DTN time.	.5618
45	When we receive prearrival notification from EMS, we notify radiology, and a neuroimaging scanner is opened up, even if the patient has not yet arrived.	.5206
8	The physical space in our ED where we provide care to patients with stroke is large enough for the entire team.	.4028
1	The process used by paramedics to alert our staff that a potential patient with stroke is being transported to our hospital is standardized.	.3908
43	When patients with stroke are transported by EMS, our ED receives advanced notification that the patient is on the way.	.3744
12	Transporting patients with stroke from the ED to the CT scanner is easy.	.3434
29	All of our physicians believe that early tPA improves outcomes in eligible patients with acute ischemic stroke.	.3250
11	Transporting patients with stroke from the ED to the CT scanner is fast.	.3044
Factor 4: "Family"		
67	The family is permitted and encouraged to be at the bedside during a stroke code.	.8201

that are associated with hospitals that had a higher percentage of IV-tPA use within 60 minutes (Table 2).

Factor 1—"stability"—includes 10 items (nine items with positive loadings and one with negative). The positive factor loadings for this factor ranged from .33 to .56, and the negative loading was −.50. The items included in this factor generally address temporal concerns associated with maintaining a stable workflow process. Multiple parties involved in emergency stroke management are included in this factor, which include education, quality improvement and management, and the need for a backup plan.

Factor 2—"shared goals"—includes nine items. The factor loadings for this factor ranged from .30 to .60. The items included in this factor generally address the goals of the institution and describe commitment to those goals by management as well as by the stroke team. The items address agreement around the institutional goals and the methods for tracking patient-level data to ensure that time frames are met by the team. The actions of various team members are evaluated within the context of the shared goals of the entire team.

Factor 3—"preparedness"—includes nine items. The factor loadings for this factor ranged from .30 to .61. The items included in this factor describe workflow processes and adequate facilities to support care of the patient with stroke. Items associated with preparedness begin with the Emergency Medical Services (EMS) prearrival communication that precipitates action by the hospital team.

Factor 4—"family"—includes only one item with a positively correlated factor loading of .82. The item included in this factor is a statement about the importance of allowing the family to remain with the patient during assessment and treatment.

Discussion

The goal of a condensed instrument to assess hospital readiness for rapid IV-tPA administration to eligible patients with ischemic stroke was accomplished. We developed a 29-item survey instrument with four factors. Early testing of this instrument indicates that higher scores are indicative of higher readiness to meet the measure of IV-tPA within 60 minutes of arrival for eligible AIS. This tool can be used to discover areas for improvement in a hospital or system looking to increase percentage of eligible patients receiving early thrombolytic therapy in AIS. The four factors identified in this analysis (stability, shared goals, preparedness, and family) complement an earlier qualitative analysis, which identified five domains associated with early IV-tPA administration (Olson et al., 2011).

Stability was the only factor that included both positively and negatively correlated items. This factor most closely resembles the process domain identified in the qualitative study (Olson et al., 2011). The items address reducing practice or process variation through standard protocols, ongoing education, and review of the team's performance to optimize patient care. The concept of process variation was first introduced by Deming and has since become an established goal in quality improvement (Batalden, 1991; Olivi, 2007). Documenting variations in systems and personnel performance can identify areas of inefficiency and provide guidance as to where system redesign is beneficial (Batalden & Splaine, 2002). Creating clear processes and training staff on their use can then reduce likelihood of errors and improve outcomes. Salas, Wilson, Burke, and Priest (2005) explored a concept with similar constructs and noted that team adaptability allows the team to recognize variation from the standard and make changes accordingly.

The shared goals factor incorporates elements from two domains identified in the qualitative study: (a) communication and teamwork and (b) organizational culture. Elements addressed include institution-wide agreement on goals, team meetings to review whether goals were met, coordination across departments, and personal responsibility to the team. These findings extend the shared mental models theory of team cognition (Gillespie & Chaboyer, 2009; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). The foundation for shared mental models, which is largely derived from military team training (Krueger & Banderet, 2007), has been extended to healthcare, most recently in the TeamSTEPPS program (Clancy & Tornberg, 2007; Clark, 2009; Weaver et al., 2010).

