Journal of Critical Care 49 (2019) 136–142

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

Quality of Care

Measuring quality indicators to improve pain management in critically ill patients

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ARTICLE INFO

Keywords:
Pain
Quality indicator
Intensive care units
Quality improvement
Pain assessment

ABSTRACT

Purpose: To evaluate the quality of pain assessment in Dutch ICUs and its room for improvement.
Materials and methods: We used a modified RAND method to develop pain assessment indicators. We measured performance on the indicators using retrospectively collected pain measurement data from Dutch ICUs, which are all mixed medical – surgical, of three months within October 2016–May 2017. We assessed the room for improvement, feasibility of data collection, and reliability of the indicators.
Results: We defined four pain assessment indicators. We analyzed 45,688 patient-shift observations from 15 ICUs. In 69.2% (IQR 58.7–84.9) of the patient-shifts pain was measured at least once (indicator 1); in 56.7% (IQR 49.6–73.5) pain scores were acceptable (indicator 2); in 11.7% (IQR 5.6–26.4) pain measurements with unacceptable scores were repeated within 1 h (indicator 3); and in 10.9% (IQR 5.1–20.1) unacceptable scores normalized within 1 h (indicator 4). We found data collection feasible because data were available for >79.3% of the admissions, and all indicators reliable as they produced consistent performance scores.
Conclusions: There is substantial variation in pain assessment across Dutch ICUs, and ample room for improvement. With this study we took a first step towards quality assurance of pain assessment in Dutch ICUs.

1. Introduction

Pain experienced during ICU stay is known to influence patient outcomes. Pain decreases comfort and sleep and increases morbidity, mortality and length of stay [1-3]. During their stay half of the ICU patients experience moderate to severe pain at rest as well as during procedures [4-6]. Furthermore, severity of pain is often underestimated by caregivers [7]. Therefore it is important to recognize and treat pain appropriately. To assess pain validated tools exist such as the Visual Analogue Scale (VAS) or Numeric Rating Scale (NRS) in patients able to self-report [8], and the Critical-Care Pain Observation Tool (CPOT) or Behavioral Pain Scale (BPS) in patients not able to self-report [9,10]. Systematic assessment of pain with these tools decreases pain incidence and improves patient outcomes [11]. In a national survey held among Dutch ICUs in 2011 > 80% of the respondents considered it important to use standardized pain assessment tools in both patients able and unable to self-report. Obstacles to pain assessment and treatment, such as unstable patients and interference of sedation with pain assessment are also reported [12,13]. The above suggests pain assessment is a suitable target for quality improvement activities.

Quality indicators are used to measure structures, processes, and outcomes of care [14]. Since 1996 the Dutch National Intensive Care Evaluation (NICE) registry supports participating ICUs to quantify, compare and improve the quality of care they offer by providing benchmark information in a quality report [15]. In 2007 the NICE registry included a set of eleven indicators developed by the Dutch Society of Intensive Care to further support ICUs in quality improvement [16]. These indicators, however, resulted in either no or limited improvement in patient outcomes [17]. Explanations for this included insufficient variation between ICUs, ambiguous indicator definitions, and lack of knowledge on how to improve quality [18]. Pain management seems a medical domain with clear directions towards quality improvement. Large bodies such as the Society of Critical Care Medicine's ICU Liberation initiative made significant efforts by the PAD guidelines and ABCDEF bundle to liberate patients from the harmful effects of pain, agitation, and delirium

Abbreviations: ICU, intensive care unit; EHR, Electronic Health Record; PDMS, Patient Data Management System; OECD, Organisation for Economic Co-operation and Development; AIRE, Appraisal of Indicators through Research and Evaluation.

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https://doi.org/10.1016/j.jcrc.2018.10.027
0883-9441/

in the ICU [2,19]. However, until now quality indicators to measure ICUs' performance on pain assessment are not yet reported by NICE or, to our knowledge, by other national ICU quality registries.

The aim of this study was to evaluate the quality of pain assessment in Dutch ICUs and its room for improvement. To do so, we developed and evaluated actionable pain assessment indicators and assessed each ICU's performance.

