Identifying validated nursing quality indicators for the intensive care unit: an integrative review

***Efi Evangelou RN; PhD, BSc, MSc,** Research Associate, Department of Nursing, School of Health Sciences, Cyprus University of Technology, Limassol, Cyprus
Ekaterini Lambrinou RN; BSc, MSc, PhD, Associate Professor, Department of Nursing, School of Health Sciences, Cyprus University of Technology, Limassol, Cyprus
Christiana Kouta RN; BSc, MSc, PhD, Associate Professor, Department of Nursing, School of Health Sciences, Cyprus University of Technology, Limassol, Cyprus
Nicos Middleton BSc, MSc, PhD, Associate Professor, Department of Nursing, School of Health Sciences, Cyprus University of Technology, Limassol, Cyprus

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***Email:** ekaterini.lambrinou@cut.ac.cy

SUMMARY

- Background: Quality indicators (QIs) play an important role in evaluating quality improvement initiatives. A generally accepted set of QIs specific to the nursing care in the intensive care unit (ICU) is not available.
- Aim: To identify QIs associated with nursing care for adult ICU in the literature. The methodological quality of QIs was assessed and associated variables of quality and quantity of nursing care were also identified.
- Methods: We employed an integrative literature review. A focused search of electronic databases was applied. Inclusion and exclusion criteria were used for the selection of relevant articles. Quality assessment of the included studies was based on the guidance document of domains and elements suggested by the Agency of Health Care Research and Quality. QIs' methodological quality was assessed using the Appraisal of Indicators through Research and Evaluation (AIRE) instrument.
- Results: The review identified 13 studies and 45 QIs associated with nursing care in the ICU. The set of QIs assessed in each study, the type of nurse staffing measure as well as morbidity and mortality rates varied considerably. Findings suggest that quality and quantity of nursing care are strongly associated with higher rates of adverse events, mortality, infections and complications in adult ICUs. Methodological quality of the QIs also differed considerably. Higher AIRE scores, indicating higher scientific evidence of methodological quality, can be used to select evidence-based and valid QIs.
- Conclusions: A number of QIs quantifying nursing care in the ICU have been identified. These QIs could be combined to form a tool which would allow to the quantification and assessment of the quality of ICU nursing care provided in a regular basis.

INTRODUCTION

Care on intensive care units (ICUs) represents a major portion of health care costs and thus consumes a large part of a hospital's financial' resources (Robert et al., 2000). In the ICU, adverse events and human error constitute substantial morbidity and mortality risks to critically ill patients; especially as a result of understaffing (De Vos et al., 2007).

Quality indicators (QIs) play an important role in quality improvement initiatives as long as they are based on evidence (Brook et al., 1996). Nursing care is considered a critical factor of patient care and thus, the assessment of QIs which specifically reflect nurses' contribution is vital (Montalvo, 2007). The identification of QIs that quantify the quality of nursing care would enable the development of sets that could be easily adopted in practice in the context of auditing performance and monitoring evidence-based practice in routine care (Mainz, 2003).

In essence, QIs are screening tools, which identify potential suboptimal clinical care and reveal specific problematic areas that need further investigation (De Vos et al., 2007). QIs may be classified according to three dimensions, which correspond to structure, process and outcome components of quality (Donabedian, 1992). Outcome indicators, in particular, reflect the effect of quality of patients' health care (Mainz, 2003). Thus, potential QIs of nursing care quality may be identified by the extent to which they indicate nurse sensitive outcomes (NSOs). NSOs refer to aspects of patients' experience, behavior or health clinical status, which are completely or partially determined by the quantity and quality of nursing care received. These may include outcomes, which are influenced by several factors, as long as there is evidence to suggest that they are also associated with nursing care (Montalvo, 2007). Nursing QIs are specific to nursing and may thus differ from medical indicators of care quality. They have been defined as those which are based on "nurses' scope and domain of practice, and for which there is empirical evidence linking nursing inputs and interventions to the outcome" (Doran and Pringle 2003, vii). It is important for nursing QIs to form a valid and reliable means of assess nursing care quality (Heslop and Lu 2014). The QIs in the ICU should be relevant to the problem, understandable, measurable, behaviourable (and thus, amenable to change), achievable and feasible, according to the RUMBA rule (Braun et al., 2010).

Most of the published studies examining the relationship between nurse staffing and patient outcomes have been performed in general wards or at the entire hospital level (Griffiths et al., 2008, Needleman et al., 2002, Van den Heede et al., 2007). National forums and agencies have proposed a number of QIs. Nevertheless, specific QIs for the ICU have not been suggested (AHRQ, 2006, ANA, 2000, JCAHO, 2007, NQF, 2004). Furthermore, forums and societies specific to the ICU propose QIs, but none is specifically and exclusively referred to as nursing-related QIs (Delgado et al., 2005, Ray et al., 2009). Currently, there is not a complete set of QIs specific to the nursing care in the ICU available (McGahan et al., 2012). In an effort to fill the gap, this study reviews the literature and pools potential QIs associated with nursing care in the ICU. These QIs may be used for the development of nursing QI sets (NQI) specific to the ICU, currently missing from the scientific literature. Identifying a select set of evidence-based and valid NQI offers the potential to assess nursing care delivered in the ICU.

AIM

To review the literature in order to identify potential Qis, specifically patient-centered clinical NSOs, that may be measured in the ICU and have been found to be associated with variables reflecting the quantity and/or quality of nursing care (i.e. nursing and setting structure variables). The secondary aim was the assessment of the methodological quality of the QIs identified.

