A Psychometric Analysis Update of Behavioral Pain Assessment Tools for Noncommunicative, Critically Ill Adults

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ABSTRACT

This is an updated, comprehensive review of the psychometric properties of behavioral pain assessment tools for use with noncommunicative, critically ill adults. Articles were searched in 5 health databases. A total of 106 articles were analyzed, including 54 recently published papers. {AQ4} Nine behavioral pain assessment tools developed for noncommunicative critically ill adults and 4 tools developed for other noncommunicative populations were included. {AQ5} The scale development process, reliability, validity, feasibility, and clinical utility were analyzed using a 0 to 20 scoring system, and quality of evidence was also evaluated. The Behavioral Pain Scale, the Behavioral Pain Scale–Nonintubated, and the Critical-Care Pain Observation Tool remain the tools with the strongest psychometric properties, with validation testing having been conducted in multiple countries and various languages. {AQ6} Other tools may be good alternatives, but additional research on them is necessary.

Key words: adult intensive care, behavioral scale, pain assessment, reliability, validity

Pain assessment is the first essential step to adequate pain management. In the intensive care unit (ICU), pain is highly prevalent while the patient is at rest and during procedures.[1,2] Assessing pain is a daily

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challenge in the ICU. Many patients are unable to self-report their pain for reasons such as altered levels of consciousness, mechanical ventilation, heavy sedation, and delirium.[3] {AQ8} Although the gold standard measure of pain remains the patient's self-report, alternative behavioral assessment tools must be used for those unable to provide a reliable self-report of pain.[4-6]

This comprehensive review is an update of a previous review[7] that evolved from the work completed on the 2013 clinical practice guidelines of the Society of Critical Care Medicine (SCCM).[8] Psychometric analysis of available behavioral pain assessment tools was updated in the 2018 SCCM clinical practice guidelines[4]; new tools and validation studies published online ahead of print or published up to May 2019 were included in this review. Our aim for this comprehensive review was to analyze the development and psychometric properties (ie, reliability and validity) of behavioral pain-assessment tools for use in noncommunicative, critically ill adults.

Methods

Search Strategy and Selection of Studies

We updated the literature sources in the present review, using the same search terms and clinical databases described in our 2013 initial review[7] and in the 2018 SCCM practice guidelines.[4] Briefly, we used general Medical Subject Heading terms such as *pain assessment, pain measurement,* and the names of behavioral pain assessment tools. {AQ9} Searches were performed by an experienced research librarian using the following databases: Cumulative Index to Nursing and Allied Health Literature, Embase, Medline, PubMed, and Web of Science. We decided to exclude Scopus because it includes a variety of academic disciplines in addition to health sciences, and the results of a Scopus search were neither specific nor relevant to the aim of this review. Studies were eligible if the population included adults ages 18 years or older in the ICU and were in English, French, or any other languages spoken by the review coauthors or their graduate students. Abstracts, reviews, case reports, editorials, and letters to the editor were excluded. Titles and abstracts were screened by 2 reviewers. Disagreements about selection of studies were discussed, and consensus was reached. The majority of included papers were in English, but some were written in other languages (namely, French, Spanish, and Korean), and we had reviewers with proficiency in these languages.

Psychometric Scoring Evaluation

The psychometric scoring system was previously described[7] and established with the consultation of 3 external experts in health measurement. The scoring system includes 5 main sections: (1) scale development (5 points), (2) reliability (5 points), (3) validity (10 points), (4) feasibility (2 points), and (5) clinical utility (1 point). The total score ranges from 0 to 23. Reliability refers to the overall reproducibility of measures obtained from an assessment tool, and strategies evaluated as part of the psychometric system included internal consistency (ie, homogeneity of the items) and interrater reliability. We removed the item related to intrarater reliability because it is optional when poor interrater reliability findings are found, but we described it in the presentation of each tool in Results, when appropriate. Validity refers to the interpretation of assessment tool scores. Criterion validation (ie, comparison with the gold standard measure of pain: the patient's self-report) and discriminative validation (ie, comparison of pain scores between painful and nonpainful procedures) were evaluated. Each tool was attributed the highest score according to available study findings. However, when assumptions were not respected in the calculation of coefficient or statistical test in most studies, the score was reduced by 1 point on the specific item that was evaluated. Weighted scores were then calculated taking into account the importance of each section (ie, more weight for reliability and validity). A total weighted score was obtained by summing the weighted scores of each section and ranged from 0 to 20. The interpretation of weighted scores was as follows: very good (score 15-20), good (score 12-14.9), acceptable but other studies are necessary (score 10-11.9), and unacceptable (score < 10).[7]

As described in our initial review,[7] the quality of evidence for each tool was evaluated as high, moderate, low, or very low, having been adapted from the Grades of Recommendations, Assessment, Development,

and Evaluation methodology used in the SCCM clinical practice guidelines process.[8,9] High quality of evidence is established in a report when the scale development was well described, multiple validation strategies were tested and replicated in different studies in an overall large sample representative of the ICU population, and validation findings were consistent across most studies. Moderate quality of evidence is determined when some validation studies with an overall moderate sample size representative of some ICU patient groups were included, multiple validation strategies were used, and findings were consistent in most studies, but some important methodological limitations were identified. Low quality of evidence is determined when very few validation studies were included, with an overall small sample not representative of different ICU patient groups, and some steps of scale development and validation were missing. {**AQ10**} When the psychometric properties related to the use of scale cannot be supported, a very low quality of evidence is established.

Data from studies included in the initial review of 2013 and in the 2018 SCCM clinical practice guidelines were extracted and psychometric scoring was done independently by 2 reviewers. In this updated review, data extraction and psychometric scoring of 3 new behavioral pain assessment tools were completed using a similar process. However, for new articles added in this review, data extraction was done by 1 reviewer and was checked by a second reviewer. Psychometric scoring of all tools was verified by 2 reviewers. Reviewers involved in the development of tools included in this review did not take part in data extraction of studies in which their behavioral pain assessment tool was tested.

Explanations of psychometric concepts and of the psychometric scoring system were provided to reviewers by the primary author (C.G.), who holds a doctorate in Nursing and Measurement. In addition to holding a doctorate degree, 2 of the reviewers (M. Bérubé, M. Boitor) completed a graduate course in health measurement. Three reviewers (C.G., A.M.J., and K.A.P.) were involved in the 2013 initial review, 3 additional reviewers participated to the 2018 SCCM clinical practice guidelines (P.M.S., J.F.P., and G.C.), and the remaining 3 reviewers were not involved in the previous review.

Results

In the initial review,[7] 32 studies were included for data extraction and analysis. The review was updated as part of the 2018 SCCM clinical practice guidelines, to which 20 other studies were added.[4] In the present updated, comprehensive review, 3 new tools developed for other patient populations and tested for their use in critically ill adults (namely, the La Escala de Conductas Indicadoras de Dolor [ESCID] Behavioral Indicators for Pain Scale, Multidimensional Objective Pain Assessment Tool [MOPAT], and Nociception Coma Scale–Revised [NCS-R]) and 54 additional studies were included, for a total of 106 articles in which scale development, validation, feasibility, implementation into practice, and/or impact on patient outcomes were described. {**AQ11**} Items and interpretation of scoring of all behavioral pain assessments tools are described in Table 1, and a summary of all validation and implementation studies is given in Tables 2 and 3 (available online at www.aacnacconline.org). {**AQ12**} Results are presented for 9 behavioral pain assessment tools developed for noncommunicative, critically ill adults and 4 such tools developed for other nonverbal populations but tested for their use in noncommunicative, critically ill adults.

Psychometric scoring for each tool is presented in Table 4. Four tools obtained very good weighted scores of greater than 15: the Behavioral Pain Scale (BPS), Behavioral Pain Scale–Nonintubated (BPS-NI), Critical-Care Pain Observation Tool (CPOT), and initial Nonverbal Pain Scale (NVPS-I) with moderate to high evidence. Good weighted scores (ie, scores of 12-14.9) were found for the revised NVPS (NVPS-R; moderate evidence), the MOPAT and the NCS-R–Intubated (NCS-R-I) with low evidence. The Behavior Pain Assessment Tool (BPAT) obtained a high acceptable weighted score (10-11.9) with moderate evidence. Unacceptable weighted scores (ie, those <10) were obtained for all other tools with low or very low evidence.

Behavioral Measures Developed for Noncommunicative, Critically Ill Adults

Behavior Observation Tool. The psychometric score of the Behavior Observation Tool (BOT) was unchanged, because no new

study was retrieved for this updated review. The BOT is a checklist of 38 behaviors clustered into facial responses, verbal responses, and body movements,[10] which were inspired by items from previous pain observation tools (namely, the Children's Hospital of Eastern Ontario Pain Scale[11] and the Pain Assessment Intervention Notation [PAIN] Scale[12]). Its content was evaluated by an expert committee for completeness and usability, and the tool was pretested with 10 critically ill adults. This tool was developed for the Thunder Project II and was tested in 5957 critically ill adults from 169 hospitals mainly located in the United States, with a few from Canada, United Kingdom, and Australia.[10]

Most patients were admitted to the ICU for a medical (46.5%) or surgical (38%) diagnosis and were able to self-report their pain. Discriminative validation was supported with increases in the frequency of almost all behaviors during standard care procedures. According to criterion validation, positive correlations were found between self-reported procedural pain intensity and the number of facial (r = 0.41), verbal (r = 0.49), and body movement responses (r = 0.37). Patients with procedural pain were 2.8, 4.1, and 10.3 times more likely to have increased facial responses, body movements, and verbal responses, respectively. These findings support the construct validity of the BOT in a large sample of patients in the ICU who could communicate.

A modified version of the BOT was tested during a nociceptive procedure (ie, endotracheal suctioning or turning) and gentle touch by Li et al[13] in 48 adults who received mechanical ventilatory support and sedation during cardiac surgery. Some behaviors were observed only during the nociceptive procedure, such as grimacing (17%) and random movement of extremities (21%). Additional validation of the BOT is required in noncommunicative patients in the ICU, and reliability needs to be examined.