2. Methods

2.1. Development of quality indicators

We developed quality indicators in three rounds using a modified RAND method [20,21], described in detail in Supplementary material 1. According to the OECD and Agency for Healthcare Research and Quality, indicators have to fulfill essential requirements: they should be relevant, actionable, valid, unambiguous, reliable, feasible to collect data for, and demonstrate room for improvement [22-24]. The involved expert panel consisted of ten national multidisciplinary experts from nine different hospitals: three anesthesiologist-intensivists (including DD), three internist-intensivists (including JJS and EdJ), two ICU nurses, one hospital pharmacist, and one research coordinator with experience in pain management, pain therapy and palliative care. The experts met after review of relevant peer reviewed literature, society guidelines and reflection on individual clinical experience to propose an initial set of quality indicators. The indicators were subsequently evaluated through a standard scoring mechanism to arrive at a concept set of quality indicators.

2.2. Participants and data collection

In the Netherlands all ICUs are mixed medical – surgical units. We invited all 83 ICUs (100%), of which eight academic ICUs and 75 non-academic ICUs, that participated in the NICE registry to submit routinely collected pain measurement data. The ICUs extracted data of at least three consecutive months concerning all patient admissions between October 2016 and May 2017 from their electronic health record (EHR) or patient data management system (PDMS) in addition to their regular uploaded data [15]. The pain data consisted of a patient identifier, date and time of pain assessment, pain score, and type of assessment tool (VAS or NRS in patients able to self-report and CPOT or BPS in patients not able to self-report). The validated pain measurement instruments have predefined thresholds to determine whether pain is unacceptable: VAS/NRS ≥ 4, CPOT≥3 and BPS ≥ 6 [7,10,11]. Delirious, comatose and patients with a Glasgow coma score < 8 were excluded from the data. Pain measurements were performed in patients at rest, usually by nurses, but also by physicians. We developed a data dictionary describing each data item needed to calculate the indicators [25] and sent these to the ICUs that positively responded to our invitation to participate. ICUs were eligible to participate when they were able to submit the data in accordance with the data dictionary. The medical ethics committee of the Amsterdam UMC, University of Amsterdam stated that ethical approval for this study was not required under Dutch national law (registration number W18_116 #18.147).

2.3. Data analysis

For each quality indicator we calculated ICUs' performance scores over a period of three consecutive months. We assessed each indicator's absolute room for improvement and variation between ICUs. Room for improvement is defined as the sensitivity of an indicator to detect variation in quality of care between ICUs [24,26]. But even when there is no variation, room for improvement can exist if desired targets are not met. We calculated median scores with interquartile ranges (IQR). Between-ICU variation was evaluated with a likelihood ratio test using ANOVA comparing a logistic regression model without 'ICU' to a model with 'ICU' as additional covariate. We adjusted for admission type (medical vs. surgical) because this could influence performance on pain assessment. We did not control for other patient factors such as age and gender because the expert panel deemed pain and its frequent assessment important in all patients irrespective of their age and gender.

Furthermore, we evaluated the feasibility of data collection for each of the indicators. This relates to the availability of routinely collected data and the lack of additional registration burden to obtain the data required to calculate the indicator [23,24]. We considered data collection feasible if pain measurement data could be extracted for at least 70% of the admitted patients, this threshold was similar to [26]. We also assessed the reliability of the indicators. We considered an indicator reliable if measurements produce consistent results when performed by different ICU professionals and when the indicator produces consistent results over time [23]. Pain measurements in ICUs are performed with standardized assessment tools that were shown to produce consistent results when used by different ICU professionals [7,27], which means that the data needed to calculate the indicators are measured in a reliable way. We calculated Krippendorff's alpha (αK) [28] for each indicator using each month as a time point to test whether they are consistent at different time points under similar conditions. A good agreement level was assumed for αK ≥ 0.8, acceptable agreement for 0.6 ≤ αK <0.8, and low agreement for αK < 0.6 [29]. We performed all analyses using R version 3.2.2 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Quality indicators

The indicator development process (Fig. 1) yielded a set of four indicators for pain assessment in ICU patients:

1. Proportion of shifts during which pain was measured at least once;
2. Proportion of shifts during which pain was measured and no unacceptable pain scores were observed;
3. Proportion of patient-shifts during which an unacceptable pain score was measured, and pain was re-measured within 1 h;
4. Proportion of patient-shifts during which an unacceptable pain score was measured, and pain was re-measured within 1 h indicating that the pain score was normalized.

