Implementation of a Delirium Prediction Score in Patients with Acute Stroke

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Abstract

Background: Delirium is common in patients with acute ischemic stroke (AIS) and intracerebral hemorrhage (ICH) (10% - 48%) and associated with worse patient outcomes. Practicing clinicians have difficulty reliably detecting delirium in patients with AIS or ICH. The prevention of delirium is therefore a potentially beneficial strategy and is most effective in patients who are at high risk for delirium. This project implemented a validated delirium prediction score (DPS) into clinical practice for use with patients with AIS or ICH.

Methods: During a 6-week implementation project, the Advanced Practice Providers (APPs) (Nurse Practitioners, *n*=9, and Physician Assistant, *n*=1) in a 10-bed Neurocritical Care Unit (NCCU) at a large urban quaternary care academic medical center used a previously validated DPS to risk-stratify consecutive admissions of patients with AIS or ICH into low (<5%), moderate (5%-20%), or high (>20%) risk categories for delirium. Compliance data were collected and analyzed with descriptive statistics. At the completion of the project, the APPs were asked to complete the System Usability Scale (SUS) and provide qualitative data to determine the usability of the DPS and assess for facilitators and barriers for the use of the DPS.

Results: Patients admitted with AIS or ICH (*n*=20) were assessed by the APPs using the DPS (*n*=18/20, 90%). The score on the SUS (76.7) was mid-point between "acceptable" and "excellent." Facilitators and barriers for use of the DPS were identified.

Conclusions: The DPS was reliably used and was considered usable by the APPs. The DPS is a valid delirium risk assessment tool that can be used in patients with AIS or ICH. The adoption of the DPS with this patient population can be a first step in identifying the most at-risk patients for developing delirium and targeting these patients for delirium prevention strategies in this vulnerable population.

Implementation of a Delirium Prediction Score in Patients with Acute Stroke

Delirium is common (10% - 48%) in patients with acute ischemic stroke (AIS) and intracerebral hemorrhage (ICH) (Shi, Presutti, Selchen, & Saposnik, 2012). Delirium is a behavior syndrome characterized by: a) developing acutely or having a fluctuating presence throughout the day; b) a disturbance in attention and/or awareness; and c) having at least one alteration in cognition (memory, orientation, perception, or hallucinations) (American Psychiatric Association, 2013). Patients with delirium have longer hospitalizations, are more likely to not regain independent function, and have a higher in-hospital and 1-year mortality when compared to those who do not develop delirium during the acute phase of their AIS or ICH (Carin-Levy, Mead, Nicol, Rush, & van Wijck, 2012; Shi et al., 2012). Whether a patient's delirium is recognized or not, the patient will experience the negative consequences of delirium.

There is a paucity of studies including patients with AIS or ICH that have investigated the efficacy of interventions to treat delirium and improve outcomes (Oldenbeuving, de Kort, van Eck van der Sluijs, Kappelle, & Roks, 2014). Therefore, a potentially more effective strategy for improving delirium-associated outcomes is to use delirium prevention strategies. Hempenius et al. (2011) noted that the largest benefit in delirium reduction was with patient populations whose incidence was greater than 30%. Therefore, it is important to identify highly at-risk patients and focus evidence-based prevention strategies on this subset of patients.

Delirium is not a homogenous syndrome. Its risk factors differ between specific disease states. Therefore, risk assessment and a subsequent prediction rule must be tailored to the specific patient population. Oldenbeuving et al. (2014) developed a reliable and valid delirium prediction score (DPS) specifically for patients with AIS or ICH. This tool can be used on admission to risk-stratify the patients into low, moderate, and high categories.

The purpose of this project was to implement and evaluate the usability of the DPS for patients who were admitted to the NCCU with AIS or ICH. The anticipated outcomes of this project were: 1) facilitation of the development and use of risk-stratified delirium prevention strategies, and 2) earlier detection of delirium in the greatest at-risk patients due to a more attuned awareness among the NCCU staff.

Theoretical Framework

The translation and implementation of the project was guided by Greenhalgh's Diffusion of Innovation in Service Organizations Model (see Figure 1) (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). This model was developed to describe the concepts that facilitate the implementation of new ideas, processes, and products into sustained use by "healthcare systems" (Greenhalgh et al., 2004). The model is used to describe the process leading from the emergence of an innovation to its sustained assimilation by a system.

According to Greenhalgh et al. (2004), the process of diffusion starts with the *innovation* (anything that is perceived as new by others). An adopter may *notice* the innovation and use it. If the adopter influences others to use the innovation, then the process of *assimilation* into wide-spread use has begun. Assimilation can occur through a *diffused* (passive) and/or *disseminated* (active) process. *Confirmation* is the successful assimilation of the innovation into routine use.

Greenhalgh describes the structural (organizational structure, etc.) and cultural (ability to absorb new knowledge, etc.) *antecedents for innovation* that influence a system's likelihood to assimilate an innovation. Lastly, a system's *readiness for innovation* will determine the likelihood of a system to assimilate any innovation at all (Greenhalgh et al., 2004). The elements of Greenhalgh's Model used to design and implement this project are detailed in Table 1.

Literature Review

Most current literature places primary emphasis on the early detection of delirium in the intensive care unit (ICU) setting through the use of validated assessment tools (Barr et al., 2013; Devlin, Al-Qadhee, & Skrobik, 2012). However, there are contradictory reports in the literature regarding the ability of nurses and physicians to recognize delirium during their routine practice whether they rely on clinical judgment or a validated assessment tool. This review presents selected literature to highlight these contradictions.

In the first study reviewed, Spronk et al. (2009) reported a descriptive cohort study examining how well nurses and physicians in the ICU recognized delirium (see Table 2). They recruited a cohort of patients (*N*=46) from a 10-bed ICU in an urban academic medical center over a 3-month period. The patients were assessed daily for delirium by a research nurse who used the Confusion Assessment Method for the ICU (CAM-ICU) (appropriate for an ICU setting). The researchers also asked the ICU nurses (RN) and physicians (MD) to assess the same patients using their best clinical judgment. The research nurse detected delirium (50% incidence) more frequently than both the RNs and MDs (35% and 28% respectively). The researchers concluded that a validated tool should be used by clinicians in routine daily care.