Behavior Pain Assessment Tool. The BPAT is a shorter version of 8 items of the BOT developed for the Thunder Project II.[10] It has been published and was analyzed as part of the 2018 SCCM clinical practice guidelines.[4] Initially available in English, the BPAT was translated into 11 different languages (Czech, Dutch, French, German, Greek, Spanish, Italian, Polish, Portuguese, Danish, and Finnish) using a forward method. A teaching video was created for the research teams involved in the validation of the BPAT. The BPAT was validated in 3851 patients from 192 ICU settings in 28 countries.[14] Interrater reliability was supported by good to excellent (>0.60) κ coefficients for most behavioral items, which were assessed at rest and during procedures by 2 raters from the ICU care team (eg, nurses, physicians, respiratory therapists, physiotherapists). A few moderate κ coefficients were found for muscle rigidity (0.43), wince (0.50), and clenched fists (0.51) at rest. Discriminative validation was demonstrated, with behaviors more likely to be present during procedures than at rest in patients in the ICU who were able or not able to self-report. Regarding criterion validation, moderate correlations were found during procedures between the BPAT scores and the 0 to 10 pain intensity (r = 0.54) and pain distress (r = 0.49) scores. A BPAT cut-point score greater than 3 could adequately classify 75% of patients with or without severe pain with good sensitivity (62%) and specificity (75%). An additional item related to compliance with mechanical ventilatory support would enhance its applicability in patients in the ICU who were receiving such support. The BPAT's feasibility and implementation in clinical practice need to be studied.

Behavioral Pain Scale and Behavioral Pain Scale–Nonintubated. A total of 39 published ICU studies using the BPS and/or BPS-NI were selected, including 19 new articles published since the 2018 updated SCCM practice guidelines.[4] The psychometric scores of both the BPS and the BPS-NI were increased by more than 2 points with cumulative evidence. A training poster for the BPS/BPS-NI[15] is available on the SCCM's ICU Liberation webpage (https://www.sccm.org/ICULiberation/Resources/Behavioral-Pain-Scale-Training-Poster). Studies were conducted in 17 countries. The original versions of the BPS[16] and BPS-NI[15] were developed in French, and both tools were translated into English using a forward method. The BPS was translated in 9 other languages: Brazilian,[17] Brazilian Portuguese,[18] Dutch,[19] Italian,[20] Chinese,[21] Mandarin,[22] Norwegian,[23] Polish,[24] and Swedish.[25] The BPS-NI was translated in 4 other languages: Chinese,[26] Italian,[20] Norwegian,[23] and Swedish.[25] All used a forward-backward

translation method except for the Dutch version of the BPS,[19] for which a forward method was used. The Swedish versions of the BPS and BPS-NI[25] were translated following the 10-step process established by the International Society for Pharmacoeconomics and Outcomes.[26] {**AQ13**} The Chinese versions of the BPS and BPS-NI[21,27] and the Polish version of the BPS[24] were translated using a rigorous, multiple-step process with forward-backward translation, expert committee, and pretest.

The BPS was validated in 25 studies involving 1791 patients in the ICU who had various medical, surgical, and/or trauma diagnoses,[16,19,21,22,24,28-39] and in studies that included specific ICU groups such as patients with brain injury[17,40-45] and patients who underwent cardiac surgery.[46] {**AQ14**} The BPS-NI was validated in 2 studies[15,20] with 75 patients in medical and surgical ICUs, including 30 with delirium.[15] Both tools were simultaneously validated in 6 studies with 658 patients in medical and surgical ICUs.[18,23,25,27,46,47] {**AQ15**}

Internal consistency was examined in 14 studies for the BPS,[17,19,22,24,29-31,35,38-41,45,48] 2 studies for the BPS-NI,[15,20] and 3 studies for both tools.[26,46,47] Good (>0.70) or acceptable (0.50-0.70) Cronbach α values were found in most studies, and a low value (<0.20) was only found in patients at rest preprocedure for the Polish version of the BPS.[24] However, in 9 studies (69%),[15,22,29-31,35,40,46,47] Cronbach αs were calculated using dependent data (ie, repeated observations within subjects), which may inflate the coefficient values.

Interrater reliability was tested in 18 studies for the BPS,[16,17,19,21,24,28-31,33,35,36,38-40,44,45,48] both studies for the BPS-NI,[15,20] and all 6 studies for both tools.[18,23,25,27,46,47] Weighted κ and/or intraclass correlation coefficients (ICCs) greater than 0.60 were reported in most studies, and a lower value (0.36) was obtained at rest for the Norwegian version of the BPS-NI.[23] Low percentages of agreement (36%-46%) were also reported during postprocedure assessments for the BPS.[38] Such findings may be obtained when raters do not focus on the same behaviors during the observation period. Not enough practice with the tool may also explain lower results. Nurses, physicians, and other health professionals were involved as raters in most studies except that of Liu et al,[47] in which raters were the investigator and a research assistant.

Regarding validation strategies, discriminative validation comparing painful and nonpainful conditions or standard care procedures (Table 2) was examined in most validation studies (n=29 of 32; 91%). Significant increases in BPS/BPS-NI scores during painful procedures were found in 2 studies for the BPS-NI[15,20] and all 6 studies that used both tools,[18,23,25,27,46,47] compared with rest and/or nonpainful procedures.[15-21,23-25,27,29-31,33-38,40-48] {**AQ16**} The 2 most common painful procedures were endotracheal/tracheal suctioning (n=18 studies) and turning or repositioning/changing position (n=16 studies). Klein et al[18] performed a standardized stimulation by pressure algometry for the validation of the Brazilian Portuguese version of the BPS and BPS-NI. Nonpainful procedures were performed in 17 studies, and the 3 most commonly used were eye cleaning (n=5 studies),[17,38,41,44,45] noninvasive blood pressure (n=3 studies),[24,33,47] and arterial or central catheter dressing change (n=3 studies).[15,16,29]

Criterion validation was tested in 7 studies for the BPS,[21,29,32,33,36,37,40] in 1 study for the BPS-NI,[20] and in 1 study for both tools.[27] Moderate to high correlations (range, 0.56-0.89) were obtained between BPS/BPS-NI and numeric rating scores (NRS) ranging from 0 to 10 or descriptive scores ranging from 0 to 4.[20,27,29,36,37] Lower correlations (<0.40) were found between BPS and NRS ranging from 0 to 10 when patients were at rest.[32,36] A cut-point score was only explored for the English, French, and Chinese versions of the BPS. Receiver-operating curve (ROC) analysis showed that the BPS cut-point ranged from 5 to 6.5, with better classification during painful procedures such as nursing care and endotracheal suctioning (area under the curve [AUC] range, 0.73-0.83)[21,33,37] compared with the other tools (AUC range, 0.60-0.73).[32,37] {**AQ17**} Sensitivity varied from 52% to 90% and specificity from 46% to 92%. Self-reports of pain at rest and during procedures were combined in some studies for the calculation of correlation[37] or ROC analysis.[33] In the Bernard et al study,[40] BPS scores during painful procedures (eg, turning, endotracheal suctioning) were used as the reference standard compared to preprocedure BPS scores in 50 patients in the ICU who had brain injury. Correlated ROC curves were compared and the authors reported an AUC of 0.96 for a BPS cut-point score of 4. The threshold was

lower in this sample of patients with brain injury in the ICU than the thresholds obtained when the patient's self-report of pain was used as the gold standard for this type of analysis. {**AQ18**} To our knowledge, cut-point scores of other language versions of the BPS and BPS-NI remain to be studied.

The feasibility and clinical relevance of the use of the BPS were evaluated in 4 studies.[16,40,46,49] The BPS was evaluated as easy to use or to learn, precise or accurate, and useful by the majority of clinicians (most were nurses). In the initial validation study of the BPS, few evaluators (25%) expressed some concerns regarding its complexity.[16] Five implementation studies with results reported in 6 papers in 4 countries (Australia, France, Germany, and Norway) were identified: 3 for the BPS only (French and English versions)[49-51] and 3 for the BPS and BPS-NI (French and Norwegian versions).[52-54] Nurses' adherence to use of the Norwegian version of the BPS/BPS-NI as part of a pain management algorithm was high (75%).[53] An increase in the documentation of pain assessments[50,54] and decrease in the incidence of severe pain and adverse events[49,52] were described. A reduction in mechanical ventilation duration and/or ICU length of stay was found in 2 studies,[49,54] but no change was reported in 1 study.[51] Implementation of pain and delirium monitoring was associated with a decrease in mortality rate in 1 study.[50] {**AQ19**} Changes in the ordering and/or use of analgesics and sedatives were also described.[49,52,54]

Critical-Care Pain Observation Tool. A total of 59 CPOT studies conducted in the ICU setting were included in this review, 35 of which were new articles published after the previous review. {**AQ20**} The CPOT reached the maximum psychometric score based on cumulative and new evidence. Studies were conducted in 19 countries. The CPOT was initially developed in French[55,56] (using various sources, including literature, chart reviews, and consultation with critical care clinicians) and a content validation process,[56] and it was translated into English using a forward-backward method.[58] The directions for CPOT use are available in French[59] and English[60] and can be found on the SCCM's ICU Liberation webpage (http://www.sccm.org/ICULiberation/Resources/Critical-Care-Pain-Observation-Tool-How-to-Use-it). It is now available in 17 other languages (Table 2). Most used a forward-backward translation method (ie, the Danish,[61] Dutch,[62] German,[63] Greek,[64] Japanese,[65] Korean,[66] Persian,[67] Polish,[68] Mandarin,[22] Swedish,[69] and Turkish[70] versions of the CPOT). The Spanish version[71] and another Dutch[19] version of the CPOT were translated using a forward method. The translation method of the Italian version of the CPOT was not specified by the authors.[72] The Finnish and the Norwegian versions of the CPOT[73,74] were translated following the International Society for Pharmacoeconomics and Outcomes 10-step process.[26] The Brazilian Portuguese[18] and Chinese[75] versions were translated using a similar rigorous process with forward-backward translation, cognitive interviewing, expert committee, and pretest. The language version of the CPOT was not specified in 9 studies conducted in countries where English is not the primary language.