Table 1 describes details of the indicators. The indicators only look at pain measurements conducted with validated pain assessment tools (i.e. VAS, NRS, BPS or CPOT); pain is considered unacceptable when VAS/NRS ≥ 4, CPOT≥3 and BPS ≥ 6. The indicators target adequate pain assessment for each ICU patient during each shift, meaning the unit of observation is a patient-shifts. In Dutch ICUs there are three shifts in a 24-h period: day, evening and night shift. We chose patient-shift as the unit of observation because it concurs with national guidelines advising that patients' pain should be monitored at least three times a day to assure a maximum of comfort for the patient [30]. Detailed results of the rating in round 2 and expert consensus meeting in round 3 can be found in Table 2.

3.2. Room for improvement in ICU pain management

Fifteen ICUs (18.1%), of which three were academic and twelve non-academic ICUs, submitted retrospectively collected pain data (see ICU characteristics in Supplementary material 2). Two of these ICUs were represented in the expert panel that developed the indicators. The data concerned 45,688 patient-shift observations from 4267 admissions (of which 45.5% were medical) spanning a three month period. In 69.2% (IQR 58.7; 84.9) of the patient-shift observations ICUs performed at least one pain measurement (indicator 1); in 56.7% (IQR 49.6; 73.5) patient-shifts in which pain was measured pain was acceptable

