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Original Research Report

Validation of a Nurse-Based Delirium-Screening Tool for Hospitalized Patients

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Background: *Guidelines recommend daily delirium monitoring of hospitalized patients. Available delirium-screening tools have not been validated for use by nurses among diverse inpatients.* **Objective:** *We sought to validate the Nursing Delirium-Screening Scale (Nu-DESC) under these circumstances.* **Methods:** *A blinded cross-sectional and quality-improvement study was conducted from August 2015–February 2016. Nurses' Nu-DESC scores were compared to delirium diagnosis according to Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) criteria. A total of 405 consecutive hospitalized patients were included. Nu-DESC-positive (threshold score ≥2) patients were matched with equal numbers of Nu-DESC-negative patients, by sex, age, and nursing unit. Nurses recorded a Nu-DESC score for each patient on every 12-hour shift. A Nu-DESC-blinded evaluator interviewed patients for 2 consecutive days. Delirium diagnosis was determined by physicians using DSM-5 criteria applied to collected research data. Sensitivity and specificity of the Nu-DESC were calculated. In an exploratory analysis, the performance of the Nu-DESC was analyzed with the addition of bedside measures of attention.* **Results:** *The sensitivity of the Nu-DESC at a threshold of ≥2 was 42% (95% CI: 33–53%). Specificity was 98% (97–98%). At a threshold of ≥1, sensitivity was 67% (52–80%) and specificity 93% (90–95%). Similar results were found with the addition of attention tasks.* **Conclusion:** *The Nu-DESC is a specific delirium detection tool, but it is not sensitive at the usually proposed cut point of ≥2. Using a threshold of ≥1 or adding a test of attention increase sensitivity with a minor decrease in specificity.*

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Key words: inpatient delirium screening, Nu-DESC, nursing delirium screen.

INTRODUCTION

Delirium surveillance is recommended for hospitalized patients due to the pervasive nature and deleterious effects of delirium, which may be mitigated by early identification, diagnosis, and treatment.[1–3] Delirium is characterized by disturbances in attention, awareness, and cognition that are acute or subacute in onset and fluctuating in nature. Often, there is evidence of a causative underlying general medical

Received March 31, 2017; revised May 30, 2017; accepted May 30, 2017. From the Department of Internal Medicine (A.H.); Department of Psychiatry (J.B., J.A.B.); Department of Epidemiology and Biostatistics (J.N.); Department of Neurology (S.A.J.); Department of Nursing (J.C., M.L.); Department of Anesthesia (J.L.); and Department of Neurology (V.D.),University of California San Francisco, San Francisco, CA. Send correspondence and reprint requests to Vanja Douglas, MD, UCSF Department of Neurology, 505 Parnassus Ave M798, San Francisco, CA 94143-0114; e-mail: vanja.douglas@ucsf.edu

condition.[4] Delirium affects 11–64% of hospitalized patients, depending on the cohort studied, and has been shown to independently lead to greater mortality and morbidity,[2,5–9] translating into increased costs for the health care system ranging from $38–$152 billion per year in the United States alone.[10] Studies have demonstrated that more than 50% of cases of delirium are missed, which is associated with further increased morbidity and mortality due to delay in diagnosis and management.[1,11–16]

Delirium screening may be an important means of decreasing the severity and duration of delirium episodes, thereby potentially lessening its consequences and costs.[17–19] Tools have been developed to assist with the diagnosis of delirium in a more time-efficient manner than the rigorous application of the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) criteria by formal clinical interview.[2] The Nursing Delirium-Screening Scale (Nu-DESC) was designed for nurses, who are more frequently at a patient's bedside and are thus in a position to witness the characteristic fluctuations of delirium. The Nu-DESC is a scale that rates the severity of 5 delirium characteristics from 0 (not present) to 2 (severe) based purely on the nurse's observations of their patient's behavior over the course of their shift and takes only 1–2 minutes to complete.[20]

Although the Nu-DESC has the advantage of being brief and simple, it has not been thoroughly validated in diverse inpatient populations. The original study introducing the tool reported a sensitivity of 85.7% and specificity of 86.8% among hematology-oncology/internal medicine patients when the threshold for delirium diagnosis was set at ≥ 2.[20] However, a subsequent study using the same threshold in postoperative patients demonstrated 29% sensitivity at a threshold of ≥ 2 and 72% sensitivity at a threshold of ≥ 1.[21]

Other delirium-screening tools exist, but either show low sensitivities when used by bedside nurses or take a longer time to administer than the Nu-DESC. The Confusion Assessment Method (CAM)[22] was designed for use by nonpsychiatry-trained physicians and has been widely validated for use by researchers or trained individuals, but when applied by nurses had a sensitivity of 66.7% and specificity of 90.7%.[23] The Clinical Assessment of Confusion also has a low sensitivity (36%).[24] The Delirium Observation Scale had good predictive validity against a DSM-IV-TR delirium diagnosis, but was only studied in a cohort with 22 delirious patients and is a 25-item scale that takes 5 minutes to administer.[25,26] Similarly, although the NEECHAM Confusion Scale has high sensitivity (95%) and specificity (78%), it takes 10 minutes to administer.[26]

Therefore, we sought to clarify the test characteristics of the Nu-DESC in a clinically diverse inpatient population at a large tertiary hospital to determine whether this brief and efficient screen could be used by nurses systematically to accurately identify patients with delirium.