In addition to its content validation,[57] the CPOT was validated in 47 studies selected for this review, with a total of 3966 patients in the ICU who had various diagnoses and were or were not able to self-report pain. Most studies included patients with medical and/or surgical diagnoses (n = 31 studies)[18,19,22,31-34,37,46,47,58,59,61-63,66-69,71,74-84]; some of these studies also included trauma patients (n = 7 studies)[58,59,66,67,78-80]; others specifically included patients who had undergone cardiac surgery (n = 9 studies; n = 730 patients; 19%)[48,56,70,85-90] or who had brain injury (n = 7 studies; n = 690 patients; 18%).[42,91-96]

Internal consistency was examined in 17 studies.[19,22,31,46-48,61-63,67,69,70,75,77,81,83,95] Good (> 0.70) and acceptable (0.50-0.70) Cronbach α values were found in most studies, and a very low value (0.31) was only found at rest after a procedure, with the Swedish version of the CPOT.[69] However, in 7 studies,[22,31,47,62,77,81,83] Cronbach α values were calculated using dependent data (ie, repeated observations).

Interrater reliability was reported mainly with weighted κ and/or ICC values in 33 studies,[18,19,31,33,46-48,56,58,61-63,66-71,74-78,81,84,85,88,90-92,94-96] and values greater than 0.60 were obtained in 30 of these studies. Clinical staff (mainly nurses) were involved as raters in 22 studies, whereas in other studies, only the investigators and/or research staff were raters. Low values (< 0.40) were reported mainly at rest.[85,88] Lower ICCs were found both at rest (0.38) and during turning (0.56) among 4

nurses who used the Dutch version of the CPOT.[62] These nurses received a 90-minute standardized training, but there was no information regarding the evaluation of their competence using the Dutch version of the CPOT before data collection. When interrater reliability is not satisfactory, intrarater reliability is a useful strategy to identify low raters.[97,98] However, it is only possible to do with videos so raters can view them at a later date (a minimum 1-month interval is recommended) and perform their scoring of the same patient and under the same conditions. Intrarater reliability was examined in 2 studies[85,91] and ICC values greater than 0.80 were obtained for each rater except for 1 value of 0.54 for assessment at rest by 1 rater.[85]

Discriminative validation was examined in most of validation studies (n = 42 of 47; 89%). Significant increases in CPOT scores during painful procedures were found in all these studies compared with rest and nonpainful procedures.[18,19,31,33,34,37,42,46-48,56,58,59,61-63,66-71,74-82,84,85,88-96] The 2 most common painful procedures were turning or repositioning/changing position (n = 33 studies), and endotracheal/tracheal suctioning (n = 16 studies). Interestingly, oral care procedures (eg, oral suctioning, tooth brushing, swabbing with a sponge toothette) were considered as painful in a study by Dale et al[78] but as nonpainful in the studies led by Rijkenberg et al[19,48] (no specific description of the procedure was provided). In addition, a standardized stimulation by pressure algometry was performed for validation of the Brazilian Portuguese version of the CPOT.[18] Nonpainful procedures were performed in 20 studies; the 2 most commonly used were noninvasive blood pressure using cuff inflation (n = 9 studies)[33,47,58,59,75,81,85,91,96] and soft touch (n = 4 studies).[63,84,92,94]

Criterion validation was examined in 24 studies using the patient's self-report of pain presence and/or pain intensity (ie, 0-10 NRS, visual analog scale, or descriptive scale). The CPOT consistently has been associated with self-report of the presence of pain (yes/no). Moderate to high correlations were found with the self-report of pain intensity with higher coefficients (range, 0.42-0.84) during painful procedures.[37,56,58,61,76,77,85,92,96] Lower correlations (< 0.40) were found while patients were at rest in a study combining delirious and nondelirious patients,[32] in patients with spinal cord or brain injury,[95] and in some cardiac surgery samples.[87,88] The best CPOT cut-point score that adequately classifies self-reported pain during procedures (AUC range, 72%-91%) varied between 2[37,63,68,75,78,92,99] and 3.[33,58,61] During procedures, sensitivity ranged from 67% to 93% and specificity from 46% to 90%. The CPOT cut-point score was lower at rest and ranged between 1[57] and 2,[32,66,75] with sensitivity ranging from 47% to 81% and specificity from 65% to 97%. Self-reports of pain at rest and during procedures were combined in some studies to establish the best CPOT cut-point score.[62,94,95]

The feasibility and implementation of CPOT in ICU settings were described in 11 papers. The English, French, and Italian versions of the CPOT were implemented in 5 countries (Australia, Canada, Iran, Italy, United Kingdom, and United States) mainly in mixed ICUs (ie, medical/surgical/trauma). The CPOT was rated as feasible and clinically relevant by ICU nurses.[59,60,96,100,101] Training in the use of the CPOT allowed nurses to improve their diagnosis of pain in patients with low levels of consciousness.[102] However, ICU nurses highlighted that the training did not improve communication of pain assessment findings with physicians who were not familiar with the tool.[101] {**AQ21**} Documentation of pain assessments significantly increased after implementation of the CPOT, reaching or exceeding the minimum frequency interval (ie, every 2-3 hours).[103-107] Implementation of CPOT and standardized protocols also led to a reduction in sedative use[103,104,107,108] and led to appropriate use of opioids based on regular assessments to evaluate effectiveness of analgesia.[103-106,109] {**AQ22**} Positive impacts on patient outcomes also were reported, such as fewer complications,[109] shorter time requiring mechanical ventilatory support,[108] and a low recollection of severe pain by patients surviving their stay in the ICU.[103]

Behavioral Indicators of Pain Scale. To our knowledge, the ESCID was analyzed for the first time in the present review. It was developed in Spanish by Latorre-Marco et al[110] and is an adaptation of the Campbell's scale,[111] which was suggested by the Analgesia and Sedation Work Group of the Spanish Society of Intensive Care Medicine and Coronary Units.[112] {**AQ23**} As part of the adaptation

process, the authors performed content validation with 13 expert clinicians (9 nurses and 4 physicians), and a content validity index was calculated for each item. The lowest content validity index was determined for the item "compliance with ventilator" and it was modified to improve its clarity and meaning. The scale is also available in English,[113] but the translation method was not specified and the English version does not appear to have been validated yet.

The ESCID was validated with a total of 356 patients in the ICU setting in Spain: 232 with mixed diagnoses[110,113] and 124 patients with trauma.[114] Regarding internal consistency, Cronbach α values from 0.69 to 0.85 were obtained for the ESICD total score or when calculated with 1 item deleted, but repeated observations were used in the calculation of these coefficients.[110,113] A Cronbach α of 0.63 was also reported in patients who had a Richmond Agitation-Sedation Score (RASS) of −5,[113] which appears irrelevant because behaviors are not observable in unresponsive patients. Interrater reliability was examined with raters from the research team and trained nurses in 2 studies[113,114] and by members of the research team only in the initial validation study.[110] The κ coefficients using an ESCID cut-point score of greater than 3 ranged from 0.66 to 1 at all assessment times (ie, before, during, and after procedures) and at the 3 data collection days in the Lopez-Lopez et al study.[114] Analyses of variation were not significant when comparing the ESCID mean scores of raters in the Latorre-Marco et al studies.[110,113] The authors mentioned checking for intrarater reliability by comparing ESCID scores between procedures for each rater. However, such a procedure is not appropriate, because raters should have observed the patient during the same procedure twice. Considering that acute pain can vary over time, intrarater reliability through the use of videos appears the most appropriate method to allow raters to score the patient again under the same condition but at a later time.

Discriminative validation was examined in all 3 studies. Consistent findings were obtained with higher scores (ie, increases by >2 points) during painful procedures (eg, turning/repositioning, mobilization, tracheal suctioning) when compared with preprocedure rest and a nonpainful procedure (ie, gentle rub of a gauze cloth on intact skin).[110,113,114] Criterion validation remains to be tested and is a useful strategy to establish a cut-point score for clinical use. Feasibility and implementation of the ESCID in clinical practice also need to be studied.

Nonverbal Pain Assessment Tool. The Nonverbal Pain Assessment Tool (NPAT) is available in English and was validated in 220 medical and surgical patients from 4 adult ICUs.[115] No new article was retrieved for this tool when compiling the present review, and the NPAT was described in our previous review.[7] Briefly, internal consistency ($\alpha = 0.82$) was high, and interrater reliability was moderate to high ($r = 0.52$-0.88) between 2 nurses' rating scores (5 teams of 2 nurses participated). Low correlation coefficients (ie, 0.21-0.31) were found between NPAT scores and patients' self-reports of pain intensity on a scale of 0 to 10. No information about the conditions of pain assessments (eg, at rest, during care procedures) was provided. These findings supported the reliability but not the validity of the NPAT use, and additional validation of the tool would be necessary.