Rice et al. (2011) examined the accuracy of delirium assessments by medical-surgical floor staff nurses using the Confusion Assessment Method (CAM), a validated assessment tool that is appropriate for the study setting. The nurses in this facility had been using the CAM as part of their routine clinical assessment for over two years prior to the initiation of this study. The study was conducted over a 10-month period in a 541-bed academic tertiary medical center. Her team compared the CAM assessments to those performed by researchers (*N*=3) who also used the CAM (see Table 2). Using a convenience sample of patients (*N*=170) and volunteer

staff nurses (*N*=167), the nurses and researchers performed paired assessments (the same patient within the same time frame) (*N*=555) (see Table 2). The researchers detected delirium in 12 patients (7%) while the staff nurses only detected delirium in three of these patients (25%, sensitivity 25%, specificity 99.63%, $p<0.0001$).

When examining both studies on delirium assessment, some contradictions are noted. For example, Spronk et al. (2009) concluded that the research nurse using the CAM-ICU was superior to the clinical judgment of the RNs and MDs alone. However, Rice et al. (2011) demonstrated that even with the use of the CAM, the RNs significantly underperformed the researchers using the same tool. Combined, these studies highlight an important but often overlooked phenomenon: – the results obtained by dedicated research staff is not always replicated when implemented by a wider group of clinical staff.

Finally, Oldenbeuving et al. (2014) reported the development and validation of the DPS. They designed a simple delirium risk-stratification tool for patients with AIS or ICH (see Table 2). Using a prospective patient cohort (*N*=527), the researchers identified independent risk factors for delirium. They used factor analysis and factor loading models with these risk factors to develop the DPS. They established reliability and validity by testing their DPS against a second prospective cohort (*N*=273) recruited from the same clinical setting. There were no significant differences reported between these two cohorts. The researchers assessed delirium in both cohorts using the CAM. The DPS had an area under the curve (AUC) of 0.83 (95% CI; 0.77 – 0.90) with sensitivity 76% and specificity 81%. This study reported one of the first validated risk-stratification tools for patients with AIS or ICH.

Since the presented literature highlights the difficulty of detecting delirium by clinicians, the most effective strategy would be to prevent delirium in the first place. The DPS is a risk-

stratification tool developed specifically for patients with AIS or ICH and an important tool for targeting patients for prevention strategies. If patients are risk-stratified as a first step toward implementing appropriate delirium prevention strategies, it is likely that the difficulties of reliable recognition will be mediated by a lower overall incidence of delirium due to prevention. The reviewed DPS represents a valid approach to be used for this purpose.

Methods

Study Design and Population

This project was conducted in a large urban quaternary academic medical center. The Advanced Practice Providers (APPs) (Nurse Practitioners, *n*=9 and Physician Assistant, *n*=1) assigned to the NCCU were asked to implement the DPS with each adult patient admitted to the 10-bed East NCCU with an AIS or ICH (*N*=20) over a six-week period. Since the purpose of this project was to assess the feasibility and usability of the DPS, there were no exclusion criteria. Patient-specific data was not collected. The University of Maryland Baltimore Institutional Review Board approved this project and informed consent was not required.

Procedures

During the one week education phase of this project (see Figure 3), the project coordinator (PC) provided individual in-service education for each APP and reference materials needed to calculate the DPS (see Appendix A). There was a 10 day run-in phase during which the APPs calculated the DPS within 48 hours of a patient's admission to the NCCU. The APPs recorded the DPS category (low, moderate, high) in their progress note in the Electronic Medical Record (EMR). The purpose of the run-in phase was to assess the adequacy of the project procedures and APP performance of the DPS. Collecting data for final analysis immediately after the introduction of the DPS tool and the project procedures has a low likelihood of accurately

reflecting the true performance of the APPS. The PC performed audits of all APP notes in the EMR during the run-in period and provided verbal feedback to all APPs during this phase.

After completing the education and run-in phases, the implementation phase of the project continued with the APPs calculating and recording the DPS and documenting the risk category as described with the run-in phase. The PC audited patient EMRs three times a week and reported the current week and overall compliance rates to the APPs as aggregated data via email. Individual feedback and additional education were provided to individual clinicians (*n*=4/10, 40%) as needed. In previous research, Bowen, Stanton, & Manno (2012), implemented the CAM-ICU in an ICU setting using Roger's Diffusion of Innovations theory and their overall compliance benchmark was greater than 80%. This DPS implementation project used the same compliance benchmark of greater than 80%.

Data Collection

Compliance with DPS use was assessed daily by prospective record review during the 10-day run-in phase and weekly by retrospective record review during the 6-week implementation phase. Documentation of the DPS in the APPs progress notes indicated performance compliance. The compliance data was recorded as a simple tally of compliant vs. noncompliant on a de-identified paper form.

At the conclusion of the implementation phase of the project, the APPs were invited to complete the System Usability Scale (SUS) to evaluate their perceptions of the usability of the DPS. The SUS was administered through an anonymous online survey service (SurveyMonkey Inc., Palo Alto, California). Survey participation was voluntary, and completed responses were computed using the standard methodology for the SUS described below. In addition to the SUS, the participants were asked to provide subjective feedback regarding the DPS.

Instruments

The DPS is a validated four-item prediction score developed specifically to be used with patients with AIS or ICH (Oldenbeuving et al., 2014). Clinicians using the DPS cross-referenced using a provided matrix (see Appendix C) the patient's age, the National Institutes of Health Stroke Scale (NIHSS) score, stroke subtype (i.e. anterior circulation, posterior circulation, lacunar, ICH), and the presence or absence of any patient infection at the time of admission. By using the DPS, clinicians are able to risk-stratify the patient's likelihood of developing delirium (low <5%, moderate 5%-20%, high >20%). This tool is limited in that it is newly developed and has not been widely used. However, the tool was developed specifically for the target patient population. Permission to use the DPS is not required.