MATERIAL AND METHODS

Study Design

This blinded cross-sectional study compared the Nu-DESC scores obtained by nurses to a diagnosis of delirium based on DSM-5 diagnostic criteria made by both a board-certified neurologist (V.D.) and a board-certified psychiatrist (J.A.B.) through interpretation of standardized patient vignettes recorded by a trained interviewer.

Participants and Setting

The study was conducted at a university hospital in San Francisco from August 2015 to February 2016. All patients on 3 nursing units, regardless of age, primary language, or comorbid neurologic or psychiatric conditions were screened with the Nu-DESC every 12 hours as part of routine clinical care and were eligible for inclusion. One nursing unit had a neuroscience focus (neurology and neurosurgery); 2 were surgical units that also included spine neurosurgery. Of patients included in our study, 103 participants (25%) were admitted to neurology, 84 (21%) to general medicine, 82 (20%) to general or orthopedic surgery, and 136 (34%) to neurosurgery. Every Monday through Friday morning, all patients with positive Nu-DESC scores (threshold $\geq$ 2) during the previous shift were matched with an equal number of Nu-DESC-negative (score: 0–1) patients according to age ($\pm$5 years), sex, and nursing unit and were approached for participation within 8 hours. Patients who were transferred to the intensive care unit before they could be approached were excluded. The Committee on Human Research at the University

of California San Francisco approved the study. Because this study was a Quality-Improvement project designed to assess an intervention already incorporated into routine clinical care (i.e., Nu-DESC screening), a waiver of informed consent was granted, but assent was obtained from all eligible participants. Of 421 patients screened, 410 were eligible and all but 5 agreed to participate.

Test Methods

A single Nu-DESC-blinded research assistant (A.H.) evaluated Nu-DESC positive and negative patients, conducting chart reviews and structured interviews with patients, their nurses, and caregivers. Cognitive testing was performed using the Montreal Cognitive Assessment (MoCA), which includes tests of attention (forward 5-digit span and reverse 3-digit span).[27] The same evaluation was repeated on 2 consecutive days. This information was used to compile a structured clinical vignette with required elements describing baseline cognitive function, whether there was a change from baseline attention or awareness, whether cognition or consciousness or both was fluctuating, and also current level of consciousness, attention, awareness, and additional cognitive deficits. Two validated delirium-screening tools were also completed: the CAM and the Delirium Rating Scale-Revised-98 (DRS-R98).[28,29] A blank copy of the structured interview and vignette is available in the Supplementary Material. These data were then later evaluated for delirium status by a board-certified neurologist (V.D.) and psychiatrist (J.A.B.) using DSM-5 criteria, both of whom were blinded to the Nu-DESC score. A similar methodology, using an expert to assign a delirium diagnosis to standardize information obtained by a research assistant, has been described previously.[30]

The research assistant was a fourth-year medical student trained in evaluating delirium and in the performance of the CAM and DRS-R98. Training used standardized methodology and consisted of sequential delirium assessments with independent ratings until perfect agreement was reached on the CAM and DRS-R98 between the research assistant and the trainer (V.D.).

Measures

Standard demographic characteristics, nursing unit, postoperative status, and medical comorbidities were collected from the medical record.

Nursing Delirium-Screening Scale

The Nu-DESC is an observational screen for delirium that assesses 5 items: (1) disorientation, (2) inappropriate behavior, (3) inappropriate communication, (4) hallucination, and (5) psychomotor retardation. Each characteristic is scored by severity from 0 (absent) to 2 (severe). The evaluation is based on a composite of observations collected over a 12-hour period. It takes less than 2 minutes to complete and is designed for use by nursing staff. A threshold of ≥ 2 is considered a positive screen for delirium.[20] The Nu-DESC was administered by trained nurses on participating hospital units. All nurses were given an in-service regarding use of the Nu-DESC. A nurse champion on each floor provided continuing education and encouraged compliance with Nu-DESC administration, which averaged 71%. The highest Nu-DESC score recorded in the electronic medical record over the 2-day evaluation period and the 12 hours immediately preceding it (5 observations) was used and compared to the reference standard.