Nonverbal Pain Scale—Initial and Revised Versions. Of the 12 studies using NVPS-I or NVPS-R included in the present review, 5 were published after the previous review. {**AQ24**} Ten were validation studies with a total of 778 patients in the ICU, and 2 were implementation studies. The psychometric scores of both versions of the NVPS were increased by more than 3 points with new evidence. Two versions of the NVPS exist: the NVPS-I and the NVPS-R. The initial version of the NVPS was developed in English and includes 3 behavioral and 2 physiological indicators; its content was evaluated by critical care experts.[116] The NVPS-R, in which the skin physiologic indicator was modified for a respiratory item (ie, respiratory rate, oxygen saturation, compliance with ventilator), is also available.[117] In addition to the English version, the NVPS-I was translated into Polish using a forward method and a content validation process with ICU nurses,[24] and the NVPS-R was translated into Turkish using a forward-backward method and a content validation process with 9 specialists[118]; an overall content validity index of 1.00 was reported for the Turkish version. {**AQ25**} Both versions of the tool were translated for a study conducted in Iran, but neither the language nor

the translation method was specified by the authors.[119]

The NVPS-I was validated in 3 studies with 237 patients with medical, surgical, trauma, neurologic, or burn diagnoses.[24,36,116] The NVPS-R was validated in 5 studies with 417 patients with medical, surgical, trauma, and neurologic diagnoses.[31,35,46,96,118] Both versions of the tool were simultaneously validated in 2 studies with 124 patients with various diagnoses.[117,119]

Internal consistency was examined in 8 studies and results were variable for both the NVPS-I and the NVPS-R: Cronbach α coefficients ranged from 0.36 to 0.72 at different times.[24,117] The highest values of 0.62 and 0.78 were obtained during the painful procedure for the NVPS-I[117] and the Turkish version of the NVPS-R,[118] respectively. The value of Cronbach α was improved during the nonpainful and painful procedures when physiologic indicators (eg, vital signs, skin) were removed in the Polish version of the NVPS-I.[24] Higher Cronbach α values (0.75-0.86) were obtained when repeated observations were used for the calculation of the coefficients.[31,35,46,116,119]

Interrater reliability was tested with raters from the research team and ICU nurses in most studies but not in that of Rahu et al,[36] in which only the investigators were involved as raters. Percentages of agreement (>90%)[117] as well as ICC values and κ coefficients were high (0.60-0.95) in several studies.[31,35,47,119] Lower interrater reliability coefficients were found with the Polish version of the NVPS-I ($\kappa = 0.44$)[24] and for the English version of the NVPS-R, with ICCs in the latter ranging from 0.34 to 0.49 at rest before and after procedures and an ICC of 0.55 during the nonpainful procedure (ie, noninvasive blood pressure).[96] {**AQ26**}

Discriminative validation was tested in most studies (n = 7 of 10; 70%) and was supported by significant increases in the tool's scores during painful procedures compared with rest and nonpainful procedures.[24,35,36,46,96,117,119] The most common painful procedures were endotracheal suctioning and/or turning or repositioning,[24,35,36,46,96,117,119] and various nonpainful procedures were used across studies. It is worth mentioning that the skin indicator of the NVPS-I did not increase significantly during endotracheal suctioning.[117]

Criterion validation was explored in only one study of the NVPS-I[36] and one of the NVPS-R[96]; in the Iranian study, both versions were used.[119] In association with the 0 to 10 scale of self-reported pain intensity, a low correlation of 0.31 was found during turning for the English version of the NVPS-R,[96] and moderate correlations 0.41 and 0.56 were obtained during physical examination and during endotracheal suctioning for the English version of the NVPS-I, respectively.[36] Using 269 self-reports of the presence or absence of pain from 60 patients in the ICU, the authors of the Iranian study reported sensitivity and specificity greater than 95%, with a cut-point score of 1.5 for both the translated versions of the NVPS-I and of the NVPS-R.[119]

The implementation of the English version of the NVPS-I in 2 neurological and trauma ICU settings was evaluated in Canada[120] and in the United States.[121] In the latter study, by Sacco et al,[121] the NVPS-I was implemented as part of an analgesia and sedation guideline. There was an increase in the documentation of pain assessments, and patients reported an overall decrease in their pain after implementation of the tool.[120] A decrease in the average number of sedation days and in analgesic treatment duration was found in that implementation study.[121] The tool or guideline was rated as easy to use by ICU nurses in both studies. Although the ICU nurses' satisfaction with the guideline was positive in the Sacco et al study,[121] nurses in the Topolovec-Vranic et al study[120] were less likely to agree that the NVPS-I would ease the assessment of their patients' pain, make them confident to request fewer or more analgesics, or improve their pain management practice. The feasibility and clinical relevance of the English version of the NVPS-R was evaluated by 10 ICU nurses in 1 validation study in Canada.[96] Although the NVPS-R was rated as easy to use by nurses, its clinical relevance was only supported by 20% of them. Physicians' practices with regard to pain management and inconsistent pain assessment and management practices of the staff were mentioned as major barriers by ICU nurses.[96]

Pain Assessment Intervention Notation. The PAIN was analyzed in our previous review,[7] and no new article was retrieved for the present update. The PAIN algorithm is a

tool developed by a team of critical care nurses and pain experts and intended to combine pain assessments with subsequent pain interventions.[12] Clinicians are directed to first use a checklist of 4 behaviors and 5 physiologic signs to determine the presence or absence of pain. The nurse is then prompted to elicit the patient's degree of pain intensity on a 0 to 10 NRS. The management steps of the algorithm involve assessing for potential problems influencing opioid administration and making an analgesic treatment decision. The PAIN tool was tested with 31 recently extubated, self-reporting adults in the ICU after surgery.[12] The number of behavioral and physiological indicators observed was significantly associated with the nurses' proxy ratings of 0 to 10 pain intensity on an NRS (r = 0.17 to 0.77). However, the relationship between the patient's self-report of pain intensity and behavioral and physiological indicators was not calculated; therefore, criterion validation was not described in this sample. Nine of 11 nurse evaluators of 31 patients deemed the instrument to be helpful, whereas a few nurses (n = 4) found the PAIN tool to be too complex.[122] Although the PAIN tool was tested in a small sample of patients in the ICU who were able to communicate, most psychometric properties were not examined. The PAIN tool is based on the nurse's clinical judgment and appears to be more of a pain-management educational tool than a single pain scale per se.

Tools Developed for Non-ICU Populations

Face, Legs, Activity, Cry, Consolability. The psychometric analysis of the Face, Legs, Activity, Cry, Consolability (FLACC) was described in our previous review,[7] and no new article was retrieved for the present update. The tool was initially developed for children with cognitive impairment,[123] and its use was validated in a sample of 29 adults and 8 pediatric patients from medical and surgical ICUs by Voepel-Lewis et al.[124] A Cronbach α coefficient of 0.88 was obtained using dependent data (n = 73 observations from 37 patients), which was improved to 0.93 by removing the "cry" item from the scale. Such a finding may indicate that the cry item is not relevant to adults in the ICU. Interrater reliability was demonstrated with an ICC of 0.98 for the FLACC scores between 2 nurse raters who completed 60 observations in 29 adult patients in the ICU. Significant reductions in FLACC scores ($P < .001$) comparing before and after analgesic administration or painful and nonpainful procedures supported discriminative validation. Additional research is necessary to adapt the content of the FLACC for the ICU adult population and to establish the reliability and validity of its use in noncommunicative, critically ill adults.

Multidimensional Objective Pain Assessment Tool. The Multidimensional Objective Pain Assessment Tool (MOPAT) was newly analyzed in this review. The tool includes 4 behavioral and 4 physiologic indicators. Its content development was based on the ratings of pain descriptors by 20 nurses according to their own experience of assessing pain in noncommunicative and cognitively impaired patients in hospice.[125] The validity, reliability, and clinical usefulness of the MOPAT was tested in noncommunicative hospice patients.[125] The blood pressure indicator was reported as having a negligible effect.[125]

The MOPAT (including the blood pressure indicator) was evaluated in 27 patients in the medical ICU who were unable to self-report pain.[126] Internal consistency of MOPAT total scores was moderate during and after painful procedures, with Cronbach α values of 0.68 and 0.72, respectively. Cronbach α values were higher for the behavioral component (≥ 0.80) compared with the physiologic component during and after the painful procedures (0.37 and 0.57, respectively). {**AQ27**} Interrater agreement among 3 raters (from 2 investigators and 21 nurses) was 68% and 83% for the behavioral component, 80% and 79% for the physiologic component (κ coefficients not provided) at the 2 times. Discriminative validation was demonstrated for behavioral and physiologic indicators, as well as for the MOPAT total score—all showing significantly higher scores during versus after a painful procedure (eg, turning, suctioning). The physiologic indicators had a very small effect on the variation of the total score. The Clinical Utility Questionnaire was used to evaluate the nurses' perceptions regarding the usefulness of the MOPAT. The tool was considered easy to use and helpful in determining the presence of pain in a noncommunicative patient by more than 93% of the responders,

but 20% were undecided about whether the tool assisted them in communicating to others about a patient's pain.[126]

The MOPAT was validated in a small ICU sample but was evaluated as feasible and clinically useful by ICU nurses.[126] {**AQ28**} Overall, the behavioral indicators appear to be the most helpful, whereas the physiologic indicators require additional study. The item related to "patient sounds" is not applicable to patients receiving mechanical ventilatory support and would require an alternative item for this ICU clientele. Implementation studies in clinical practice are needed.

Nociception Coma Scale–Revised. The NCS-R[127] is a short version (with the visual response removed) of the 4-item NCS developed for nociception and pain assessment in patients with brain injury with disorders of consciousness.[128] The initial version of the NCS was developed on the basis of an extensive literature review and pilot data, and it was tested in 48 patients from various settings (eg, acute care, neurology, neurorehabilitation, nursing homes) but not in the ICU. The NCS-R was newly analyzed in the present review. It was tested in a total of 60 acute care patients with brain injury in 2 studies by Chatelle et al.[127,129] In their 2012 study,[127] 21 patients with acute brain injury (including patients in the ICU) were part of a larger sample with chronic patients who were 1 month to 6 years after injury (n = 64). Patients were assessed at baseline (rest), with a non-nociceptive stimulation (taps on the patient's shoulders), and with a nociceptive stimulation (pressure on the nail bed measured in Newton-meters). In this study,[127] Chatelle et al initially used the NCS, with which they obtained poor validity results. They decided to remove the visual response item, which led to improved findings. The NCS-R could discriminate among baseline, the non-nociceptive, and the nociceptive stimulations. The researchers used ROC analysis to compare curves between the non-nociceptive and the nociceptive stimulations.[127] A cut-point score of 4 with a sensitivity of 73% and a specificity of 97% was found. The NCS-R cut-point score varied according to the patient's level of consciousness and was lower (score of 3) for those in a vegetative state. In the 2016 study of Chatelle et al,[129] discriminative validation of the NCS-R was supported with significant lower scores after administration of an analgesic compared with before administration in 39 patients with brain injury who were in the ICU and neurology units. Chatelle et al used an NCS-R cut-point score of 4 as a criterion to confirm the presence of pain before the administration of an analgesic. Neither internal consistency nor interrater reliability were examined in these studies.[127,129] Of note, the score of 3 for the facial expression item (the cry item) is greater than that given for grimace (score of 2). It remains unclear from the scoring description if facial contraction should be present in addition to cry to obtain the highest score on this item.[128] Also, the item "verbal response" would not be applicable to patients receiving mechanical ventilatory support.