Usability is an attribute of any product or process. In the context of this project, usability refers to the following components of the DPS and its use: 1) learnability – how easy was it to learn to use; 2) efficiency – does it take too much time to use; 3) memorability – how difficult will it be to use after a long period of non-use (i.e. how easy to re-learn); and 4) satisfaction – how enjoyable was it to use the DPS. The System Usability Scale (SUS) was used to measure the usability of the DPS. The SUS has been used extensively for more than 25 years and has been cited in over 1,200 publications (Brooke, 2013). The SUS is a valid 10-item questionnaire that is scored on a standard 5-item Likert scale (Strongly Disagree = 1 to Strongly Agree = 5) (see Appendix D). The SUS remains valid even when the sample size is small (Kortum & Peres, 2014). After collecting all of the participants' responses, the SUS is scored using a standard formula (see Appendix E). The total score is interpreted using the following ranges: Not Acceptable (0–64), Acceptable (65–84), and Excellent (85–100) (Bangor, Kortum, & Miller, 2008). The SUS is permitted for non-commercial, academic purposes without prior permission.

Data Analysis

All descriptive analyses were performed using computer software (Microsoft Excel for Mac, Version 15.13.1). Compliance was assessed with descriptive statistics both weekly (*n*, %) and in the aggregated total over the course of the six-week project (*N, M, SD, %*). The results of the SUS were analyzed using the standard SUS methodology (see Appendix D). Due to the small patient sample size and limited variables to be collected, no further analyses were planned.

Results

Compliance

Over the six-week implementation phase, the APPs were compliant with the use of the DPS (*n*=18/20, 90%) (see Figure 3). Most of the APPs (*n*=7/10, 70%) completed at least one DPS. Two patients (one each in weeks 2 and 3) did not have a documented DPS assessment. Both of these patients were cared for by the same two APPs. On individual follow-up, these APPs said “it takes too much time” (*n*=1) and “I just don't care about it” (*n*=1). They declined to further participate in the project.

Usability

The SUS survey was completed by the APPs (*n*=8/10, 80%). The SUS score was 76.7, within the range considered acceptable (65–84). The responses to the open-ended questions regarding the usability, barriers, and facilitators of the DPS (see Table 6) were overall positive. The respondents found the DPS to be easy to learn and use. They did not identify anything about the DPS that they disliked. The identified barriers included the challenge of remembering to use a new tool and that incomplete pre-admission documentation posed a challenge for using the DPS.

Discussion

Patients with AIS or ICH are at-risk for delirium. The patients who are at the highest risk are twice as likely to develop delirium (Miller & Miller, 2008). Delirium is associated with worse clinical outcomes (Carin-Levy et al., 2012; Shi et al., 2012). Delirium can be difficult to detect in the clinical setting. Therefore, effective prevention strategies should be implemented, especially with the most at-risk patients. The implementation of a valid and usable DPS for this patient population (AIS or ICH) could allow clinicians to identify highly at-risk patients and target those patients for delirium prevention strategies.

The purpose of this project was to implement and evaluate the usability of the DPS to risk-stratify patients admitted to the NCCU with AIS or ICH. The DPS was successfully implemented (compliance = 90%) by the APPs. The APPs also judged the DPS to be usable. Their qualitative feedback was positive (see Table 4).

The author successfully designed and implemented this project using the principles outlined in Greenhalgh's Diffusion Model. This model was used as a structure to increase the likelihood of success through the best sequencing of the essential elements of the project (see Table 1 and Appendix A). This theory-based approach assisted the author in the journey from the discovery of the innovation to the adoption by the APPs through diffusion and dissemination.

Factors that also supported the project included a culture of inquiry at the clinical site and within the APP team. Early and enthusiastic adoption by some of the APPs, who then became "champions" greatly facilitated the implementation. Lastly, there was strong support for the project from the nursing and medical leadership.

The DPS is a valid and usable tool for delirium prediction. The strengths of the DPS include: 1) all of the four data elements should be available by the time of a patient's admission;

2) it is easy to use; and 3) it is specific to the target patient population. One limitation of this project is that it was underpowered to detect significant results. In addition, the study did not track the actual incidence of delirium in this population, which could have strengthened the validity of the DPS tool. The major limitation of the DPS is that it is not valid in any patient population other than AIS or ICH. If the NCCU were to incorporate the DPS into routine use, additional tool(s) would need to be identified for additional populations. The author has not been able to identify any single tool that is valid with all patient populations in the specific NCCU.

Future implementation of another admission assessment tool (whether for delirium or another phenomenon) would be strengthened by increasing the number of staff involved in the design of the project as well as the number of staff performing the duties of the project coordinator. Placing the tool within the routine documentation process (e.g. EMR) would address the identified barrier of remembering to do the assessment. A minority of APPs (2/11, 18%) demonstrated behaviors of resistance to change. The demonstrated resistance is a common response seen with change implementation. Future projects should include planning for and proactively managing resistance (Bruckman, 2008; Young, 2007). A more thorough discussion of resistance management is beyond the scope of this paper.

In conclusion, patients with AIS or ICH commonly have delirium and when they do, they have worse clinical outcomes. In order to best prevent delirium, the clinician must first identify at-risk patients at the time of admission to the acute care setting. The author has presented a successfully implemented, reliable and usable DPS that was developed for risk-stratifying patients with AIS or ICH in the NCCU. The DPS tool was judged to be usable in the study setting. In conclusion, the DPS is a tool that should be considered for use with patients with AIS or ICH in a NCCU setting.