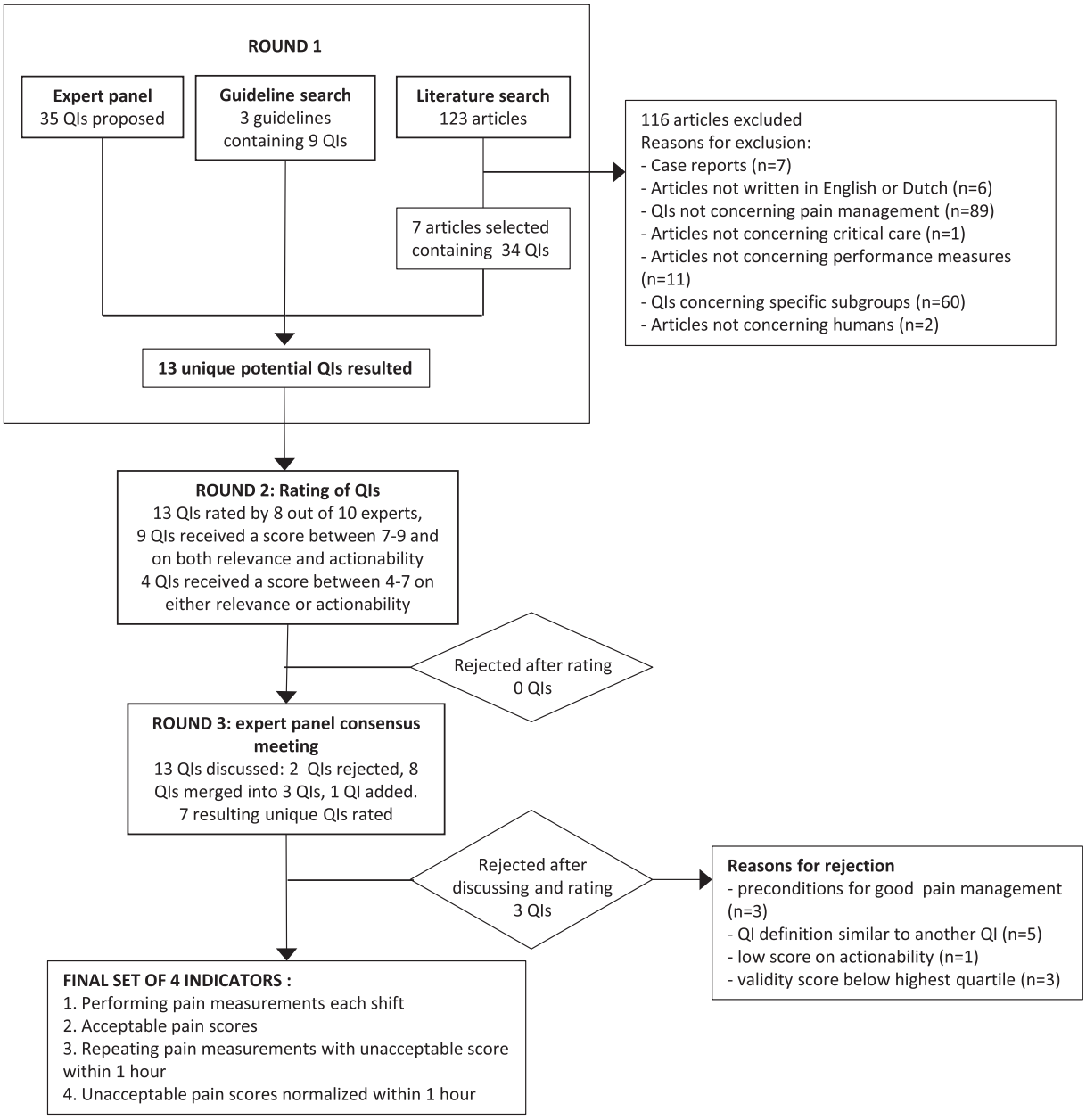

Fig. 1. Process of indicator development.

(indicator 2); in 11.7% (IQR 5.6; 26.4) pain measurements with unacceptable scores were repeated within 1 h (indicator 3); and in 10.9% (IQR 5.1; 20.1) unacceptable pain scores were normalized within 1 h (indicator 4). Table 3 additionally shows the median scores with IQR for each indicator by day, evening and night shift; and the minimum and maximum score achieved by ICUs. Fig. 2 shows the indicator scores per ICU. For all four indicators the likelihood ratio test comparing the logistic regression models without 'ICU' and with 'ICU' as a covariate showed a significant difference in model fit ($p < 0.001$); indicating scores significantly varied between ICUs. When we adjusted for type of admission this difference remained ($p < 0.001$).

By means of sensitivity analysis we re-calculated indicators 3 and 4 that depended on repeated pain measurements within 1 h after the previous measurement, by considering a cut-off of 2 and 3 h instead of 1 h. Pain measurements with an unacceptable score were repeated within 2 h in 29.7% (IQR 12.5; 47.1) of the shifts with an unacceptable score and within 3 h in 40.7% (IQR 25.0; 54.6). Unacceptable pain scores were normalized within 2 h in 22.7% (IQR 10.0; 36.2) of the time and within 3 h in 32.1% (IQR 14.3; 46.4).

We found data collection for all four indicators feasible: for 90.9% (range 79.3; 99.4) of the patient admissions pain measurements were available. We found all four indicators to be reliable as they produced consistent performance scores over time with a αK of respectively 0.95, 0.90, 0.82 and 0.80 for indicator 1 to 4.

4. Discussion

With our developed set of four reliable and actionable pain assessment indicators we identified considerable variation in pain assessment between Dutch ICUs and clinical performance scores far below the theoretical optimum of 100%. This result indicates room for improvement in pain assessment in Dutch ICUs; especially for repeating pain measurements and normalizing pain scores within 1 h after observing an unacceptable pain score (indicator 3 and 4). During the development of the indicators the expert panel thoroughly discussed which threshold

Table 1
Final list of actionable quality indicators to monitor appropriate pain assessment in an ICU.