To make the NCS-R applicable to patients in the ICU receiving mechanical ventilatory support, Bernard et al[40] replaced the verbal response item of the NCS-R with the compliance with ventilator item of the BPS and called it the NCS-R-I (I for intubated). They tested this version in 50 patients in the ICU with brain injury who were intubated. A Cronbach α of 0.69 was found for internal consistency, and interrater reliability was supported with a weighted κ of 0.84 between the investigator and nurse raters. Significant increases in the NCS-R-I scores were found during both the non-nociceptive (ie, assessment of the sedation level using the RASS procedure) and the nociceptive procedures (ie, tracheal suctioning and turning), but the increase was greater during the nociceptive procedures. Using the nociceptive procedures as the reference criterion and the non-nociceptive procedure as a comparator, correlated ROC curves resulted in an AUC of 0.97 for an NCS-R-I cut-point score of 2. ICU nurses (n = 15 of 21; 71% response rate) evaluated the NCS-R-I as precise (93%), useful (100%), and easy to learn (80%).

Pain Assessment in Advanced Dementia Tool. The Pain Assessment in Advanced Dementia (PAINAD) tool was developed to assess pain in individuals with advanced dementia.[130] It was validated by Paulson-Conger et al[83] for use in 100 adult patients in 4 medical ICUs (cardiac, medical, surgical, and neurologic) of a level I trauma center in the United States. The PAINAD tool was analyzed as part of the 2018 SCCM clinical practice guidelines,[4] and 1 new validation study with 50 patients who were admitted to

the ICU for spinal cord or brain injury was added in this review,[95] which led to a 3-point increase in its psychometric score. In the study by Paulson-Conger et al,[83] patients were assessed only once, while at rest, by the principal investigator or trained data collectors (1 per critical care unit). Internal consistency was supported with a Cronbach α of 0.80. Correlation between PAINAD and CPOT scores was 0.86. Such a high correlation between the tools' scores is not surprising—they include similar items. Comparing 2 tools measuring the same construct (in this case, pain behaviors) refers to convergent validation but, ideally, it should be done by selecting 2 different assessment methods and not similar tools.[98] In the study by Sulla et al,[95] a correlation of 0.67 was found between the PAINAD and self-reported NRS scores and almost a perfect classification ability (AUC = 0.98) using repeated observations. The use of the PAINAD tool in critically ill adults cannot be supported, because some validation strategies remain to be examined (ie, interrater reliability) or replicated (ie, criterion and discriminative validation), and some tests (correlation and ROC curve analysis) were performed using methods not considering dependent data. In addition, the PAINAD tool's content should be adapted for use with patients receiving mechanical ventilatory support, for whom the item "vocalization" is not applicable.

Discussion

Validation studies of behavioral pain assessment tools in critically ill adults have increased substantially in recent years. In fact, half of all studies included in this review were published in the last 3 years. Considering these additional studies, higher psychometric scores were obtained for many tools, including the BPS, BPS-NI, CPOT, NVPS-I, NVPS-R, and PAINAD, when compared with those of the 2018 SCCM clinical practice guidelines.[4] The BPS, BPS-NI, and the CPOT remain the behavioral pain assessment tools with the strongest psychometric properties, as stated in the 2018 SCCM guidelines.[4] These tools underwent external validation in several countries (not including Canada and France, where they were originally developed) and have been translated into several different languages. Comparison of the BPS and the CPOT yielded similar psychometric results.[18,19,22,31,33,34,37,46-48] The BPAT is the tool that was validated in the most countries (n = 28) and is available in multiple languages. Good psychometric findings have been reported for the initial and revised versions of the NVPS for their use in the ICU; however, the physiologic indicators did not perform as well as the behavioral indicators. Similar findings were obtained using the MOPAT, with the behavioral indicators performing better compared with physiologic indicators. Tools developed for pediatric and non-ICU populations would require some adaptation to be valid in the adult ICU population. This strengthens the fact that use of a tool is valid for a specific population and in a given context,[98] and that use of the tool in a different patient group or context of care is contingent on its additional validation in these new circumstances.

In many studies, a lack of attention to basic assumptions in statistics was noted. The most frequent was the calculation of Cronbach α or correlation coefficients on the basis of the number of observations (eg, 300 observations) within subjects (eg, 30 patients) assessed at different times, which may inflate the values of these coefficients. A more accurate approach is to calculate and report these coefficients using the sample of patients at each assessment time (eg, before, during, and after procedures). A Cronbach α is based on shared variance among items, which may be low when calculated at rest because the tools' scores tend to be low. Cronbach α also is influenced by the number of items (ie, a greater number of items increases the coefficient value).[131] Therefore, we may question the relevance of this statistic for the validation of behavioral pain assessment tools.

Confusion regarding validation strategies was also noted. In several studies, authors reported a correlation coefficient between the scores of 2 scales with similar items (eg, BPS and CPOT) and described this strategy as convergent or a criterion validation. Convergent validation refers to comparing 2 different assessment methods measuring the same concept (in this review, the concept is related to pain behaviors). Using similar assessment methods (eg, 2 behavioral pain assessment tools), therefore, is not the most useful approach, because the correlation tends to be high (> 0.80), as reported in studies[18,19,22,31,33-35,37,46-48,83,95,118] included in this review.

The use of other pain-related measures such as pain distress[14] or pain unpleasantness[85] would be more appropriate for convergent validation testing. Criterion validation refers to comparing the tool with the gold standard established in the field.[98] The patient's self-report is the gold standard criterion in the field of pain. Therefore, using 2 behavioral pain assessment tools for criterion validation is not appropriate.

ROC analysis is a common strategy to establish the performance of a test or tool to detect a problem as well as sensitivity and specificity associated with the best cut-point score.[132] A gold standard criterion must be present that allows discrimination of patients into 2 groups: 1 with pain and 1 without pain. Because behavioral pain assessment tools are developed for use with noncommunicative patients in the ICU, cut-point scores for these tools were established in most studies using the self-report of communicative patients in the ICU.[11,21,32,33,37,58,61,66,68,75,78,92,99] Although it may represent the best available approach according to the pain definition, this strategy may have limitations because the patient's self-report of pain must be reliable and is influenced by many personal and social factors. Delirium is a common source of unreliable self-report, and screening for delirium was not specified in many studies. Moreover, this approach may be appropriate if we assume that pain behaviors are the same in communicative and noncommunicative patients in the ICU. The level of consciousness and the level of sedation or agitation may influence pain behaviors. The threshold could be lower in patients with a low level of consciousness or a high level of sedation[40] or higher in agitated patients.[67] Another approach was explored by some research teams who used nociceptive procedures as the reference criterion in comparison with rest before a procedure or used nonnociceptive procedures to assess the ability of behavioral tools to detect pain.[40,127] {**AQ29**} However, not all patients experience pain during nociceptive procedures; therefore, the cut-point score instead would detect a nociceptive procedure (or nociception) than detect pain per se. For consistency in scoring criterion validation, we gave scores to studies in which the patient's self-report of pain was used as the gold standard. In future research, both criteria (ie, self-report of pain, nociceptive procedures) could be explored in ROC analysis to allow comparison between cut-point scores.

In the 2013 SCCM clinical practice guidelines,[8] validation of behavioral pain assessment tools in patients with brain injury in the ICU was identified as an area for additional research. Since then, this patient group was specifically examined in several studies with the BPS,[17,40-45] the CPOT,[42,91-96] the NCS-R,[127,129] and the NCS-R-I.[40] In most studies, only the total scale scores were provided. When compared with patients undergoing surgery and those with trauma, those with a brain injury had lower CPOT scores.[79] Interestingly, a low effect size was found for the facial expression item of the BPS,[45] and a grimace score of 2 and muscle rigidity score of 2 on the CPOT were not frequently observed.[92] In addition, specific behaviors such as orbit tightening and eye weeping were described in patients with brain injury in the ICU.[133,134] Adaptation of the content of existing scales for such patients could enhance their applicability and validity in this vulnerable group.

Potential sources of bias in conducting this analysis include the selection and weighting of items in the psychometric scoring system that influenced the scores of each scale. Also, psychometric properties are not static and may evolve with further development or adaptation and validation testing of a scale. The use of a different system would lead to different scores for each scale. Psychometric scores also were established for the use in scales for adult patients in the ICU. Therefore, they do not reflect the psychometric performance of their use in other contexts of care.

Implications for Nursing

Nurses play a key role in the assessment and management of pain, and they are advocates for their patients to ensure that pain does not go unnoticed. They are responsible for regularly assessing pain using methods appropriate to a patient's ability to communicate and to offer adequate treatment based on a multimodal analgesic approach. Behavioral pain scores as part of pain management algorithms[3,23,52] may guide nurses in the administration of a low opioid dose when appropriate, and pain reassessment is essential to evaluate the effectiveness of analgesia and adjust the treatment. Nurses can also

initiate nonpharmacologic interventions to optimize pain management.[4] Family members can be consulted about pain-related behaviors of their loved one and offered the opportunity to contribute to pain management if they feel comfortable doing so.[4-6]

Pain management is a team effort and, to optimize the nurse's role in pain management, training on any tool's use should be offered to all members of the multidisciplinary team. Communication about pain assessment and management would be enhanced if addressed during nursing handoffs and multidisciplinary daily rounds, with all attendees understanding the methods used for obtaining crucial information about the patient's pain. In addition, ICU leaders, such as clinical nurse specialists or educators, are encouraged to conduct routine quality control on the use of pain assessment tools by clinicians so accurate information is used to make treatment decisions.