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Table 1

Selected Elements of Greenhalgh's Diffusion of Innovation in Service Organizations Model Used for the Translation and Implementation of a Delirium Prediction Score (DPS) with Acute Stroke

Major Concept	Sub-Concept	Notes
The Innovation	Relative Advantage	DPS developed and validated in patients with AIS or ICH
	Complexity	DPS has 4 simple data elements, scored once within 48 hours of admission
	Trial ability	May be piloted prior to full implementation
	Observability	Increased diagnosis of and earlier intervention for delirium
	Task Issue	The implementation results in the performance of an auditable task that increased the likelihood of adoption
	Knowledge Required to use the DPS	Specific training on the use of the tool was required
Adoption by Individuals	Concern in Pre-adoption Stage	APPs needed to: • Be aware of the innovation • Have sufficient information about what the DPS is and how it is used • Have clarity about what using the DPS will mean to them
	Concerns in Early Use Stage	APPs needed: • Feedback about the success of the DPS in meeting the intended goals • Support and clarification about how to use the DPS and how to incorporate it into clinical decision making
	Concerns in Establishment Stage	APPs needed: • Feedback about the clinical benefits of continued use of the DPS • Had the opportunity to adapt and refine the use of the DPS
Assimilation by the System	Formal Decision Making Process	The institution made delirium prevention and treatment a clinical priority in the NCCU
	Evaluation Process	The DPS is the only reliable and valid delirium prediction method developed specifically for AIS or ICH
	Planned and Sustained Implementation Process	This was the focus of the implementation plan

Table 1 (cont.)

Major Concept	Sub-Concept	Notes
Diffusion and Dissemination	Network Structure	Incorporate the vertical structure typical of nursing organizations (Unit Nurse Manager, CNE, Charge Nurses, SCN)
	Champions	The APPs were the DPS Champions
	Formal Dissemination Program	Most effective if the program: • Does not place a significant burden on the APPs • Tailored to the specific needs of the APPs in the NCCU • Used relevant and appropriate language, training methods, etc. • Included appropriate evaluation and dissemination of outcomes
System Antecedents for Innovation	Structural Determinants of Innovation	The institution and the NCCU had the following positive characteristics: • Embraced complexity and specialization in each ICU • Supported by the nursing and medical leadership • Stable leadership structure and adequate tenure of leaders • Emphasis on professionalism throughout the organization
System Readiness for Innovation	Tension for Change	The APPs did not have an existing method of risk-stratification
	Innovation-System Fit	The DPS fit within the clinical assessment and documentation system
	Assessment of Implications	The outcomes of the project were reported to the APPs and medical staff
	Support and Advocacy	The implementation plan had the support of the APPs and medical leaders in the NCCU
	Dedicated Time and Resources	The implementation plan included the establishment of adequate resources for staff education, monitoring, and outcomes measurement
	Capacity to evaluate the Innovation	Compliance with performance of the DPS and discussion of the score results with the multidisciplinary team was measured and reported as appropriate

Note. AIS = acute ischemic stroke; APP = Advanced Practice Provider (Nurse Practitioner or Physician Assistant); CNE = Clinical Nurse Educator; DPS = delirium prediction score; ICH = intracerebral hemorrhage; ICU = Intensive Care Unit; NCCU = Neurocritical Care Unit; SCN = Senior Clinical Nurse. Adapted from "Diffusion of innovations in service organizations: systematic review and recommendations" by T. Greenhalgh, G. Robert, F. Macfarlane, P. Bate, and O. Kyriakidou, 2004, *Milbank Quarterly*, *82*(4), 581-629. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2690184/

Table 2

Summary Table of Literature Review

Author Year Country	Study objective	Design	Sample (*N*)	Outcomes studied	Results	Level* and Quality Rating**
Olden-beuving, de Kort, van Eck van der Sluijs, Kappelle, & Roks 2014 Nether-lands	Develop and validate a risk score to predict delirium in patients with AIS or ICH. Final goal of the risk score was to develop a tool that could be used by a clinician with easily obtainable information at the time of patient admission.	Both cohorts were prospectively recruited in a large urban academic medical center. **Development cohort** • Cohort patients with AIS or ICH enrolled in a previous study of delirium. • Identified independent risk factors for delirium • Used factor analysis and factor loading to develop a tool **Validation cohort** • Prospective cohort **Validity testing** • Prospective cohort	Development cohort (527) Prospective cohort (273)	Delirium: CAM The CAM-ICU would have been a more appropriate tool for measuring delirium in this setting. The authors do not discuss the criteria for their selection choice.	No significant difference between the characteristics of the development and validation cohorts. Results: (AUC, 95% CI, Sensitivity%, Specificity%) (0.84, 0.80-0.89, 76%, 81%) Included: Age, NIHSS, Stroke sub-type, Infection y/n The authors developed a color coded matrix that allows the clinician to quickly use cross tabulation to determine the patient's risk category – low (<5%), moderate (5%-20%), or high (>20%). The matrix also contains the specific risk% within each cell of the matrix (see Appendix B)	IV - A

Table 2 (cont.)

Author Year Country	Study objective/ intervention or exposures compared	Design	Sample (*N*)	Outcomes studied	Results	Level* and Quality Rating**
Spronk, Riekerk, Hofhuis, & Rommes 2009 Nether-lands	How well ICU nurses and Intensivists recognize delirium during daily care compared to the CAM-ICU.	Descriptive Cohort design • 10-bed ICU • 3-months • Inclusion: All patients admitted with LOS > 48 hrs. • Exclusion: Dementia Language barrier Deafness Active psychosis Severe neurological disorder (e.g. stroke). • Care nurses and Intensivists were asked to assess for delirium based on clinical impression. • Reference diagnosis established with CAM-ICU performed by research nurses.	Patients (46)	Delirium: a) Care nurses & Intensivists asked: Delirium yes, no, or unable to assess b) CAM-ICU performed by research nurse Level of patient arousal: RASS	Delirium diagnosed by: CAM-ICU (*n*=23, 50%) Nurse: sensitivity 0.35 specificity 0.98 Intensivist: sensitivity 0.28 specificity 1.00 Delirium is not detected by care nurses and Intensivists 65% - 72% of the cases, even when specifically asked to assess for delirium	III - C

Table 2 (cont.)