DSM-5 Reference Standard

A board-certified neurologist and psychiatrist independently applied DSM-5 criteria to the 405 clinical vignettes written by the research assistant. Disagreements between these physicians were adjudicated by discussion until a consensus was reached ($n = 6$, $\kappa = 0.97$). Compared with the CAM assigned by the research assistant, application of DSM-5 criteria resulted in a different diagnosis 12 times ($\kappa = 0.94$). Delirium diagnosis was further categorized into hypoactive, hyperactive, and mixed subtypes based on DSM-5 definitions using DRS-R98 categories.[31,32]

Nu-DESC with Attention Measure

Patients also underwent 2 tests of attention during each evaluation by the research assistant: a forward 5-digit span and reverse 3-digit span. These tests were chosen because they are part of the MoCA, easily translated and cross-culturally understood. In an

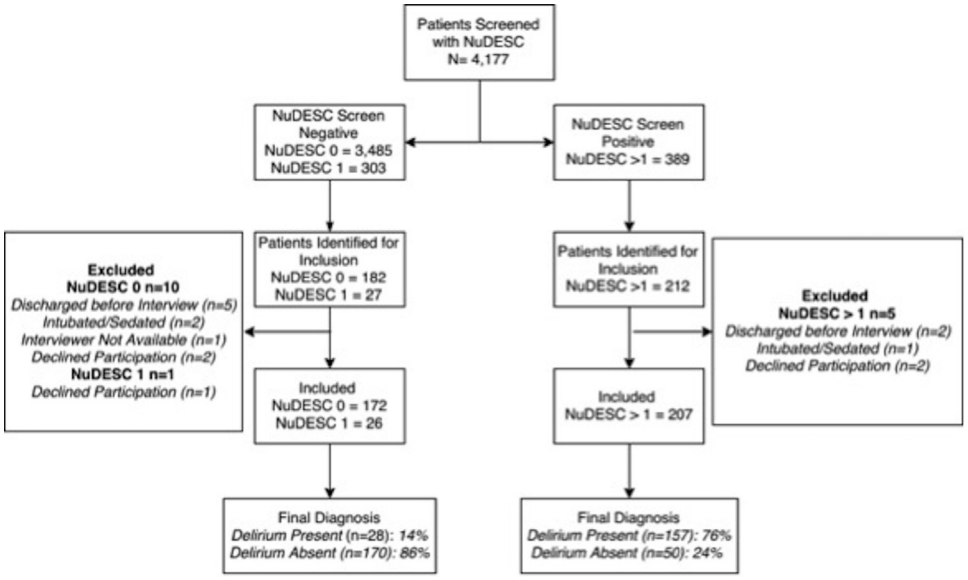
exploratory analysis, an incorrect attention task on either day added a point to the highest 2-day Nu-DESC score.

Statistical Analysis

Demographic and descriptive characteristics of the sample were stratified according to Nu-DESC status. Categorical variables were compared using the chi-squared test and continuous variables using the Student's *t*-test. Because patients who screen positive with the Nu-DESC are selected for a resource-intense delirium treatment pathway, one of our primary goals was to understand the positive predictive value (PPV) of the Nu-DESC. Therefore, we used an outcome-dependent sampling design by identifying patients based on their Nu-DESC screen results to enable us to capture as large a proportion of patients with a Nu-DESC score of ≥ 2. As the rate of delirium in our hospital in prior studies ranged from 12–15%, a cohort study design would have required assessment of too many screen-negative, nondelirious patients to capture enough screen-positive patients to obtain a reliable PPV.[33,34] We chose to match controls by nursing unit, age, and sex because we suspected that the Nu-DESC might be falsely positive in older patients with major neurocognitive disorder and in patients with traumatic and other brain injury on the neurosciences unit. To account for the verification bias that this sampling strategy introduces, we weighted the sample using the rates of Nu-DESC 0, 1, and ≥ 2 on the units under study and using the assumption that the false-negative rate in the Nu-DESC-negative patients who underwent verification in our study was the same as the false-negative rate in the Nu-DESC-negative patients who did not undergo verification in order to estimate delirium prevalence (Figure 1). Sensitivity and specificity were calculated for the Nu-DESC vs DSM-5 delirium diagnosis at Nu-DESC thresholds of ≥ 2 and ≥ 1 by fitting a weighted logistic regression with standard errors that accommodated the matching strategy.[35] The area under the receiver operating characteristic curve (AUC) for the Nu-DESC was computed. A target sample size of 392 was determined using an expected false-negative proportion of 0.15,[20] aiming for a 95% confidence interval with a precision of ± 0.05 around the sensitivity of the Nu-DESC.[36]

Because the Nu-DESC relies solely on behavioral observations and does not include a test of attention, we conducted an exploratory analysis to determine whether the addition of an attention task would increase the sensitivity of the Nu-DESC. The test characteristics were determined after the Nu-DESC score for each patient was recalculated by adding 1 point for failing either the forward 5-digit or reverse

FIGURE 1. Flowchart of Participant Recruitment, Nu-DESC Evaluation, and DSM-5 Diagnosis.



3-digit span test performed on consecutive days by the research assistant. A threshold of ≥ 2 was used for these analyses. The analysis was considered exploratory because the attention tasks were not performed by the bedside nurses during routine assessment, as was the rest of the Nu-DESC.