Preparedness included items that described the ability to quickly and easily move the patient through the stroke process beginning with the EMS encounter. The qualitative domain of performance monitoring and feedback also addressed the ability of the system to be ready to respond. Much of the preparedness factor revolves around the relationship or plan in place to be acted upon before the patient arrives to the hospital. This is consistent with prior recommendations from the American Stroke Association (Acker et al., 2007). Systematic preparedness is substantiated through integrating EMS into the hospital stroke team protocols, performance measures with frequent and meaningful feedback on the measures, and ongoing collaboration between EMS and hospital providers. Literature indicates that preparedness not only decreases delays in treatment but also increases the proportion of appropriate patients receiving reperfusion therapy (Behrens et al., 2002; Belvis et al., 2005). The one item included in the factor for family addressed both allowing and encouraging the inclusion of family. This is supported by Olson et al. (2011) in their discussion of the process domain,

which includes family as part of the care process team. Having family in attendance is important because they can give information on the patient's history and medications and last known well time (Hughes, 2011). Family members may also provide consent for IV-tPA treatment if the patient is unable to respond. In addition, educating family members during the acute phase of stroke care on the patient's condition, discharge medications, and community resources helps prepare the family for the patient's transition to home and reduces the impact of inadequate handoffs to other providers (Black-Schaffer, 2002). Evidence-based practice now supports open visitation models that incorporate family as partners in the acute care of patients (Ciufo, Hader, & Holly, 2011).

The effort to reduce door-to-needle times for AIS is a quality improvement initiative. As Fonarow et al. (2011) note, key strategies to provide early IV-tPA include emergency medical service prenotification, efficient activation of the stroke team, rapid assessment, use of standard protocols, premixing tPA, a team-based approach to providing care, and rapid data feedback. Prior work in performance improvement identified key factors for success including (a) credible performance benchmarks; (b) rapid and on-going feedback on performance, (c) a plan of action using locally designed measures, (d) staff buy-in, (e) management support, and (f) a learning culture (Bradley et al., 2007; Naylor, 1998; Peterson, 2005).

One surprising finding was that the qualitative study identified a domain of "overcoming barriers," but this domain did not link directly to a singular factor. There were two items (numbers 21 and 40) in the stability factor that at least partially focus on addressing barriers. Recently, Lusardi (2012) noted that education, support (management), and regular meetings are keys to overcome barriers to change. Given that there are items in the stability and shared goals factors that specifically address education, support, and meetings, we propose that overcoming barriers are integrated within these two factors.

Limitations

There are several limitations that must be recognized. The instrument was developed only using input from hospitals that were participating in GWTG-Stroke. Stroke care is a moving target, and hospital teams who responded to the survey may not be representative of all hospitals; an expanded instrument may be more appropriate for non-GWTG-Stroke hospitals. It is likely that these hospitals have already begun to put into place specific things to reduce door-to-needle times. For example, the statement "We have an order set or stroke pathway that we follow for our stroke codes" was eventually excluded. This does not mean that stroke pathways are not important. Rather, if all GWTG-Stroke hospitals have pathways and agree that pathways are important, then the statement is excluded from the factor analysis because it does not discriminate early IV-tPA administration.

The survey participants were identified as the point of contact for GWTG-Stroke. The survey asked participants to rate their level of agreement, and there is no mechanism to ensure that a different practitioner at the same hospital would have responded exactly the same for each item. Finally, because four of the items must be scored inversely, it may be confusing to some practitioners. Future work on this instrument should explore if these items could be rephrased to facilitate scoring.

Conclusion

We have developed the first instrument for assessing hospital readiness to administer IV-tPA within 60 minutes of patient arrival to the emergency department. This analysis supports the initial validity of an instrument to assess components of care associated with the early administration of thrombolytic therapy for patients with AIS. Additional instrument development and testing will determine if this instrument applies for other reperfusion therapy (i.e., mechanical thrombolysis).

References

Acker, J. E. III., Pancioli, A. M., Crocco, T. J., Eckstein, M. K., Jauch, E. C., Larrabee, H., … Stranne, S. K. (2007). Implementation strategies for emergency medical services within stroke systems of care: A policy statement from the American Heart Association/American Stroke Association Expert Panel on Emergency Medical Services Systems and the Stroke Council. *Stroke, 38*(11), 3097–3115. doi:10.1161/STROKEAHA.107.186094

Adams, H. P. Jr., del Zoppo, G., Alberts, M. J., Bhatt, D. L., Brass, L., Furlan, A., … Wijdicks, E. F. (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–e534. doi:115/20/e478 [pii]10.1161/CIRCULATIONAHA.107.181486

American Heart Association & American Stroke Association. (2012). TARGET: Stroke initiative. Retrieved from www.strokeassociation.org/targetstroke

Batalden, P. B. (1991). Building knowledge for quality improvement in healthcare: an introductory glossary. *Journal of Quality Assurance, 13*(5), 8–12.