Author Year Country	Study objective/ intervention or exposures compared	Design	Sample (*N*)	Outcomes studied	Results	Level* and Quality Rating**
Rice, Bennett, Gomez, Theall, Knight, & Foreman 2011 United States	Compared the CAM-ICU performance variations between of hospital nurses and expert diagnosticians	Design: Prospective descriptive Setting: 541-bed tertiary care academic medical center • Paired evaluations (nurse vs. expert) performed every other day performed within the same time frame and the same patient both using CAM-ICU	Volunteer Staff Nurses (167) Patients (170) Age mean 75.8 yrs. Total paired evaluations (555)	Delirium: CAM-ICU	Delirium detected: • Researcher *N*=12 (7%) • Nurses agreement with expert *N*=3/12 (25%) Sensitivity 25% Specificity 99% 0.34 PPV 0.60 NPV 0.98 The nurses had a significant Type-1 error rate (75%) but no significant Type-2 errors.	II - A

Note. * = See Table 5. ** = See Table 6. AIS = acute ischemic stroke; AUC = area under the curve; CAM = Confusion Assessment Method; CAM-ICU = Confusion Assessment Method for the Intensive Care Unit; CI = confidence interval; ICH = intracerebral hemorrhage; ICU = Intensive Care Unit; LOS = length of stay; NIHSS = National Institutes of Health Stroke Scale; NPV = negative predictive value; PPV = positive predictive value; RASS = Richmond Agitation Sedation Scale; ROC = receiver operating characteristics curve.

Table 3.

Delirium Prediction Score (DPS) Completion Percentages per Week and Total

	Admissions (*N*)		DPS Compliance (*n*, %)			
Week	Unit Total	Stroke/ICH	Completed		Not Completed	
1	10	1	1	100	0	0
2	10	4	3	75	1	25
3	10	5	4	80	1	20
4	9	2	2	100	0	0
5	12	5	5	100	0	0
6	7	3	3	100	0	0
M	9.67	3.33	3.00	92.5	0.03	7.5
SD	3.26	3.26	3.04	13.36	0.52	11.73
Total	58	20	18	90%	2	10%

Note. ICH = intracerebral hemorrhage; *M* = mean; *SD* = standard deviation

Table 4.

Responses to Open Ended Questions Regarding the Usability, Barriers, and Facilitators of the Delirium Prediction Score

Question	Response
Please describe what you liked about the DPS score.	• I appreciated the table to help us easily figure out the score! • It has potential to be useful to predict those who may be more likely to develop delirium and potentially intervene, prevent or at least be looking for delirium in our differential for high risk patients.
Please describe what you would change about the DPS score.	• Nothing I thought it was very simple to use. • Unsure, my first experience with it. My questions about how to calculate it were easily answered and once clarified, I found it easy to use.
Please describe any facilitators that you noticed about the implementation process for the DPS score.	• The availability of the handout describing how to score patients was very helpful • I had to get a few things clarified to effectively use the score, but once I had those questions answered I found the score easy to calculate.
Please describe any barriers that you noticed about the implementation process for the DPS score.	• The only real barrier to completing the score is remembering to complete the score on admission that will come with repetition • If not calculated initially, it can be challenging to go back and find the admission NIHSS and info Needed after the fact as you are relying on other providers (*sic.*) documentation (sometimes outside the NCC team) which may or may not include what you need. Extrapolating a NIHSS from a documented exam can be challenging.

Table 5

Rating System for the Hierarchy of Evidence

Level of the Evidence	Type of the Evidence
I	Evidence from: systematic review meta-analysis of all relevant randomized controlled trails (RCTs) practice-guidelines based on systematic review of RCTs
II	Evidence obtained from well-designed RCT
III	Evidence obtained from well-designed controlled trials without randomization
IV	Evidence from well-designed case-control and cohort studies
V	Evidence from systematic reviews of descriptive and qualitative studies
VI	Evidence from a single descriptive or qualitative study
VII	Evidence from the opinion of authorities and/or reports of expert committees

Note. Adapted from *Evidence-Based Practice in Nursing & Healthcare: A Guide to Best Practice, Second Edition,* p. 12, by B. M. Melnyk and E. Fineout-Overholt, 2011, Philadelphia: Wolters Kluwer Health | Lippincott Williams & Wilkins.

Table 6

Rating Scale for Quality of the Evidence

Rating	Evidence Type	Characteristics
(A) High	Scientific	Consistent results with sufficient sample size, adequate control, and definitive conclusions; consistent recommendations based on extensive literature review that includes thoughtful reference to scientific evidence
	Summative reviews	Well-defined, reproducible search strategies; consistent results with sufficient numbers of well-defined studies; criteria-based evaluation of overall scientific strength and quality of included studies; definitive conclusions
	Experiential	Expertise is clearly evident.
(B) Good	Scientific	Reasonably consistent results, sufficient sample size, some control, with fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence.
	Summative reviews	Reasonably thorough and appropriate search; reasonably consistent results with sufficient numbers of well-defined studies; evaluation of strengths and limitations of included studies; fairly definitive conclusions.
	Experiential	Expertise seems to be credible.
(C) Low quality or major flaws	Scientific	Little evidence with inconsistent results, insufficient sample size, conclusions cannot be drawn.
	Summative reviews	Undefined, poorly defined, or limited search strategies; insufficient evidence with inconsistent results; conclusions cannot be drawn.
	Experiential	Expertise is not discernable or is dubious.