To determine how the Nu-DESC functioned in different populations of patients, subgroup analyses were conducted in postoperative patients and those with neurologic or psychiatric comorbidity. Because of our sampling strategy, sensitivity and specificity of the Nu-DESC could not be calculated for these subgroups as the overall rate of Nu-DESC scores in each subgroup was not known. However, because selection for verification did not depend on the presence or absence of delirium directly, and only on the Nu-DESC screen results, naïve estimates of PPV and negative predictive value (NPV) in our sample are free of bias, although they still depend on the prevalence of delirium in the population or subgroup.[35] Postoperative patients were defined as those who had received a surgical procedure under general anesthesia during the current admission and were further separated into those who had received craniotomies and those who had not. Patients with a neurologic comorbidity were defined as having a preexisting disease affecting the central nervous system (CNS), and those with psychiatric comorbidity were identified by recorded DSM-5 disorders including Schizophrenia Spectrum and Other Psychotic Disorders, Bipolar and Related Disorders, Depressive Disorders, Anxiety Disorders, and Substance-Related and Addictive Disorders. All statistical analyses were two-sided with statistical significance set at $P < 0.05$. Analyses were conducted using STATAv.13.1.[37]

RESULTS

Participant Characteristics

A total of 421 patients were eligible for participation in the study. Of those, 5 (1.2%) declined participation, 7 (1.7%) were discharged before interview, 3 (0.7%) transferred to the intensive care unit before being interviewed, and 1 (0.2%) was not seen due to interviewer availability, leaving 198 Nu-DESC-negative and 207 Nu-DESC-positive patients as the study group (Figure 1). There were no statistical differences between groups according to age, sex, hospital unit, language, and postoperative status (Table 1). There were fewer surgical patients who screened positive on the Nu-DESC (30; 14%) than those screened negative (52; 26%, $P = 0.003$). There were significantly more patients with neurologic comorbidity who screened positive on the Nu-DESC (150; 75%) than those screened negative (91; 49%, $P < 0.001$). Similarly, there were more Nu-DESC-positive than Nu-DESC-negative patients with psychiatric comorbidities (52; 25% vs 26; 13%, $P = 0.002$), respectively.

Nu-DESC Test Characteristics

The estimate for delirium prevalence during the period under study was 17.6%. The analyses of the Nu-DESC in comparison to DSM-5 criteria are presented in Table 2. Using a threshold ≥ 2, the Nu-DESC had 42% sensitivity (95% CI: 33–53%) and 98% specificity for a diagnosis of delirium (95% CI: 97–98%). When the threshold was lowered to ≥ 1, the sensitivity increased to 67% (95% CI: 52–80%) and specificity decreased to 93% (95% CI: 90–95%). The AUC of the Nu-DESC was 0.82 (Figure 2).

Nu-DESC with Attention Assessment Test Characteristics

The inclusion of attention tasks increased sensitivity of the Nu-DESC and decreased the specificity, similar to the effect of decreasing the threshold to ≥ 1 (Table 2). The AUC for the Nu-DESC with the addition of the forward 5-digit span task was 0.84 and 0.83 with the addition of the reverse 3-digit span task.

Subgroup Analyses

The PPV and NPV of the Nu-DESC, using a threshold of ≥ 2, were highest for noncraniotomy postoperative patients and patients without CNS comorbidities (Table 3). In patients with neurologic comorbidity, the PPV was 71% (95% CI: 63–78%) and the NPV 79% (95% CI: 69–87%). For those with psychiatric comorbidity, the PPV was 71% (95% CI: 57–82%) and the NPV 81% (95% CI: 60–93%). The PPV was particularly low in patients with depressive disorders (0.58).

Delirium Subtypes

Of the 185 patients found to be delirious by DSM-5 criteria, 22 (12%) presented in the hyperactive state,

TABLE 1. Demographic Characteristics and Comorbidities by Nu-DESC Status

Characteristics	Nu-DESC negative *n* (%) N = 198	Nu-DESC positive *n* (%) N = 207	*P* value
Demographics			
Age, mean (SD), y	63 (17)	64 (18)	0.09
Sex			
Female	99 (50)	101 (49)	0.81
Primary language			
English	166 (84)	163 (78)	0.20
Spanish	13 (6.6)	10 (4.8)	0.45
Other	18 (9.2)	34 (16)	0.22
Primary service*			
Neurosurgery	63 (32)	73 (35)	0.46
Neurology	44 (22)	59 (29)	0.15
Medicine	39 (20)	46 (22)	0.61
Surgery	52 (26)	30 (14)	0.003
Postoperative†	91 (50)	84 (41)	0.28
Craniotomy	39 (20)	44 (21)	0.70
Comorbidity			
Neurologic‡	91 (46)	150 (73)	<0.001
Psychiatric§	26 (13)	52 (25)	0.002
No CNS Comorbidities‖	92 (47)	38 (18)	<0.001

CNS = central nervous system; Nu-DESC = Nursing Delirium-Screening Scale; SD = standard deviation.

* Primary service the patient was on at the time of the evaluation. Surgery includes general, orthopedic, and urological surgery.

† All patients who received general anesthesia and were admitted for postoperative care.

‡ Included only diagnoses of neurologic conditions affecting the central nervous system. The most common were stroke, epilepsy, brain tumor, and major neurocognitive disorder.