Future Research Steps

Implementation studies have focused mainly on pain management practice indicators and short-term patient outcomes. Still unexplored, however, is the impact pain management protocols based on the regular use of pain assessment tools have on long-term patient outcomes, such as chronic pain development and quality of life. In addition, behavioral pain assessment tools can only be used in patients able to behaviorally react to stimulation. Therefore, they are minimal or absent in patients who are heavily sedated (eg, RASS of –4) and are not observable in unresponsive patients (eg, Glasgow Coma Scale score of 3; RASS of –5). Behavioral pain assessment tools can also be challenging to use in very agitated patients.[67] In such situations, clinicians can consider that a patient might be in pain if a responsive patient in a similar condition would most likely report pain, and alternative assessment methods must be explored. Although vital signs are not valid for pain assessment purposes in the ICU when considered individually,[3-6] innovative technology may have some potential. The use of the Analgesia Nociception Index (which is based on heart rate variability) and the Nociception Level Index (which is based on multiple parameters related to heart rate, heart rate variability, galvanic skin response, and peripheral temperature) have been studied for ICU pain assessment,[42,135,136] but more research is needed.

Conclusions

The use of validated behavioral pain assessment tools is crucial for noncommunicative patients in the ICU. The BPS, BPS-NI, and CPOT, which were specifically developed for this population, have shown the strongest psychometric properties with highest evidence; their use is feasible and positively influenced pain management practices and patient outcomes. It is important that all members of the multidisciplinary team be trained to use the behavioral pain assessment tool selected for their ICU setting so they can interpret pain scores and better communicate about pain assessment findings. Assessing pain properly is the key step to improved pain management and better care for noncommunicative patients in the ICU.

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AUTHOR QUERIES

The following queries are indicated on your galley pages by a highlighted {**AQ1**} or {**AQ2**} and so on embedded in the text. Please respond to each query directly on the galley whenever possible, indicating how the galley is to be altered. Other comments or longer changes can be marked on this query sheet and returned with the galleys. Be sure to respond to each query; if OK, mark OK.

AQ1: Per journal style, each author's full name is used on byline—we supplied these from release forms. Please confirm authors' names and affiliations, and the corresponding author's address are correct.

AQ2: Per journal style, fellowships are not listed in the author byline.

AQ3: Please note there was an affiliation with the footnote number 12 ("School of Nursing, University of California, San Francisco"), but none of the authors' names were marked with footnote 12, so that was removed. If this affiliation should be retained, please indicate which author is associated with it.

AQ4: Does the edit to the previous sentence preserve your intended meaning?

AQ5: The sentence that began "Three of those tools" was removed from the Abstract because it was an unconditional claim of priority. In the main text, where claims of priority (ie, "for the first time" and similar phrasing) are made, they have been retained but qualified (ie, "to our knowledge" has been added). Edit OK?

AQ6: Is the edit to the previous sentence correct?

AQ7: As done for the first author, please indicate each author's role at their listed affiliation(s). XXX has been used as a placeholder where this information should be supplied.

AQ8: Does the edit to the previous sentence preserve your intent?

AQ9: Is the edit to the previous sentence OK?

AQ10: Do the edits to the previous sentence preserve your intent?

AQ11: Please confirm the abbreviation ESCID was expanded correctly in the previous sentence.

AQ12: After discussion with Mary Fran, we'd like to make current Tables 2 and 3 online content, both for space and because they contain supplemental information. We would like to make them Appendices A and B (this would also allow us to avoid having to renumber references throughout to match our style--currently refs in tables are not numbered sequentially within content call-out).

AQ13: In the original manuscript, reference 27 was cited before reference 26; therefore, those entries were switched in References and their in-text citations also were switched, so original reference 27 is now reference 26 and vice versa.

AQ14: Do the edits to the previous sentence preserve your intent?

AQ15: References 47 and 48 were cited in the text before reference 46; therefore, these entries were rearranged in References to be listed in the order they are cited, and their in-text citations also have been renumbered.

AQ16: The phrases in the previous sentence were rearranged from the original version. Does the edit retain your intended meaning?

AQ17: Does the edit to the previous sentence preserve your intent?

AQ18: OK to add "thresholds" in previous sentence? Please specify what "those" refers to, if that isn't correct.

AQ19: In the previous sentence, please confirm "decrease in mortality" referred to "mortality rate," as edited, rather than "mortality risk" or other term.

AQ20: Is the edit to the previous sentence correct?

AQ21: In the previous sentence, please confirm "it" was identified correctly as "the training" rather than "the CPOT."

AQ22: Does the edit to the previous sentence preserve your intent?

AQ23: Throughout the article, all instances of "ESCID scale" were changed to "ESCID" because the acronym includes the word "scale" (in Spanish).

AQ24: Edit OK to the previous sentence?

AQ25: Is the edit correct to the previous sentence?

AQ26: In the previous sentence, is the edit correct that indicates the range of ICC values refers to the English version of the NVPS-R?

AQ27: In the previous sentence, is the edit correct?

AQ28: In the previous sentence, is the edit correct assuming the statement was still referring to reference 126?

AQ29: Does the edit to the previous sentence preserve your intent?

AQ30: Please provide English translation of title.

Table 1: Description of Behavioral Pain Assessment Tools

Name	N Items	Items	Item Score	Total Score	Cut-Off Score
Behavior Assessment Tool (BOT)	38	Facial responses: grimace, frown, wince, eyes closed, eyes wide open with eyebrows raised, looking away in opposite direction of pain, grin/smile, mouth wide open to expose teeth and tongue, clenched teeth exposing slightly open mouth Verbal responses: moaning, screaming, whimpering, crying, using protest words, verbal complaints of pain Body movement: no movement, rigid, arching, clenched fists, shaking, withdrawing, splinting, flailing, picking/touching site, restlessness, rubbing/massaging, repetitive movements, defensive grabbing, pushing, guarding	Yes/No	0 to 38	Not established
Behavior Pain Assessment Tool (BPAT)	8	Neutral expression, grimace, wince, eyes closed, moaning, verbal complaints of pain, rigid, clenched fists	Yes/No	0 to 8	Pain >3
Behavioral Pain Scale (BPS) Behavioral Pain Scale–Nonintubated (BPS-NI)	3	Facial expression, movements with upper limbs, compliance with ventilator (BPS), vocalization (BPS-NI)	1 to 4	3 to 12	Pain >5
Critical-Care Pain Observation Tool (CPOT)	4	Facial expression, body movements, muscle tension, compliance with ventilator **OR** vocalization	0 to 2	0 to 8	Pain >3
ESCID Behavioral Indicators of Pain Scale	5	Face, restlessness, muscle tone, compliance with ventilator, consolability	0 to 2	0 to 10	Not established 0 = No pain 1–3 = Mild 4–6 = Moderate >7 = Severe
Face, Legs, Activity, Cry, Consolability (FLACC)	5	Face, legs, activity, cry, consolability	0 to 2	0 to 10	Not established
Multidimensional Objective Pain Assessment Tool (MOPAT)	8	Behavioral dimension: Facial expression, restlessness, muscle tension, patient sounds Physiologic dimension: Blood pressure, heart rate, respiratory rate, diaphoresis	0 (none) to 3 (severe) 0 (no change) 1 (change)	0 to 16	Not established
Nociception Coma Scale–Revised (NCS-R) Nociception Coma Scale–Revised-Intubated (NCS-R-I)	3	Facial expression response, motor response, verbal response (NCS-R), compliance with ventilator (NCS-R-I)	0 to 3	0 to 9	Pain > 4
Nonverbal Pain Assessment Tool (NPAT)		Emotion, movement, verbal cues, facial cues, positioning/guarding	0 to 2	0 to 10	Not established

Continued

Table 1: *Continued*

Name	N Items	Items	Item Score	Total Score	Cut-Off Score
Nonverbal Pain Scale (NVPS)	5	Behavioral indicators: Face, activity (movement), guarding Physiologic indicators: I-vital signs, II-skin	0 to 2	0 to 10	Not established
Nonverbal Pain Scale–Revised (NVPS-R)	5	Behavioral indicators: Face, activity (movement), guarding Physiologic indicators: Vital signs, respiratory—respiratory rate/oxygen saturation, compliance with ventilator	0 to 2	0 to 10	Not established
Pain Assessment Intervention Notation (PAIN)	9	Behavioral dimension: movements, vocalization, facial indicators, and posturing/guarding Physiological dimension: heart rate, blood pressure, respiratory rate, perspiration, pallor	Yes/No		Not established
Pain Assessment in Advanced Dementia (PAINAD)	5	Breathing, negative vocalization, facial expression, body language, consolability	0 to 2	0 to 10	Not established using gold standard As per the author's description: 0 = No pain 1–3 = Mild 4–6 = Moderate 7–10 = Severe

Abbreviation: ESICD, Spanish acronym of Behavioral Indicators for Pain Scale.

Table 2: Description of Validation Studies (n = 86)

Author	Year	Country	Tool	Language Version	ICU Clientele/Sample	Able to Self-Report	Unable to Self-Report	Internal Consistency	Interrater Reliability	Content Validation	Criterion Validation	Discriminative Validation	Procedure/Treatment
Ahlers et al[28]	2008	Netherlands	BPS	NM	113 surgical	X	X		X				
Ahlers et al[29]	2010	Netherlands	BPS	NM	80 medical and surgical	X	X	X	X		X	X	Turning, arterial catheter dressing change
Aissaoui et al[30]	2005	Morocco	BPS	English	30 medical		X	X	X			X	ET suctioning, peripheral venous cannulation
Al Darwish et al[31]	2016	Saudi Arabia	BPS CPOT NVPS	NM	47 medical and surgical		X	X	X			X	Turning, suctioning
Aktas et al[70]	2017	Turkey	CPOT	Turkish	66 cardiac surgery	Conscious/ intubated		X	X			X	ET suctioning
Azevedo-Santos et al[17]	2016	Brazil	BPS	Brazilian	15 neurocritically ill (mainly TBI)		X	X	X			X	ET suctioning, eye cleaning
Bernard et al[40] (in press)	2019	France	BPS NCS-R NCS-R-I	French	50 with brain injury		X	X	X		X	X	ET suctioning, turning, evaluation of the sedation level
Boitor et al[85]	2016	Canada	CPOT	English	125 cardiac surgery	X			X		X	X	Mediastinal tube removal, NIBP
Bouajram et al[32]	2018	United States	BPS CPOT	English	115 medical and surgical (with and without delirium)	X	X				X		
Buttes et al[76]	2014	United States	CPOT FLACC	English	75 medical and surgical	X			X		X	X	Repositioning
Carletti et al[20]	2016	Italy	BPS-NI	Italian	45 medical	X	X	X	X		X	X	Turning on both sides, hygiene care, central venous or arterial catheter dressing change
Chanques et al[15]	2009	France	BPS-NI	French	30 medical and surgical (with delirium)		X	X	X			X	Turning for toilet, central or arterial catheter dressing change
Chanques et al[46]	2014	United States	BPS BPS-NI CPOT NVPS-R	English	30 medical		X	X	X			X	ET suctioning, repositioning, turning
Chatelle et al[127]	2012	Belgium	NCS-R	NM	64 with brain injury (21 in the acute stage)		X				X	X	Taps on the patient's shoulders, pressure on the nail bed (measured in Newton-meters)
Chatelle et al[129]	2016	Belgium	NCS-R	NM	39 with brain injury		X					X	Analgesic treatment
Chen et al[21]	2011	China	BPS	Chinese	70 medical	X	X		X		X	X	ET suctioning, body temperature
Chen et al[27]	2016	China	BPS BPS-NI	Chinese	212 surgical	X	X	X	X	X	X	X	ET suctioning, changing position, body temperature
Chen et al[77] (accepted)	2019	China	CPOT	Chinese	129 surgical	X		X	X		X	X	Changing position and ET suctioning, body temperature