Note. Adapted from "Examining the support for evidence-based nursing practice," by R. P. Newhouse, 2006, *Journal of Nursing Administration, 36*(7-8), 337-340

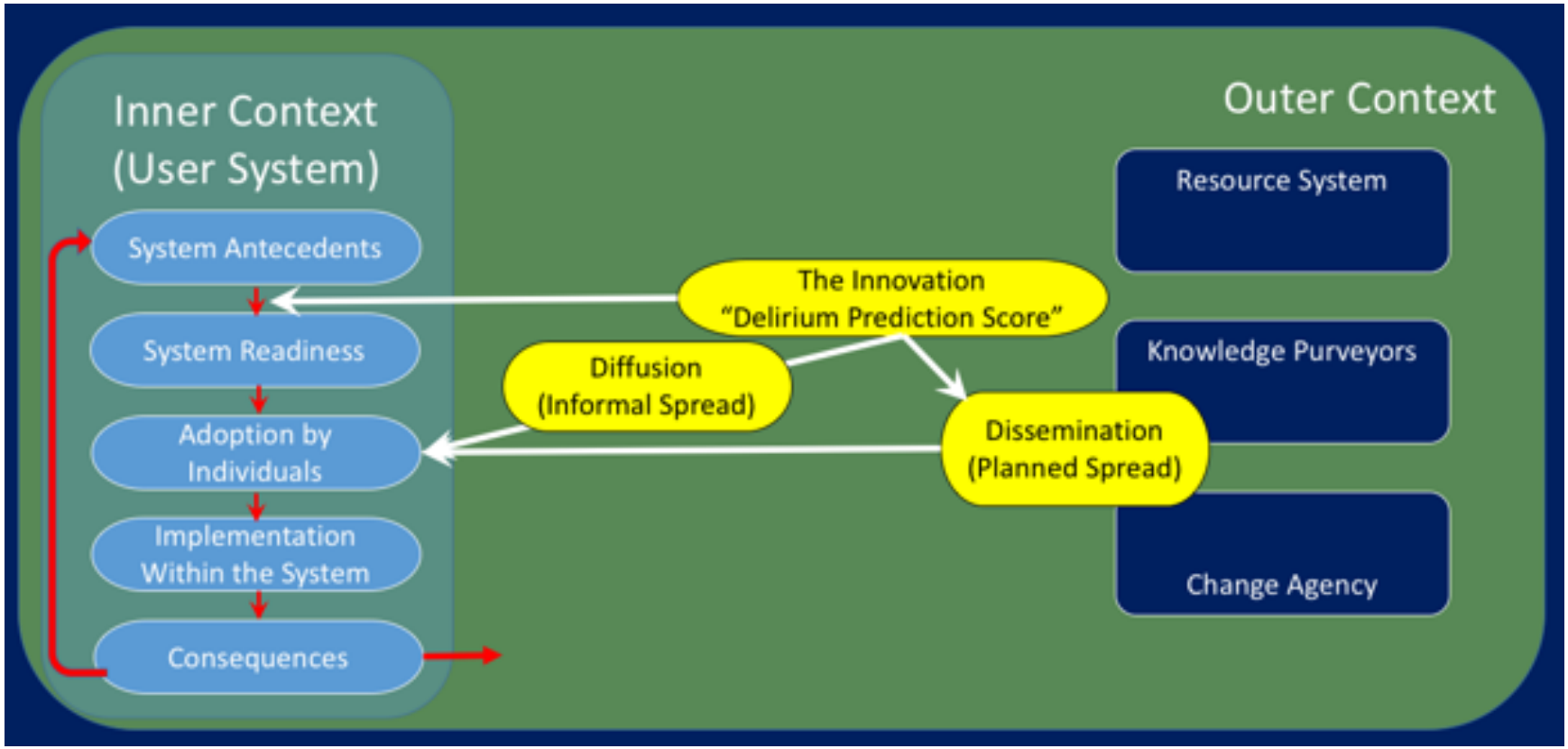

Figure 1. Greenhalgh's Diffusion of Innovation in Service Organizations Model. This model of Greenhalgh's is used to illustrate the components with a system (Inner Context), the resources needed to effect a change (Outer Context), and where the Innovation fits into the system and how it can be incorporated into sustained use through Diffusion and Dissemination. Adapted from "Diffusion of innovations in service organizations: Systematic review and recommendations," by T. Greenhalgh, G. Robert, F. Macfarlane, P. Bate, and O. Kyriakidou, (2004), *The Milbank Quarterly*, *82*(4), p. 595.