§ Included only recorded *Diagnostic and Statistical Manual of Mental Disorders*, *Fifth Edition* disorders such as schizophrenia spectrum and other psychotic disorders, bipolar and related disorders, depressive disorders, anxiety disorders, and substance-related and addictive disorders.

‖ Patients without neurologic or psychiatric comorbidities.

142 (77%) in a mixed state, and 21 (11%) in the hypoactive state. The Nu-DESC correctly identified 21 (95%) of 22 hyperactive and 124 (87%) of 142 mixed delirium patients, but only identified 12 (57%) of 21 hypoactive patients using a threshold of ≥ 2. When the threshold was lowered to ≥ 1, the Nu-DESC correctly identified with 22 (100%) of 22 hyperactive delirium, 133 (94%) of 142 mixed state, and 17 (81%) of 21 hypoactive delirium. Adding a reverse digit span task to the Nu-DESC using a threshold of ≥ 2 resulted in similar percentages. A forward digit span added to the Nu-DESC using the same threshold correctly identified 21 (95%) of 22 hyperactive delirium, 133 (94%) of 142 mixed delirium, and 16 (76%) of 21 hypoactive delirium among participants.

DISCUSSION

This prospective study of 405 inpatients demonstrates that the Nu-DESC, when administered by nurses in routine clinical practice caring for general internal medicine, neurology, neurosurgical and surgical patients, can identify delirious patients with high specificity, but it lacks sensitivity to screen for all delirious patients. Although sensitivity of the Nu-DESC could be increased by changing the threshold of a positive screen to ≥ 1, a third of cases are still missed by this approach.

The sensitivity in the current study was similar to that found in 91 postoperative patients in a prospective cohort study.[21] It was lower than other previously

TABLE 2. Test Characteristics of the Nursing Delirium-Screening Scale (Nu-DESC)

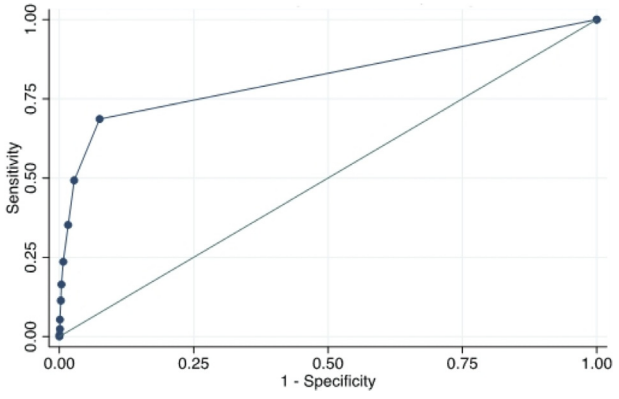
	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)
Nu-DESC (N = 405)				
Threshold ≥2	42 (33–53)	98 (97–98)	76 (69–81)	86 (80–90)
Threshold ≥1	67 (52–80)	93 (90–95)	74 (68–79)	92 (87–96)
Threshold ≥2 with forward 5-digit span	57 (44–69)	91 (87–94)	76 (70–82)	89 (84–95)
Threshold ≥2 with reverse 3-digit span	51 (39–62)	93 (89–95)	76 (69–81)	92 (87–95)

NPV = negative predictive value; Nu-DESC = Nursing Delirium-Screening Scale; PPV = positive predictive value.

published Nu-DESC studies, but this is likely because they did not correct for verification bias.[20] In our study, the Nu-DESC was less sensitive in detecting mixed and especially hypoactive delirium. This is likely due to the purely observational nature of the tool, which does not involve bedside testing of attention or cognition and does not involve a caregiver interview to determine whether a change in mental status has occurred. This may lead nurses to overlook more subtle cases. In addition, the Nu-DESC may be biased toward detecting hyperactive delirium because 2 of the 5 items in the rating scale address the hyperactive subtype: inappropriate behavior and hallucinations. Conversely, only 1 of 5 items (psychomotor retardation) targets hypoactive delirium.

We explored several ways to increase the sensitivity of the Nu-DESC. Lowering the threshold for a positive screen to ≥1 increased the sensitivity from 42–67%, but the specificity decreased from 98–93%. Adding a test of attention, using either a forward or reverse digit span, also increased the sensitivity but not to the degree that lowering the threshold did. It is possible that more nursing education would change the test characteristics of the Nu-DESC. Nurses received a brief in-service on how to score the Nu-DESC when the screening tool was adopted, but there was no continuing education program during the period of this project. As most cases that were missed were hypoactive delirium, a focused education program with an emphasis on the psychomotor retardation and disorientation aspects of the Nu-DESC may lead to increased scoring of these items.

FIGURE 2. Receiver Operating Characteristic (ROC) Curve for the Nursing Delirium-Screening Scale (Nu-DESC).