Indicator	Definition	Indicator type	Numerator	Denominator	Optimal value
1. Performed pain measurements each shift	Percentage of patient-shift observations during which pain was measured at least once. *Specified for subgroups: 1) type of admission, 2) type of shift*	Process	Number of patient-shift observations during which pain was measured at least once	Total number of all patient-shift observations	100%
2. Acceptable pain scores	Percentage of patient-shift observations during which pain was measured[a] and no unacceptable pain scores were observed *Specified for subgroups: 1) type of admission, 2) type of shift*	Outcome	Number of patient-shift observations during which pain was measured[a] and no unacceptable pain scores were observed	Total number of patient-shift observations during which pain was measured[a]	100%
3. Repeat pain measurements with unacceptable score within 1 h	Percentage of patient-shift observations during which an unacceptable pain score was measured[a], and pain was re-measured within one hour *Specified for subgroups: 1) type of admission, 2) type of shift*	Process	Number of patient-shift observations during which an unacceptable pain score was measured[a], and pain was re-measured within one hour	Total number of all patient-shift observations during which an unacceptable pain score was measured[a]	100%
4. Unacceptable pain scores normalized within 1 h	Percentage of patient-shift observations during which an unacceptable pain score was measured[a], and pain was re-measured within one hour indicating that the pain score was normalized *Specified for subgroups: 1) type of admission, 2) type of shift*	Outcome	Number of patient-shift observations during which an unacceptable pain score was measured[a], and pain was re-measured within 1 h indicating that the pain score was normalized	Total number of all patient-shift observations during which an unacceptable pain score was measured[a]	100%

[a] Only pain scores measured with a standardized pain assessment tool, such as the Visual Analog Scale (VAS), Numerical Rating Scale (NRS), Behavioral Pain Scale (BPS), or Critical-Care Pain Observation Tool (CPOT) are included.

to use. A 1 h threshold, although considered to be challenging, was chosen because timely pain relief is essential to prevent systemic and physiologic adverse effects [31] and analgesic agents used at the ICU have a quick onset [32,33]. Our sensitivity analyses on these indicators considering a cut-off of 2 and 3 h instead of the original 1 h still revealed ample room for improvement.

We found high feasibility of data collection, because the participating ICUs had pain measurements available for at least 79.3% of the admissions. The missing data can either indicate data collection problems influencing feasibility of the indicators, or suboptimal pain assessment resulting in failure to monitor pain each shift in every patient. Since only 18.1% of the invited ICUs (15 out of 83) submitted their pain measurement data, retrospective data extraction may have been difficult for many ICUs. A potential reason was that ICUs had insufficient time or resources to extract the data before the given deadline; in particular for ICUs that depended on software vendors to make adaptations to their local EHR or PDMS. Despite the limited response rate we still consider data collection feasible because most ICUs already have the required pain measurement data available in their EHRs or PDMS, and we expect software vendors will develop functionality which supports extraction of these data.

A multicenter European Survey found 49% of the ICUs monitoring pain every eight hours or more in each patient [34]. In our study none of the participating ICUs performed pain measurements every eight hours in each patient. However, survey data are known to be influenced by response bias or reflect intentions instead of actual practice, which

Table 2
Results of round 2 and 3 of the indicator development process.