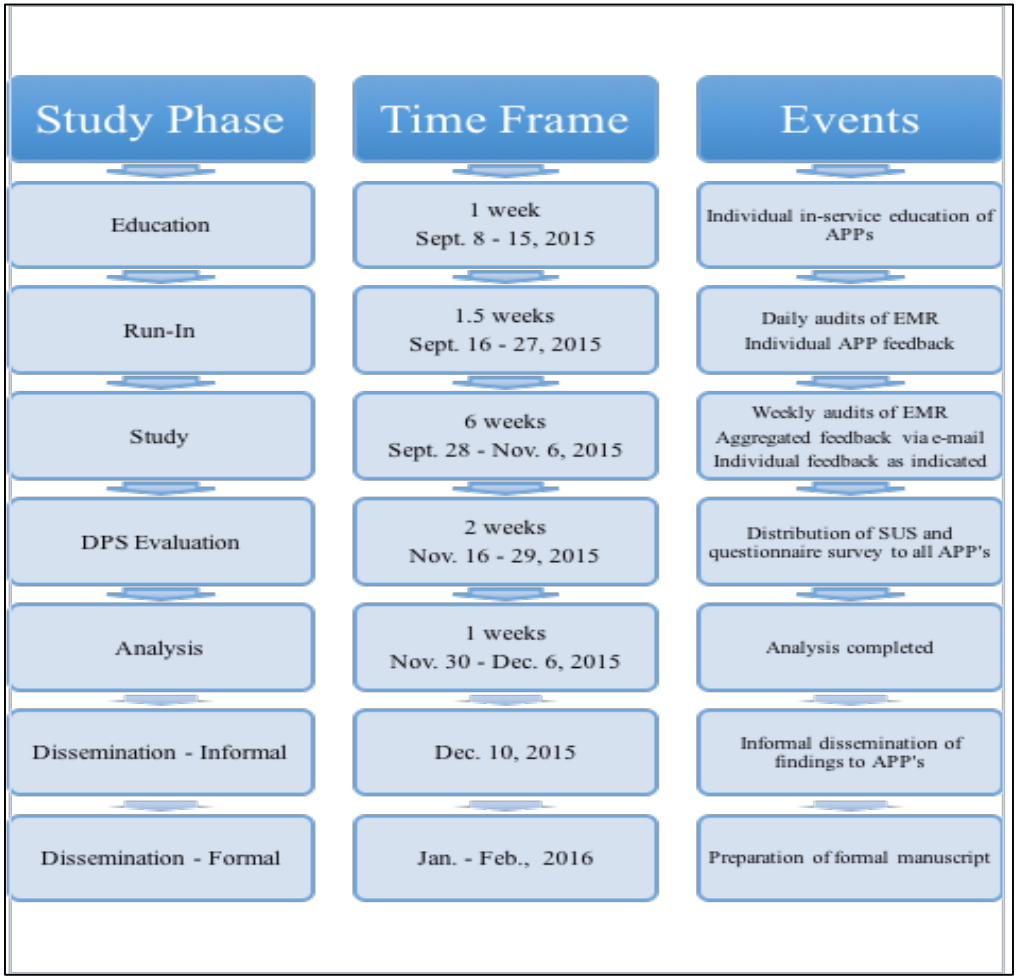

Figure 2. Flow diagram of Implementation of a Delirium Prediction Score in Patients with Acute Stroke project.

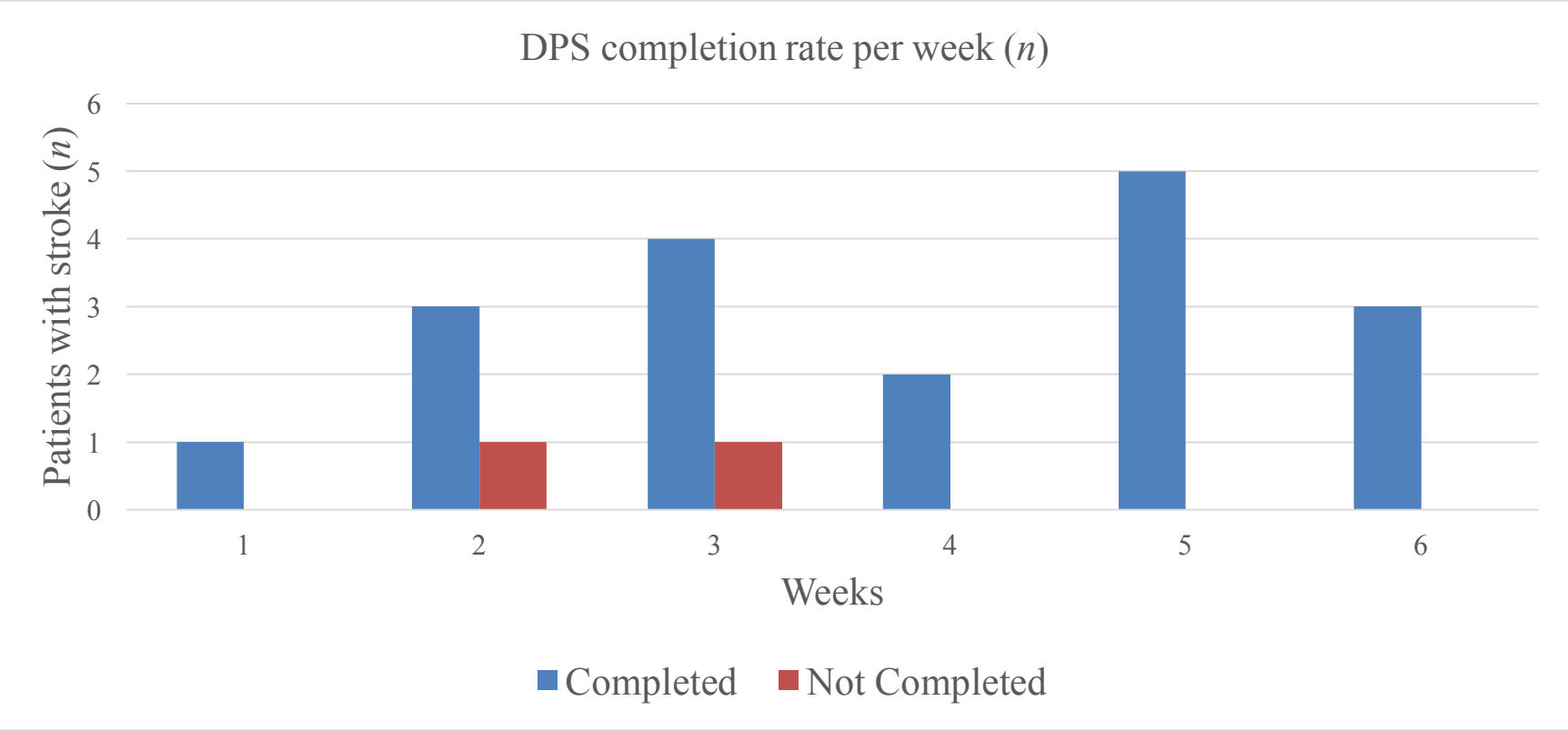

Figure 3. Total number of completed and not completed DPS assessments per week. Included trend lines for completed and not completed assessments.

Appendix A

Detailed Implementation Plan and Timeline

What	Who	When	How
Pre-implementation education			
Educate APPs on the DPS	PC	Sep. 8 – 15, 2015	Interactive individual in-service. Review delirium • Definition • Assoc. outcomes • Prevention strategies • Treatment strategies DPS training • Score items • Calculating the score • Interpreting the score Documentation – add risk-category to diagnosis section of the APPs progress note.
Project implementation			
Distribute DPS interpretation matrixes • 8.5 x 11" laminated matrixes will be placed in each patient's bedside chart • Laminated pocket card matrixes will be distributed to all APPs. • Additional materials will be stored in the APPs office. • Essential for calculating the patient risk-category	PC	Sep. 8 – 15, 2015	Distribute as planned Audit their presence and replenish as needed Record the total resources expended
Monitor compliance with DPS completion during the project period. This data will be collected as an aggregate total and not recorded for each individual patient. This procedure does not involve data collection with unique patient identifiers	PC	Daily during the 10-day run-in period Every week during the 6-week pilot project	Goal $\geq$ 80% Calculate compliance in the aggregate Provide additional feedback and education for APPs as needed