The importance of specificity in comparison to sensitivity of a screening tool depends on the actions triggered by a positive result. Higher sensitivity with lower specificity (i.e., threshold ≥1) may be desired if a positive Nu-DESC triggers a nonpharmacologic nursing care plan aimed at both prevention and treatment of delirium, in which inclusion of some patients who screen positive but do not have delirium is acceptable. However, a higher specificity (i.e., as with a threshold ≥2) may be warranted if the positive Nu-DESC triggers a more resource-intense intervention such as a geriatrics, psychiatry, or neurology consultation.

This study included a large proportion of patients with neurological and neurosurgical comorbidities, which may cause the tool to have a lower specificity. This is because the tool rates behaviors characteristic of delirium that overlap with major neurocognitive disorder, neurodevelopment disorders, and other psychiatric disorders, but is not designed to determine whether these behaviors represent a change from baseline. However, determining the acuity of an abnormal behavior requires training, experience, and a more time-consuming interview of collateral sources such as a family member. This highlights a fundamental trade-off with the Nu-DESC compared with other delirium screens such as the CAM.

TABLE 3. Positive Predictive Value (PPV) and Negative Predictive Value (NPV), by Comorbidity

Subgroup	PPV (95% CI)	NPV (95% CI)
Primary service		
Neurosurgery	0.80 (0.68–0.88)	0.83 (0.71–0.91)
Neurology	0.70 (0.56–0.81)	0.86 (0.73–0.95)
Medicine	0.73 (0.58–0.85)	0.80 (0.64–0.91)
Surgery*	0.83 (0.65–0.94)	0.94 (0.84–0.99)
Postoperative† ($n = 175$)	0.85 (0.69–0.94)	0.94 (0.83–0.98)
Craniotomy ($n = 83$)	0.73 (0.57–0.85)	0.82 (0.66–0.92)
Other ($n = 92$)	0.79 (0.68–0.86)	0.89 (0.80–0.94)
Not Postoperative ($n = 230$)	0.74 (0.65–0.81)	0.83 (0.74–0.89)
Neurologic comorbidities‡ ($n = 241$)	0.71 (0.63–0.78)	0.79 (0.69–0.87)
Stroke ($n = 85$)	0.76 (0.62–0.86)	0.71 (0.52–0.85)
Brain tumor ($n = 69$)	0.80 (0.63–0.91)	0.85 (0.68–0.94)
Epilepsy ($n = 56$)	0.61 (0.42–0.77)	0.87 (0.65–0.97)
Major neurocognitive disorder ($n = 34$)	0.72 (0.53–0.87)	0.60 (0.17–0.93)
Other ($n = 64$)	0.74 (0.59–0.86)	0.82 (0.56–0.95)
Psychiatric comorbidities§ ($n = 78$)	0.71 (0.57–0.82)	0.81 (0.60–0.93)
Depressive disorders ($n = 34$)	0.58 (0.34–0.79)	0.80 (0.51–0.95)
Substance-related and addictive disorders ($n = 25$)	0.74 (0.49–0.90)	0.83 (0.36–0.99)
Anxiety disorders ($n = 19$)	0.92 (0.60–1.0)	0.86 (0.42–0.99)
Schizophrenia spectrum and other psychotic disorders ($n = 10$)	0.67 (0.31–0.91)	1.0 (0.06–1.0)
Bipolar and related disorders ($n = 9$)	0.67 (0.24–0.94)	0.67 (0.13–0.98)
No CNS comorbidities‖ ($n = 130$)	0.92 (0.78–0.98)	0.92 (0.84–0.97)

CNS = central nervous system; NPV = negative predictive value; PPV = positive predictive value.

* Surgery includes general, orthopedic, and urological surgery.

† All patients in the hospital recovering from surgery using general anesthesia.

‡ Patients with a comorbid neurologic condition affecting the central nervous system.

§ Included only recorded *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* disorders such as schizophrenia spectrum and other psychotic disorders, bipolar and related disorders, depressive disorders, anxiety disorders, and substance-related and addictive disorders. The group "other" was not included due to minimal numbers for statistical relevance ($n = 2$).

‖ Patients without comorbid neurologic or psychiatric conditions.

Although the Nu-DESC takes less time and training to administer and may be easier to introduce into a health system, it lacks a key diagnostic feature of delirium, namely a subacute to acute change from baseline. However, any patient identified by a positive Nu-DESC is, if not delirious, likely at high risk of developing delirium based on baseline cognitive impairment and may benefit from nonpharmacologic interventions similar to those designed for delirious patients. Nevertheless, in populations with a high prevalence of neurologic or psychiatric comorbidities, a positive Nu-DESC screen should be interpreted cautiously and followed up with a more thorough evaluation by a clinician experienced in the diagnosis of delirium in the context of established CNS disorders.