Batalden, P., & Splaine, M. (2002). What will it take to lead the continual improvement and innovation of health care in the twenty-first century? *Quality Management in Health Care, 11*(1), 45–54.

Behrens, S., Daffertshofer, M., Interthal, C., Ellinger, K., van Ackern, K., & Hennerici, M. (2002). Improvement in stroke quality management by an educational programme. *Cerebrovascular Diseases, 13*(4), 262–266.

Belvis, R., Cocho, D., Marti-Fabregas, J., Pagonabarraga, J., Aleu, A., Garcia-Bargo, M. D., … Marti-Vilalta, J. L. (2005). Benefits of a prehospital stroke code system. Feasibility and efficacy in the first year of clinical practice in Barcelona, Spain. *Cerebrovascular Diseases, 19*(2), 96–101. doi:10.1159/000082786

Black-Schaffer, R. M. (2002). Communication among levels of care for stroke patients. *Topics in Stroke Rehabilitation, 9*(3), 26–38.

Bradley, E. H., Nallamothu, B. K., Curtis, J. P., Webster, T. R., Magid, D. J., Granger, C. B., … Krumholz, H. M. (2007). Summary of evidence regarding hospital strategies to reduce door-to-balloon times for patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. *Critical Pathways in Cardiology, 6*(3), 91–97. doi:10.1097/HPC.0b013e31812da7bc 00132577-200709000-00001 [pii]

Ciufo, D., Hader, R., & Holly, C. (2011). A comprehensive systematic review of visitation models in adult critical care units within the context of patient- and family-centred care. *International Journal of Evidence-Based Healthcare, 9*(4), 362–387. doi:10.1111/j.1744-1609.2011.00229.x

Clancy, C. M., & Tornberg, D. N. (2007). TeamSTEPPS: Assuring optimal teamwork in clinical settings. *American Journal of Medical Quality, 22*(3), 214–217. doi:10.1177/1062860607300616

Clark, P. R. (2009). Teamwork: Building healthier workplaces and providing safer patient care. *Critical Care Nursing Quarterly, 32*(3), 221–231. doi:10.1097/CNQ.0b013e3181ab923f

Drescher, M. J., Spence, A., Rockwell, D., Staff, I., & Smally, A. J. (2011). Point-of-care testing for coagulation studies in a stroke protocol: A time-saving innovation. *American Journal of Emergency Medicine, 29*(1), 82–85. doi:10.1016/j.ajem.2009.09.020

Eissa, A., Krass, I., & Bajorek, B. V. (2012). Barriers to the utilization of thrombolysis for acute ischaemic stroke. *Journal of Clinical Pharmacy and Therapeutics*, *37*(4), 399–409. doi:10.1111/j.1365-2710.2011.01329.x

Fonarow, G. C., Smith, E. E., Saver, J. L., Reeves, M. J., Hernandez, A. F., Peterson, E. D., … Schwamm, L. H. (2011). Improving door-to-needle times in acute ischemic stroke: The design and rationale for the American Heart Association/American Stroke Association's Target: Stroke initiative. *Stroke, 42*(10), 2983–2989. doi:10.1161/STROKEAHA.111.621342

Gillespie, B., & Chaboyer, W. (2009). Shared mental models enhance team performance. *Nursing in Critical Care, 14*(5), 222–223. doi:10.1111/j.1478-5153.2009.00357.x

Hughes, P. A. (2011). Comprehensive care of adults with acute ischemic stroke. *Critical Care Nursing Clinics of North America, 23*(4), 661–675. doi:10.1016/j.ccell.2011.08.009

Jauch, E. C., Saver, J. L., Adams, H. P. Jr., Bruno, A., Connors, J. J., Demaerschalk, B. M., … Council on Clinical, Cardiology. (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

Krueger, G. P., & Banderet, L. E. (2007). Implications for studying team cognition and team performance in network-centric warfare paradigms. *Aviation, Space, and Environmental Medicine, 78*(5 suppl), B58–B62.