Appendix A

Detailed Implementation Plan and Timeline

What	Who	When	How
Project implementation (cont.)			
Data collection			
Complete data collection for DPS compliance	PC	Every week November 6, 2015	• Complete DCS's • Secure and maintain all paper data in a locked file cabinet in locked room • Prepare spreadsheet • Enter collected data into the spreadsheet • Maintain spread sheet on facility computer
Data Analysis Prepare tables: • Compliance rate for the complete study period (*M*, *SD*, %) • Assess for weekly variation	PC	December 6, 2015	• Overall compliance rate (*M, SD,* %) • Aggregated total SUS and individual item analysis (*M, SD*) • List of identified facilitators and barriers
Dissemination / Post-Implementation			
• Present final results at the December APP staff meeting		December 10, 2015	Complete all data collection and finalize the Excel spread sheet.
• Prepare and present the completed Scholarly Project for academic review and DNP defense		January - February, 2015	
• Submit the completed project in abstract form for a national clinical/academic meeting		July, 2015	
• Submit the completed project in manuscript form to a peer reviewed journal (after presentation at a national meeting).		December, 2016	

APP = advanced practice provider (Nurse Practitioner/Physician Assistant); DNP = Doctor of Nursing Practice; DPS = Delirium Prediction Score; *M* = mean*;* PC = project coordinator; *SD* = standard deviation; SUS = System Usability Scale.

Appendix B

Interpretation Matrixes for Determination of Risk of Developing Delirium using the Delirium Prediction Score (DPS).

No Infection

Age	ICH				Lacunar				Posterior				Anterior			
NIHSS	0-1	2-3	4-6	7+	0-1	2-3	4-6	7+	0-1	2-3	4-6	7+	0-1	2-3	4-6	7+
< 40	0	1	2	4	0	1	2	5	1	1	3	7	1	3	6	13
40-50	0	1	2	5	1	1	3	7	1	2	4	9	1	3	8	16
50-60	1	1	3	6	1	2	4	9	1	2	5	12	2	4	10	20
60-70	1	2	4	8	1	2	5	12	1	3	7	15	2	6	12	25
70-80	1	2	5	11	1	3	7	15	2	4	9	18	3	7	16	31
80-90	1	3	6	14	2	4	9	18	2	5	11	23	4	9	20	37
> 90	2	4	8	17	2	5	11	23	3	6	14	28	5	12	24	43

Infection

Age	ICH				Lacunar				Posterior				Anterior			
NIHSS	0-1	2-3	4-6	7+	0-1	2-3	4-6	7+	0-1	2-3	4-6	7+	0-1	2-3	4-6	7+
< 40	1	2	6	13	2	4	8	17	2	5	10	21	4	9	18	35
40-50	1	3	7	16	2	5	10	21	3	6	13	26	5	11	23	41
50-60	2	4	9	20	3	6	13	26	3	8	16	32	6	14	28	48
60-70	2	5	12	25	3	7	16	33	4	10	21	38	8	18	34	55
70-80	3	7	15	30	4	10	21	38	6	12	25	45	11	22	40	62
80-90	4	9	19	36	6	13	25	45	7	16	31	52	13	27	47	68
> 90	5	11	24	43	7	16	31	52	9	20	37	58	17	33	54	74

Note. Individual value in colored boxes represents the risk percentage. Green represents low-risk category (< 5%), Yellow represents moderate-risk category (5% - 20%), Red represents high-risk category (> 20%). ICH = intracerebral hemorrhage; LACI = Lacunar Infarction; NIHSS = National Institutes of Health Stroke Scale; PACI = Partial Anterior Circulation Infarction; POCI = Posterior Circulation Infarction; TACI = Total Anterior Circulation Infarction. Adapted from "An early prediction of delirium in the acute phase after stroke," by A.W. Oldenbeuving, P. L . M de Kort, J. F. van Eck van der Sluijs, L. J. Kappelle, and G. Roks, 2014, *Journal of Neurology, Neurosurgery, and Psychiatry*, *85*(4), 431–434

Appendix C

System Usability Score (SUS)

		Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
	Question	0	1	2	3	4
1	I think that I would like to use this product frequently	☐	☐	☐	☐	☐
2	I found the product unnecessarily complex	☐	☐	☐	☐	☐
3	I thought the product was easy to use	☐	☐	☐	☐	☐
4	I think that I would need the support of a technical person to be able to use this product	☐	☐	☐	☐	☐
5	I found that the various functions in this product were well integrated	☐	☐	☐	☐	☐
6	I thought that there was too much inconsistency in this product	☐	☐	☐	☐	☐
7	I would imaging that most people would learn to use this product very quickly	☐	☐	☐	☐	☐
8	I found the product very awkward to use	☐	☐	☐	☐	☐
9	I felt very confident using the product	☐	☐	☐	☐	☐
10	I needed to learn a lot of things before I could get going with this product	☐	☐	☐	☐	☐

Note. Adapted from "An empirical evaluation of the System Usability Scale," by A. Bangor, P. T. Kortum, and J. T. Miller, 2008, Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, *24*(6), 574–594.

Appendix D

How to score the System Usability Score (SUS)

The SUS score is a single number that represents the overall usability of a system (e.g. product, process)

The **ODD** number questions assess **POSITIVE** qualities of the system

The **EVEN** number questions assess **NEGATIVE** qualities of the system

The SUS has a built in bias that places greater emphasis of the negative qualities than the positive ones.

Scoring process

1. Determine the numerical value or each response to the 10 questions with Strongly Disagree = 1 and Strongly Agree = 5
2. For each of the **ODD** number questions, subtract 1 from the raw response value (range 0 to 4)
3. For each of the **EVEN** number questions, subtract 5 from the raw response value (range -4 to 0)
4. Sum all of the adjusted scores to obtain an adjusted overall score (range 0 to 40)
5. Multiply the adjusted overall score by a factor of 2.5 to obtain a normalized final score (range 0 to 100)

Note. Adapted from "An empirical evaluation of the System Usability Scale," by A. Bangor, P. T. Kortum, and J. T. Miller, 2008, Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, *24*(6), 574–594.