Despite the inclusion of patients with neurologic and psychiatric comorbidities, the specificity, PPV, and NPV for the entire cohort remained high. In previous studies of the Nu-DESC, such patients were excluded or underrepresented, resulting in higher specificity but limiting the screening tool's applicability to patients without CNS disease. Indeed, patients with CNSs disorders were overrepresented in our cohort, as a large proportion of patients were on the neurology and neurosurgery unit. This limits the generalizability of our findings. However, our sample was large enough to draw conclusions about subgroups, and among medical and surgical patients without neurologic or psychiatric comorbidities; the Nu-DESC's PPV and NPV were very high, at 92%. In nonneurosurgical patients, PPV and NPV were both high at 83% and 94%. This indicates that the Nu-DESC may perform better than reported here in a general hospital without a dedicated neuroscience unit.

Limitations

Our study has several limitations. We used a sampling strategy to maximize the opportunity to evaluate patients with positive Nu-DESC scores, and patients were matched by age, sex, and hospital unit in order to avoid obtaining a control group with younger patients without neurological comorbidities. However, this likely led to a control group that was older and over-represented by neurological comorbidities than the hospital as a whole. Given the lower NPV of the Nu-DESC in these patients, this sampling strategy likely led to a conservatively low sensitivity estimate.

Our cohort was enriched with neurology and neurosurgery patients, which limits the generalizability of our findings. Even though our sample included a substantial number of general medicine patients, comparable to previous research on the Nu-DESC,[20] the results would best generalize to a population with high rates of CNS comorbidity such as Acute Care for the Elderly units and tertiary referral hospitals.

The research assistant evaluated patients up to 8 hours after the completion of the initial Nu-DESC that led to inclusion in the study. Such lag time might engender varying results (e.g., a delirious patient might no longer have been delirious by the time of the research assistant's evaluation). However, the Nu-DESC was administered every 12 hours and the formal evaluations were conducted on 2 consecutive days, giving a more thorough overview of each patient's condition during a 2-day period and the ability to detect fluctuations.

For reasons of feasibility, the neurologist and psychiatrist who diagnosed delirium applied DSM-5 criteria to structured clinical vignettes, rather than direct patient interviews. Therefore, it is possible that the diagnosis of delirium was not correct for some subjects in this study. However, there is precedent for use of such methodology in the study of delirium,[30] and the amount of information captured in the structured clinical vignettes, MoCA, CAM, and DRS-R98 was robust, making it unlikely that many cases were misclassified.

CONCLUSION

This study shows that the Nu-DESC is a sensitive and specific screening tool for hyperactive delirium using a threshold of ≥ 2 that can be easily applied by nurses in a fast-paced, clinically diverse hospital environment. However, it is less sensitive to patients with hypoactive and mixed delirium. Lowering the threshold to ≥ 1 or adding a test of attention improves detection of these patients. Although the Nu-DESC represents an efficient way for hospitals to incorporate delirium screening into routine nursing practice and conform to current guidelines, it must be recognized that some cases of delirium may go undetected due to the tool's low sensitivity. Future research aimed at increasing the sensitivity of the Nu-DESC would be useful.

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APPENDIX A. SUPPORTING INFORMATION

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.psym.2017.05.005.

References

1. Young J, Inouye SK: Delirium in older people. Br Med J. 2007; 334(7598):842–846
2. Wong CL, Holroyd-Leduc J, Simel DL, Straus SE: Does this patient have delirium?: value of bedside instruments. J Am Med Assoc 2010; 304(7): 779–786
3. Excellence NIfHaC. Delirium: prevention, diagnosis and management. NICE; 2010.
4. American Psychiatric Association. DSM-5 Task Force. Diagnostic and statistical manual of mental disorders: DSM-5. Available from: https://ucsf.idm.oclc.org/login?url=http://uclibs.org/PID/261189.
5. Greer N, Rossom R, Anderson P, et al. Delirium: screening, prevention, and diagnosis—a systematic review of the evidence. VA Evidence-based Synthesis Program Reports. Washington, DC; 2011