Quality indicators	Round 2: Individual rating[a]		Round 3: Consensus meeting				
	Relevance	Actionability	Group discussion	Individual expert rating[a]			Conclusion
				Relevance	Actionability	Validity[b]	
1. The average number of measured pain scores per patient.	7.0	7.0		8.0	8.5	8.0	Accepted
2. Days on which pain scores were measured.	7.0	6.5	Combined with 1				
3. Use of standardized pain assessment tool in communicative patients.	8.5	9.0	Precondition for good pain assessment				
4. Use of standardized pain assessment tool in sedated patients.	8.0	8.5	Precondition for good pain assessment				
5. Availability of a list of potential painful procedures and how to handle them.	8.0	8.5		8.5	5.5	2.5	Rejected
6. Measuring procedural pain.	8.0	8.5	Combined with 8				
7. Prevention of procedural pain.	8.0	8.5		7.5	8.0	3.0	Rejected
8. Acceptable pain scores.	8.5	8.5		8.0	8.5	8.0	Accepted
9. The amount of time pain scores are at an ideal level.	7.0	6.5	Combined with 8				
10. Normalize unacceptable pain scores within one hour.	8.5	9.0		9.0	9.0	9.0	Accepted
11. Pain scores lowered with 30% after (non-)pharmacological therapy.	6.0	8.0	Combined with 10				
12. Sedated patients at the ICU with unacceptable pain scores.	6.0	7.5	Combined with 8				
13. Pain protocol.	9.0	9.0	Precondition for good pain assessment	9.0	7.5	4.0	Rejected
14. Repeat pain measurement within one hour in case of unacceptable pain scores.	Not available: added in round 3	Not available: added in round 3	Added	9.0	9.0	9.0	Accepted

[a] Data presented as median scores.
[b] Highest quartile ≥ 8.

Table 3
Median and interquartile scores of the ICUs on the four quality indicators in total and per shift type.

Indicator	Median (IQR)[a]	Lowest scoring ICU	Highest scoring ICU
Performed pain measurements each shift, %	69.2 (58.7–84.9)	48.0	94.2
Day shift	77.5 (60.4–87.1)	42.1	93.5
Evening shift	69.4 (58.5–87.0)	41.0	92.5
Night shift	68.9 (60.9–87.5)	28.4	97.4
Acceptable pain scores, %	56.7 (49.6–73.5)	29.7	84.3
Day shift	60.4 (47.7–74.9)	32.4	83.8
Evening shift	51.6 (48.7–74.7)	29.1	80.5
Night shift	59.6 (48.1–76.0)	24.7	89.0
Repeat pain measurements with unacceptable score within 1 h, %	11.7 (5.6–26.4)	0.0	45.2
Day shift	8.8 (4.4–19.2)	0.0	46.0
Evening shift	12.7 (4.4–31.8)	0.0	41.4
Night shift	17.7 (4.2–31.9)	0.0	48.6
Unacceptable pain scores normalized within 1 h, %	10.9 (5.1–20.1)	0.0	36.0
Day shift	5.6 (3.3–15.1)	0.0	37.9
Evening shift	10.3 (4.2–28.6)	0.0	34.9
Night shift	16.8 (3.4–27.2)	0.0	42.9

[a] QR = interquartile range; Q1-Q3.

could have influenced their results. Though we cannot exclude the possibility that in our study some of the participating ICUs have measured pain more frequently, but did not record it in their EHR or PDMS.

Previous studies also assessed acceptable pain scores. Chanques et al. showed almost 60% of the ICU patients in the intervention group did not have a pain event (BPS < 6 and/or NRS < 4) [11]. Van Gulik et al. found 54% of the patients in the intervention group experiencing no pain event during their ICU stay [35]. Despite using a different unit of observation (i.e. patients rather than patient-shifts), these results seem comparable to ours. To our knowledge we are the first to report on pain measurements repeated and normalized within 1 h in case of an unacceptable score.