Continued

Table 2 *Continued*

Author	Year	Country	Tool	Language Version	ICU Clientele/Sample	Able to Self-Report	Unable to Self-Report	Internal Consistency	Interrater Reliability	Content Validation	Criterion Validation	Discriminative Validation	Procedure/Treatment
Cheng et al[33]	2018	China	BPS CPOT	Chinese	316 medical	X	X		X		X	X	ET suctioning, NIBP
Chookalayi et al[119]	2017	Iran	NVPS NVPS-R	Translated but language NM	60 mixed dx (medical, surgical, trauma, neurological)	X	X	X	X		X	X	Turning, washing eyes with normal saline
Chookalayia et al[67]	2018	Iran	CPOT	Persian	65 medical, surgical, and trauma	X	X	X	X		X	X	Changing position, washing eyes
Dale et al[78]	2018	Canada	CPOT	English	98 medical, surgical, and trauma	X	X		X		X	X	Oral suctioning, tooth brushing, swabbing with a sponge toothette
Delghani et al[41]	2014	Iran	BPS	NM	50 TBI		X	X				X	ET suctioning, eye care with normal saline
Echegaray-Benites et al[91]	2014	Canada	CPOT	English	43 brain surgery	X			X		X	X	Turning, NIBP
Emsden et al[63]	2019	Switzerland	CPOT	German	60 medical and surgical	X		X	X		X	X	Turning, gentle touch
Faritous et al[86]	2016	Iran	CPOT	NM	70 cardiac surgery		X					X	Suctioning, changing position
Frandsen et al[61]	2016	Denmark	CPOT	Danish	70 medical and surgical	X	X	X	X		X	X	Turning, arm wash
Gélinas et al[56]	2006	Canada	CPOT	French	105 cardiac surgery	X	X		X		X	X	Positioning/turning
Gélinas et al[99]	2009	Canada	CPOT	French	105 cardiac surgery (same as in Gélinas et al[56])	X					X		Turning
Gélinas et al[80]	2011	Canada	CPOT	French	9 medical, surgical, and trauma		X					X	Turning, ET suctioning
Gélinas et al[59]	2015	Canada	CPOT	French	45 medical, surgical, and TBI		X					X	Turning, NIBP
Gélinas and Arbour[79]	2009	Canada	CPOT	French and English	257 medical, surgical, and trauma (58 new patients)	X	X				X	X	Turning
Gélinas et al[57]	2009	Canada	CPOT	French	17 clinicians (nurses and physicians)					X			
Gélinas and Johnston[58]	2007	Canada	CPOT	English	55 medical, surgical, and trauma	X	X		X		X	X	Turning, NIBP
Gélinas et al[14]	2017	28 countries	BPAT	English and 12 other languages	3851 mixed dx, 192 ICUs from 28 countries	X	X		X		X	X	12 procedures: turning, ET suctioning, mobilization, respiratory exercises, positioning, peripheral blood draw, peripheral IV insertion, wound care, ET suctioning, chest tube removal, arterial line insertion, wound drain removal

Continued

Table 2 *Continued*

Author	Year	Country	Tool	Language Version	ICU Clientele/Sample	Able to Self-Report	Unable to Self-Report	Internal Consistency	Interrater Reliability	Content Validation	Criterion Validation	Discriminative Validation	Procedure/Treatment
Ghanbari et al[87]	2016	Iran	CPOT	NM	150 cardiac surgery	X					X		Suctioning
Gomarverdi et al[34]	2019	Iran	BPS CPOT	NM	90 (dx not specified)		X					X	Changing position, suctioning, mouthwash, respiratory therapy
Gutysz-Wojnicka et al[24] (in press)	2018	Poland	BPS NVPS	Polish	28 medical, trauma, and neurologic		X	X	X	X		X	ET suctioning or turning, NIPB or dressing change
Hsiung et al[22]	2016	Taiwan	BPS CPOT	Chinese Mandarin	10 surgical		X	X		X			ET suctioning
Hylén et al[25]	2016	Sweden	BPS BPS-NI	Swedish	20 medical, surgical, and trauma		X		X	X		X	Repositioning
Jendoubi et al[42]	2017	Tunisia	BPSC-POT	NM	21 TBI		X					X	ET suctioning
Joffe et al[92]	2016	United States	CPOT	English	79 with brain injury	X	X		X		X	X	Turning, gentle touch
Juarez et al[35]	2010	United States	BPS NVPS-R	English	200 medical and surgical		X	X	X			X	Turning
Kabes et al[117]	2009	United States	NVPS NVPS-R	English	64 surgical and trauma		X	X	X			X	Suctioning or repositioning
Kanji et al[81]	2016	Canada	CPOT	English	40 medical and surgical with delirium		X	X	X			X	Repositioning, ET suctioning, wound dressing change, NIBP
Kaya and Erden[118]	2019	Turkey	NVPS-R	Turkish	74 surgical		X	X		X			ET suctioning
Keane[88]	2013	United States	CPOT	English	21 cardiac surgery	X			X		X	X	Positioning
Khanna et al[82]	2018	India	CPOT	NM	60 medical and surgical		X					X	Positioning, ET suctioning
Kiavar et al[89]	2016	Iran	CPOT	NM	91 cardiac surgery		X					X	ET suctioning, changing position
Klein et al[115]	2010	United States	NPAT	English	220 medical and surgical			X	X	X	X		
Klein et al[18]	2018	Brazil	BPS BPS-NI CPOT	Brazilian Portuguese	168 medical and surgical		X		X			X	Turning, standardized stimulation by pressure algometry
Kotfis et al[68]	2018	Poland	CPOT	Polish	71 medical and surgical	X	X		X		X	X	Positioning and turning, eyelid wiping with normal saline
Kwak et al[66]	2012	Korea	CPOT	Korean	202 medical, surgical, and trauma	X	X		X		X	X	Suctioning
Latorre-Marco et al[110]	2011	Spain	ESCID	Spanish	42 mixed (medical, surgical, trauma, neurological)		X	X	X	X		X	
Latorre-Marco et al[113]	2016	Spain	ESCID	Spanish	190 mixed (medical, surgical, trauma, neurological)		X	X	X			X	Turning/repositioning, ET suctioning, gentle rubbing of a gauze cloth on intact skin

Continued

Table 2 *Continued*

Author	Year	Country	Tool	Language Version	ICU Clientele/Sample	Able to Self-Report	Unable to Self-Report	Internal Consistency	Interrater Reliability	Content Validation	Criterion Validation	Discriminative Validation	Procedure/Treatment
Lee et al[93]	2013	Korea	CPOT	NM	31 with brain injury and brain surgery		X					X	ET suctioning
Li et al[13]	2009	United States	BOT	English	48 cardiac surgery		X					X	ET suctioning or turning, gentle touch
Li et al[75]	2014	China	CPOT	Chinese	63 medical and surgical	X		X	X		X	X	Turning, NIBP
Linde et al[90]	2013	United States	CPOT	English	30 cardiac surgery	X	X		X			X	Turning, ET suctioning, compression stocking, central catheter dressing change
Liu et al[47]	2015	China	BPS BPS-NI CPOT	Chinese	117 medical and surgical		X	X	X			X	Suctioning, NIBP
Lopez-Lopez et al[114]	2018	Spain	ESCID	Spanish	124 trauma		X		X			X	Mobilization, ET suctioning, gentle rubbing of a gauze cloth on intact skin
Navarro-Colom et al[39]	2015	Spain	BPS	NM	34 medical and surgical		X	X	X				Mobilization
Nürnberg et al[69]	2011	Sweden	CPOT	Swedish	40 medical and surgical		X	X	X			X	Turning, arm/face wash
Odhner et al[116]	2003	United States	FLACC NVPS	English	59 burn, surgical, and trauma		X	X	X				Turning or suctioning
Olsen et al[23]	2015	Norway	BPS BPS-NI	Norwegian	111 (dx not specified)		X		X n=11			X	Turning
Paulson-Conger et al[83]	2011	United States	CPOT PAINAD	English	100 medical		X	X					
Payen et al[16]	2001	France	BPS	French	30 surgical and trauma		X		X			X	Mobilization, central venous catheter dressing change
Puntillo et al[12]	1997	United States	PAIN	English	31 surgical	X				X			
Puntillo et al[10]	2004	United States, Canada, Australia	BOT	English	5957 mixed (medical, surgical, trauma, burn, other); 169 sites from 4 countries (United States, Canada, Australia, and United Kingdom)	X					X	X	Femoral sheath removal, central venous catheter placement, ET suctioning, wound care, wound drain removal, turning
Rahu et al[36]	2015	United States	BPS FLACC NVPS	English	150 medical and trauma	X	X		X		X	X	ET suctioning, physical examination
Ribeiro et al[43]	2017	Brazil	BPS	Brazilian (Azevedo)	20 TBI		X					X	ET suctioning, eye cleaning
Ribeiro et al[44]	2018	Brazil	BPS	Brazilian	27 TBI		X		X			X	ET suctioning, eye cleaning