6. Inouye SK, Rushing JT, Foreman MD, Palmer RM, Pompei P: Does delirium contribute to poor hospital outcomes? A three-site epidemiologic study. J Gen Int Med 1998; 13(4):234–242
7. Inouye SK, Schlesinger MJ, Lydon TJ: Delirium: a symptom of how hospital care is failing older persons and a window to improve quality of hospital care. Am J Med 1999; 106(5):565–573
8. McCusker J, Cole M, Abrahamowicz M, Primeau F, Belzile E: Delirium predicts 12-month mortality. Arch Intern Med 2002; 162(4):457–463
9. Inouye SK, Westendorp RG, Saczynski JS: Delirium in elderly people. Lancet. 2014; 383(9920):911–922
10. Leslie DL, Marcantonio ER, Zhang Y, Leo-Summers L, Inouye SK: One-year health care costs associated with delirium in the elderly population. Arch Intern Med 2008; 168(1):27–32
11. Collins N, Blanchard MR, Tookman A, Sampson EL: Detection of delirium in the acute hospital. Age Ageing 2010; 39(1):131–135
12. Rockwood K, Cosway S, Stolee P, et al: Increasing the recognition of delirium in elderly patients. J Am Geriatr Soc 1994; 42(3):252–256
13. Inouye SK, Foreman MD, Mion LC, Katz KH, Cooney LM Jr.: Nurses' recognition of delirium and its symptoms: comparison of nurse and researcher ratings. Arch Intern Med 2001; 161(20):2467–2473
14. Gustafson Y, Brannstrom B, Norberg A, Bucht G, Winblad B: Underdiagnosis and poor documentation of acute confusional states in elderly hip fracture patients. J Am Geriatr Soc 1991; 39(8):760–765
15. Milisen K, Foreman MD, Wouters B, Driesen R, Godderis J, Abraham IL, et al: Documentation of delirium in elderly patients with hip fracture. J Gerontol Nurs 2002; 28(11):23–29
16. O'Keeffe ST, Lavan JN: Clinical significance of delirium subtypes in older people. Age Ageing 1999; 28(2):115–119
17. Solia LKK: Delirium. In: Sadock BJ, Sadock VA, Ruiz P, editor. Kaplan and Sadock's Comprehensive Textbook of Psychiatry. 9th ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2009
18. Hasemann W, Tolson D, Godwin J, Spirig R, Frei IA, Kressig RW: A before and after study of a nurse led comprehensive delirium management programme (DemDel) for older acute care inpatients with cognitive impairment. Int J Nurs Stud 2016; 53:27–38
19. Naughton BJ, Saltzman S, Ramadan F, Chadha N, Priore R, Mylotte JM: A multifactorial intervention to reduce prevalence of delirium and shorten hospital length of stay. J Am Geriatr Soc 2005; 53(1):18–23
20. Gaudreau JD, Gagnon P, Harel F, Tremblay A, Roy MA: Fast, systematic, and continuous delirium assessment in hospitalized patients: the nursing delirium screening scale. J Pain Symptom Manage 2005; 29(4):368–375
21. Neufeld KJ, Leoutsakos JS, Sieber FE, Joshi D, Wanamaker BL, Rios-Robles J, et al: Evaluation of two delirium screening tools for detecting post-operative delirium in the elderly. Br J Anaesth 2013; 111(4):612–618
22. Inouye SK, van Dyck CH, Alessi CA, Balkin S, Siegal AP, Horwitz RI: Clarifying confusion: the confusion assessment method. A new method for detection of delirium. Ann Intern Med 1990; 113(12):941–948
23. Lemiengre J, Nelis T, Joosten E, Braes T, Foreman M, Gastmans C, et al: Detection of delirium by bedside nurses using the confusion assessment method. J Am Geriatr Soc 2006; 54(4):685–689
24. Pompei P, Foreman M, Cassel CK, Alessi C, Cox D: Detecting delirium among hospitalized older patients. Arch Intern Med 1995; 155(3):301–307
25. Schuurmans MJ, Shortridge-Baggett LM, Duursma SA: The delirium observation screening scale: a screening instrument for delirium. Res Theory Nurs Pract 2003; 17(1):31–50
26. Grover S, Kate N: Assessment scales for delirium: a review. World J Psychiatry 2012; 2(4):58–70
27. Nasreddine ZS, Phillips NA, Bedirian V, Charbonneau S, Whitehead V, Collin I, et al: The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc 2005; 53(4):695–699
28. Trzepacz PT, Mittal D, Torres R, Kanary K, Norton J, Jimerson N: Validation of the Delirium Rating Scale-revised-98: comparison with the delirium rating scale and the cognitive test for delirium. J Neuropsychiatry Clin Neurosci 2001; 13(2):229–242
29. Inouye SK, van Dyck CH, Alessi CA, Balkin S, Siegal AP, Horwitz RI: Clarifying confusion: the confusion assessment method. A new method for detecting delirium. Ann Intern Med 1990; 113:941–948
30. Kuhn E, Du X, McGrath K, Coveney S, O'Regan N, Richardson S, et al: Validation of a consensus method for identifying delirium from hospital records. PLoS One 2014; 9(11):e111823
31. de Rooij SE, van Munster BC, Korevaar JC, et al: Delirium subtype identification and the validation of the Delirium Rating Scale–Revised-98 (Dutch version) in hospitalized elderly patients. Int J Geriatr Psychiatry 2006; 21(9): 876–882
32. Slor CJ, Adamis D, Jansen RW, Meagher DJ, Witlox J, Houdijk AP, et al: Delirium motor subtypes in elderly hip fracture patients: risk factors, outcomes and longitudinal stability. J Psychosom Res 2013; 74(5):444–449
33. Leung JM, Sands LP, Wang Y, et al: Apolipoprotein E e4 allele increases the risk of early postoperative delirium in older patients undergoing noncardiac surgery. Anesthesiology 2007; 107(3):406–411
34. Douglas VC, Hessler CS, Dhaliwal G, et al: The AWOL tool: derivation and validation of a delirium prediction rule. J Hosp Med 2013; 8(9):493–499
35. Zhou XH: Correcting for verification bias in studies of a diagnostic test's accuracy. Stat Methods Med Res 1998; 7 (4):337–353
36. Hulley SB: Designing clinical research. 3rd ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2007 xv, 367 pp
37. StataCorp. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP; 2013