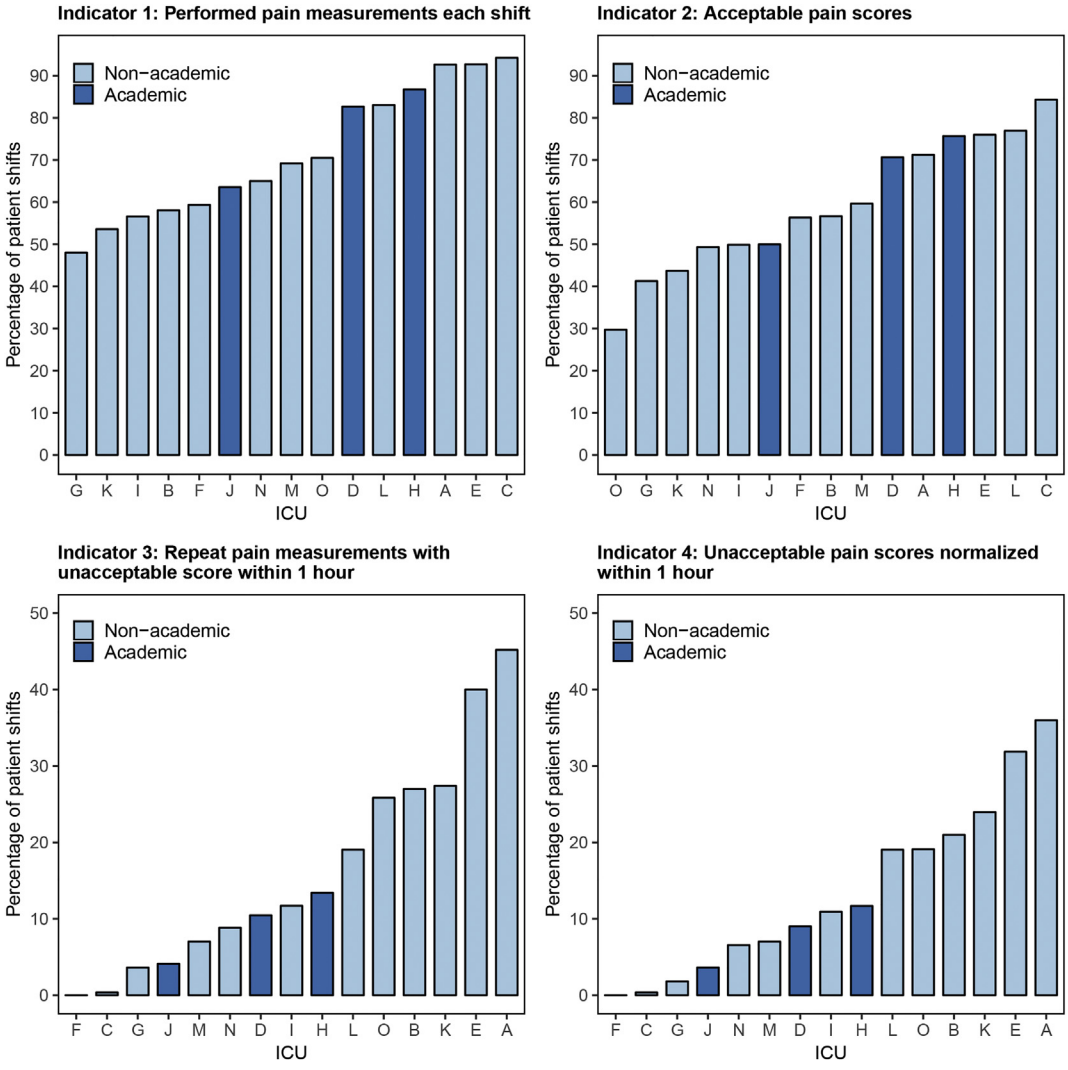

Fig. 2. Indicator scores per ICU.

A strength of our study is that we used quality indicators developed following a modified RAND approach in which scientific evidence and expert opinions were combined similar to the commonly used and validated original method and to earlier used methods [20,21]. We believe that the developed indicators are generalizable as for the development international guidelines and literature were reviewed and our expert panel consisted of members with international experience and expertise on the topic. Furthermore, we assessed pain measurement with higher fidelity compared to other studies. For example, we assessed performed pain measurements per shift while Kemp et al. assessed measurements over a 24-h period and the Dutch patient safety program recommends to measure pain three times a day [30,36].