Continued

Table 2 *Continued*

Author	Year	Country	Tool	Language Version	ICU Clientele/Sample	Able to Self-Report	Unable to Self-Report	Internal Consistency	Interrater Reliability	Content Validation	Criterion Validation	Discriminative Validation	Procedure/Treatment
Ribeiro et al[45]	2019	Brazil	BPS	Brazilian	37 TBI (including the 27 patients in 2018 study)		X	X	X			X	ET suctioning, eye cleaning
Rijkenberg et al[19]	2015	Netherlands	BPS CPOT	Dutch	68 medical		X	X	X			X	Turning, oral care
Rijkenberg et al[48]	2017	Netherlands	BPS CPOT	Dutch	72 cardiac surgery		X	X	X			X	Turning, oral care
Ross et al[84]	2016	Canada	CPOT	English	22 medical (at high risk of dying)		X		X			X	Turning, gentle touch
Severgnini et al[37]	2016	Italy	BPS CPOT	NM	101 medical and surgical	X	X				X	X	ET suctioning, peripheral venous cannulation
Shan et al[94]	2018	China	CPOT	Chinese	400 with brain injury	X	X		X		X	X	Suctioning, gentle touch
Stilma et al[62]	2015	Netherlands	CPOT	Dutch	108 medical and surgical	X	X	X	X		X	X	Turning
Sulla et al[95]	2017	Italy	CPOT PAINAD	Italian	50 with brain injury	X	X	X	X		X	X	Mobilization for hygiene
Storsveen and Hall-Lord[74]	2016	Norway	CPOT	Norwegian	18 medical and surgical (including neurological)		X		X			X	Turning
Topolovec-Vranic et al[96]	2013	Canada	CPOT NVPS-R	English	66 neurocritically ill (TBI or neurologic disorder)	X	X		X		X	X	Turning, NIBP
Vazquez et al[71]	2011	Spain	CPOT	Spanish	96 medical and surgical	Conscious	X		X			X	Positioning
Voepel-Lewis et al[124]	2010	United States	FLACC	English	29 medical and surgical (including neurological/neurosurgical)		X	X	X			X	Turning or suctioning, analgesic administration
Wiegand et al[126]	2018	United States	MOPAT	English	27 medical		X	X	X			X	Turning, suctioning, dressing change, arterial catheter insertion
Young et al[38]	2006	Australia	BPS	English	44 medical, surgical, and neurological		X	X	X			X	Repositioning, eye wash with normal saline

Abbreviations: BPS, Behavioral Pain Scale; BPS-NI, Behavioral Pain Scale–Nonintubated; CPOT, Critical-Care Pain Observation Tool; dx, diagnosis; ESCID, La Escala de Conductas Indicadoras de Dolor; ET, endotracheal/tracheal; FLACC, Face Legs Activity Cry Consolability; ICU, intensive care unit; IV, intravenous; MOPAT, Multidimensional Objective Pain Assessment Tool; NCS-R, Nociceptive Coma Scale–Revised; NCS-R-I, Nociceptive Coma Scale–Revised-Intubated; NIBP, noninvasive blood pressure; NM, not mentioned; NPAT, Nonverbal Pain Assessment Tool; NVPS, Nonverbal Pain Scale; NVPS-R, Nonverbal Pain Scale–Revised; PAINAD, Pain Assessment Intervention Notation; TBI, traumatic brain injury.

Table 3: Description of Feasibility and Implementation Studies (n = 25)

Author	Year	Country	Tool	Language Version	Design	ICU Setting	Sample	Feasibility	Clinical Relevance	Practice Indicators	Patient Outcomes
Arbour et al[109]	2011	Canada	CPOT	French	Pre/post	Medical, surgical, trauma	Patients with trauma: 15 pre, 15 post			Frequency of pain assessments, No. pain episodes, administration of analgesics, effectiveness of analgesia	MV duration, ICU length of stay, No. of complications
Asadi-Noghabi et al[102]	2015	Iran	CPOT	NM	Pre/post	NM	106 ICU nurses	X	X		
Bernard et al[40,a] (in press)	2019	France	BPS	French	Descriptive, post	Medical, surgical, neurologic ICU	15 nurses	X	X		
Bourbonnais et al[100]	2016	Canada	CPOT	English	Descriptive, post	Medical, surgical, trauma	23 ICU nurses who evaluated patients 5 times (n = 115 assessments)	X	X	Frequency of CPOT documentation, No. of pain episodes, analgesia and sedation, nonpharmacologic interventions	
Chanques et al[49]	2006	France	BPS	French	Pre/post	Medical, surgical	Patients: 100 pre, 130 post Nurses: 25 pre, 32 post	X	X	Frequency of pain and agitation assessments, administration of analgesics and sedatives	Incidence of pain and agitation, ICU length of stay, MV duration, adverse events, nosocomial infection
Chanques et al[46,a]	2014	United States	BPS BPS-NI CPOT NVPS-R	English	Descriptive, post	Medical	20 nurses	X	X		
Damico et al[103]	2018	Italy	CPOT	Italian	Pre/post	Medical, surgical, trauma	370 pre/217 post			CPOT scores, administration of analgesia and sedation	Memory of pain
De Jong et al[52]	2013	France	BPS/ BPS-NI	French	QI project	Medical, surgical	193 patients			Analgesic ordering practice, use of nonpharmacologic interventions	Incidence of severe pain, incidence of serious adverse events[b]
Faust et al[108]	2016	United States	CPOT	English	Pre/post	Medical	65 pre, 79 post			Pain and sedation scores, administration of analgesics and sedatives	MV duration, ICU length of stay, self-extubation, death
Gélinas[60]	2010	Canada	CPOT	English	Descriptive, post	Medical, surgical, trauma	33 ICU nurses	X	X		
Gélinas et al[104]	2011	Canada	CPOT	French	Pre/post	Medical, surgical, trauma	90 patients with various dx: 30 pre, 30 at 3 months, and 30 at 12 months post			Frequency of pain assessments, administration of analgesia and sedation, effectiveness of analgesia	
Gélinas et al[101]	2014	Canada	CPOT	French	Descriptive, post	Medical, surgical, trauma	38 nurses	X	X		
Gélinas et al[59,a]	2015	Canada	CPOT	French	Descriptive, post	Medical, surgical, trauma	35 nurses	X	X		
Mascarenhas et al[106]	2018	United Kingdom	CPOT	English	QI project	General ICU	Observations and chart reviews			Assess pain every 4 hours, treat pain when CPOT > 3	Measured but not reported
Olsen et al[53]	2015	Norway	BPS BPS-NI	Norwegian	Descriptive, post	2 ICUs (medical and surgical) and 1 PACU	217 nurses			Nurses' adherence to use of tools and pain management algorithm	

Continued

Table 3:*Continued*

Author	Year	Country	Tool	Language version	Design	ICU Setting	Sample	Feasibility	Clinical Relevance	Practice Indicators	Patient Outcomes
Olsen et al[54]	2016	Norway	BPS BPS-NI	Norwegian	Pre/post	2 ICUs (medical and surgical) and 1 PACU	398 pre, 252 post			Frequency of pain assessments, administration of analgesics and sedatives	ICU length of stay, MV duration
Payen et al[16,a]	2001	France	BPS	French	Descriptive, post	Trauma, surgical	28 evaluators (nurses, nurse's aides, physician, physical therapist)	X	X		
Phillips et al[105] (in press)	2018	Australia	CPOT	English	Pre/post	Medical, surgical, trauma	Medical and trauma patients: 441 pre, 344 post			Frequency of pain assessments, administration of analgesia and sedation	
Puntillo et al[122]	2002	United States	PAIN	English	Descriptive, post	3 ICUs and 2 PACUs	11 nurses	X	X		
Radtke et al[50]	2012	Germany	BPS	NM	Experimental, no randomization	Types of ICUs (n=3) not specified	619 patients			Frequency of pain assessments	ICU length of stay, MV duration, mortality
Rose et al[107]	2013	Canada	CPOT	English	Pre/post	Medical, surgical, trauma; cardiovascular	130 pre, 132 post			Frequency of pain assessments, administration of analgesics and sedatives	
Sacco et al[121]	2016	United States	NVPS-I	English	Pre/post	Trauma	Patients: 95 pre, 145 post Nurses: 27 (satisfaction with protocol use)	X	X	ICU nurse responsive to pain, administration of analgesics and antipsychotics	ICU length of stay, MV duration
Topolovec-Vranic et al[120]	2010	Canada	NVPS-I	English	Pre/post	Neurological, trauma	Patient surveys: 20 pre, 32 post Charts: 36 pre, 36 post Nurse surveys: 53 pre, 32 post	X	X	Frequency of pain assessments, administration of opioids, Staff Satisfaction Questionnaire (ease of use, satisfaction and confidence with pain assessment /management, barriers)	Patient Outcome Questionnaire (pain intensity, satisfaction with pain management)
Topolovec-Vranic et al[96,a]	2013	Canada	CPOT NVPS-R	English	Descriptive, post	Descriptive, post	20 nurses: 10 for each scale	X	X		
Williams et al[51]	2008	Australia	BPS	English	Pre/post	General, mixed	369 pre, 400 post			Administration of analgesics and sedatives	ICU length of stay, MV duration, adverse events

Abbreviations: BPS, Behavioral Pain Scale; BPS-NI, Behavioral Pain Scale–Nonintubated; CPOT, Critical-Care Observation Pain Tool; dx, diagnosis; ICU, intensive care unit; MV, mechanical ventilation; NM, not mentioned; NVPS-R, Nonverbal Pain Scale–Revised; NVPS-I, Nonverbal Pain Scale–Initial; PACU, postanesthesia care unit; PAIN, Pain Assessment Intervention Notation; pre, preintervention; post, postintervention; QI, quality improvement.

[a] Evaluation as part of a validation study.

[b] Tachycardia, bradycardia, hypertension, hypotension, desaturation, bradypnea, ventilator distress.