Kwiatkowski, T. G., Libman, R. B., Frankel, M., Tilley, B. C., Morgenstern, L. B., Lu, M., … Brott, T. (1999). Effects of tissue plasminogen activator for acute ischemic stroke at one year. National Institute of Neurological Disorders and Stroke Recombinant Tissue Plasminogen Activator Stroke Study Group. *New England Journal of Medicine, 340*(23), 1781–1787. doi:10.1056/NEJM199906103402302

Lansberg, M. G., Schrooten, M., Bluhmki, E., Thijs, V. N., & Saver, J. L. (2009). Treatment time-specific number needed to treat estimates for tissue plasminogen activator therapy in acute stroke based on shifts over the entire range of the modified Rankin Scale. *Stroke, 40*(6), 2079–2084. doi:10.1161/STROKEAHA.108.540708

Lee, S., Tsang, A., Mak, A., Lee, A., Lau, L., & Ng, K. L. (2010). Concordance between telephone survey classification and face-to-face interview diagnosis of one-year major depressive episode in Hong Kong. *Journal of Affective Disorders, 126*(1–2), 155–160. doi:10.1016/j.jad.2010.03.024

Lusardi, P. (2012). So you want to change practice: Recognizing practice issues and channeling those ideas. *Critical Care Nurse, 32*(2), 55–64. doi:10.4037/ccn2012899

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology, 85*(2), 273–283.

Mitka, M. (2011). Reducing door-to-needle time for tPA use remains an elusive goal in stroke care. *Journal of the American Medical Association, 305*(13), 1288–1289. doi:10.1001/jama.2011.378

Moser, D. K., Kimble, L. P., Alberts, M. J., Alonzo, A., Croft, J. B., Dracup, K., … Zerwic, J. J. (2007). Reducing delay in seeking treatment by patients with acute coronary syndrome and stroke: A scientific statement from the American Heart Association Council on Cardiovascular Nursing and Stroke Council. *Journal of Cardiovascular Nursing, 22*(4), 326–343. doi:10.1097/01.JCN.0000278963.28619.4a00005082-200707000-00013[pii]

Muller-Barna, P., Schwamm, L. H., & Haberl, R. L. (2012). Telestroke increases use of acute stroke therapy. *Current Opinion in Neurology, 25*(1), 5–10. doi:10.1097/WCO.0b013e32834d5fe4

Naylor, C. D. (1998). Better care and better outcomes: The continuing challenge. *Journal of the American Medical Association, 279*(17), 1392–1394. doi:jed80031[pii]

Olivi, P. (2007). Deming revisited, part 2: Process improvement and variation. *Radiology Management, 29*(3), 11–12.

Olson, D. M., Constable, M., Britz, G. W., Lin, C. B., Zimmer, L. O., Schwamm, L. H., … Peterson, E. D. (2011). A qualitative assessment of practices associated with shorter door-to-needle time for thrombolytic therapy in acute ischemic stroke. *Journal of Neuroscience Nursing, 43*(6), 329–336 310.1097/JNN.1090b1013e318234e318237fb

Peterson, E. D. (2005). Optimizing the science of quality improvement. *Journal of the American Medical Association, 294*(3), 369–371. doi:294/3/369[pii]10.1001/jama.294.3.369

Salas, E., Wilson, K. A., Burke, C. S., & Priest, H. A. (2005). Using simulation-based training to improve patient safety: What does it take? *Joint Commission Journal on Quality and Patient Safety, 31*(7), 363–371.

Saver, J. L. (2006). Time is brain-quantified. *Stroke, 37*(1), 263–266. doi:10.1161/01.STR.0000196957.55928.ab

Weaver, S. J., Rosen, M. A., DiazGranados, D., Lazzara, E. H., Lyons, R., Salas, E., … King, H. B. (2010). Does teamwork improve performance in the operating room? A multilevel evaluation. *Joint Commission Journal on Quality and Patient Safety, 36*(3), 133–142.

Weisberg, H. F. (2005). 3. Survey modes: Responses to emerging technologies. In H. F. Weisberg (Ed.), *The total survey error approach: A guide to the new science of survey research* (pp. 29–44). Chicago, CA: The University of Chicago Press.