Our study has some limitations. First, only 15 (18.1%) of the Dutch ICUs contributed their data. Although these ICUs were a representative sample of Dutch ICUs based on geographical location, size and type, they are more likely to have their electronic data registration and pain measurement practice well organized than those that did not participate. This might have led to an overestimation of the performance levels (and an underestimation of the room for improvement) we found; underlining the importance of improving quality of pain assessment in ICUs in the Netherlands. Although we are uncertain as to whether our results are completely generalizable to other countries, international research underlines that inadequate pain assessment is a global issue: almost 40% of the ICUs does not have a protocol for pain treatment and 83% do not use a standardized scale to evaluate pain [37]. Second, with our indicator set we only cover the assessment dimension of pain management, but only these indicators were judged relevant and actionable by the expert group concerning pain assessment. However, some of the rejected indicators may be included in the future. Furthermore, some variation we observed between indicator scores of the ICUs may exist because of confounding or low data quality. To control for confounding factors, which are common in retrospective studies like ours, we adjusted for admission type. To maximize the quality of the data, NICE data managers run checks and report on the data quality to the ICUs before reading the data into the registry database. In addition, the data needed to calculate the pain indicators are quite simple and do not require additional registration besides the registration in routine practice. Still, data quality can be a problem and influence the indicator scores. If the data contained no pain measurement for a patient-shift it was unclear whether the measurement was actually not performed, or whether it was performed but not recorded in the EHR or PDMS. When we discussed this with the ICUs, many reported to measure pain again after they changed or administered pain medication, but that the score is not being recorded in the EHR or PDMS or that they recorded the score later in time. In addition, given the retrospective nature of our study design we cannot exclude the possibility that measurement errors exist e.g. when nurses used the NRS when a non-verbal pain scale such as the BPS or CPOT should have been used or vice versa. This might have influenced the rate of acceptable pain scores as nurses tend to underestimate pain scores especially when a patient reports a high score [7]. We lack information on whether pain scores were self-reported or not and therefore we were not able to evaluate the effect of self-reported pain on the indicator scores. Last, our indicators aim to reduce and prevent pain during patients' ICU stay but do not consider potential unintended consequences that may occur when treating pain such as adverse drug events. The clinician should therefore take into account that favorable pharmacokinetic properties not necessarily translate into clinical advantages in the ICU setting [38].

Despite the limitations of our study, we believe that adequate pain measurement and documentation are essential to assure appropriate pain assessment. Our indicators can be of help to improve quality of pain assessment by providing ICUs with regular performance feedback on these indicators. Therefore, we included the indicators in a web-based quality dashboard as part of an audit and feedback intervention [39]. We are currently evaluating if ICUs improve on the indicators when we provide them feedback information, how the indicators relate to each other, and which (organizational) factors such as reminders to measure pain and patient-nurse ratio influence the performance on pain assessment. In the future the indicator set will be re-evaluated and extended with indicators concerning other dimensions of pain management. For example, specific clinical practices such as procedural pain [6,40] and applied treatment can be taken into account. The indicator set can also be adapted to specific criteria such as a pain assessment within 2 h after shift-onset or to specific patient groups such as patients with chronic pain as they may respond differently to painful stimuli [41].

5. Conclusion

There is room for improvement in pain assessment in Dutch ICUs. With the development and validation of four actionable quality indicators we took the first step towards quality improvement and assurance of pain assessment in Dutch ICUs.

Funding

This work was supported by the Stichting Kwaliteitsgelden Medisch Specialisten (SKMS, Dutch Foundation for Quality Funding for Medical Specialists) [29762944].

The National Intensive Care Evaluation (NICE) foundation pays the department of Medical Informatics for processing, checking and maintaining the Dutch quality registry. M.J. Roos-Blom and N.F. de Keizer are employees of the department of medical informatics and work for the NICE registry. N.F. de Keizer, D.A. Dongelmans, E. de Jonge, and J.J. Spijkstra are members of the NICE board.

Declarations of interest

None.

Acknowledgements

The authors would like to thank the panel members W. Stilma, S. Ahlers, L. van Gulik, P. Dennesen, M. van der Woude, A. Padmos, and R. Perez for their contribution to the development of quality indicators for pain assessment at the ICU. We also acknowledge all ICUs that participate in the NICE registration for their continuous effort to deliver data and improve their quality of care. Furthermore we would like to thank W. Busschers, R. Holman and F. Termorshuizen for their statistical advice.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2018.10.027.

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