METHODS

Design

This is an integrative review of published literature based on a modified framework for review research (Whittemore and Knafl 2005). The process for data extraction and synthesis was based on a detailed pre-specified protocol, as presented in the sections to follow.

Search methods

The process of searching the literature was performed based on the Center of Review and Dissemination guidance (CRD, 2009). A focused search of electronic databases Ovid Medline, PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL) and Cochrane library was applied to identify the relevant literature. The time frame of interest was 2000-2016.

The search was undertaken by using the following keywords and medical subject heading (Mesh) terms: “intensive care unit(s)” [Mesh] OR “ICU”, “quality indicators- health care” [Mesh] OR “clinical indicators”, and nurs* (nurses, nursing, nurse staffing, personnel staffing, critical care nursing) [Mesh]. The search terms were used in all possible combinations using Boolean operators. The “similar articles” tool of PubMed was also used. Furthermore, the reference lists from included studies were also reviewed in order to identify additional studies that may have not been identified in the original search. Authors did not attempt any hand searching of journals, conferences’ or abstracts’ proceedings.

Variables of interest referred to the education and certification level, years of experience, hours of nursing care per patient day, workload intensity and overtime. Nurse staffing measures such as staff mix, skill mix, staff ratio, and nurse to patient (N/P) ratio were also considered of interest. Nurse staffing measures are already recognized as structure QIs. In each one of the selected studies these measures were examined for possible association with patients’ outcomes. Any ICU patient-related clinical outcome was extracted and considered as a potential QI.

Specific inclusion criteria were applied. Only published research articles were selected. Studies were included if they had examined associations between nursing and setting related structure variables with critically ill adult patients’ outcomes. Studies that evaluated QIs already recognized as NSOs were also included. Secondary data analysis surveys were also included. Only quantitative studies were identified and included. For candidate QIs in any of the identified studies, the numerator and denominator of QIs should be given or at least it should be easily understood from the description. The relativeness to any type of ICU was set as an additional selection criterion.

Articles published in language other than English, unpublished studies, abstracts, editorials, expert opinion papers, secondary sources, such as reviews or systematic literature reviews, conceptual sources, anecdotal and opinion sources were excluded. Studies that assessed the association of QIs with nurse staffing outside the hospital, after discharge from the ICU, at the ward or during transfer from the ICU, were excluded. Studies that presented results at a hospital level were also excluded. Other structure components of quality and organizational characteristics such as daily rounds and team work were not considered.

Quality appraisal

The methodological quality of the included studies was independently assessed by two of the authors and was based on the domains and elements suggested by the Agency of Health Care Research and Quality. The assessment considered: study question, population, comparability of subjects, exposure or intervention, outcome, statistical analysis, results, discussion, funding or sponsorship (West et al., 2002).

Additionally, the methodological quality of the included QIs was assessed using the Appraisal of Indicators through Research and Evaluation (AIRE) instrument. The AIRE instrument is a new tool, which was designed and validated in the Netherlands (De Roo et al., 2013). It was previously used in peer-reviewed studies aiming to develop a set of QIs for palliative care (De Roo et al., 2013), for midwifery care (De Bruin-Kooistra et al., 2012), of musculoskeletal injury management (Strudwick et al., 2015) and care of osteoarthritis (Petrosyan et al., 2017). AIRE addresses the face and construct validity, accuracy, risk of bias, ability to achieve real quality improvement, and application of QIs (Strudwick et al., 2015).

In this review, the AIRE instrument was used to assess whether the objective and the organizational background of the identified QIs are well defined and the extent to which they built on evidence (Smeulers et al., 2015). AIRE contains four domains that examine: 1. Purpose, relevance and organizational context of the QIs, 2. Stakeholders’ involvement for the development of the QIs, 3. Scientific evidence and 4. Additional evidence, formulation, usage. Additionally, there are in total twenty items (e.g. “systematic methods were used for search for scientific evidence”) across these four domains. Each of the four authors independently scored on a 4 point Likert scale (1= strongly disagree and 4= agree) for the items given (De Roo et al., 2013). The maximum score for an item is 16 and the minimum is 4, when four authors are asked to rate. In the present study AIRE was applied for the set of the QIs identified in each study, rather than for each QI separately (Smeulers et al., 2015). In the absence of guidance regarding definition of high, medium and low scores for the items, the authors considered as high: 16-14, medium: 13-9 and low: 4-8. Higher scores are indicating valid and widely used QIs. A score of 50% and higher in all four domains indicates higher methodological quality (Strudwick et al., 2015).

Data extraction

A structured data extraction form was used to collect information from the studies, which are summarized in Table 1. The data extraction form included: 1. Authors/ publication date, Country and Data collection period, 2. Research aim(s), 3. Methods, and 4. Quality indicators and formula or definition 5. Nurse staffing variables and definition and 6. Results (main). The initial selection included the screening of titles and abstracts against the inclusion criteria. The second stage is referred to the screening of the full papers in order to identify articles that fulfill the inclusion criteria. Two of the authors extracted information and independently reviewed eligibility criteria of the articles obtained. Any disagreements were resolved through consensus, and when necessary, with the involvement of the third author. The process ended up with full consensus after detailed examination of full text articles and consideration of predetermined inclusion criteria. In the case of incomplete information the article was excluded. A flow diagram of the search strategy is depicted in Figure 1.

Data synthesis

Similar data were categorized and organized together so as to enable comparison and interpretation (Table 1). Moreover, QIs were categorized as primary (e.g. mortality, cost) and secondary (e.g. infections, complications) (Amavardi et al., 2000, Pronovost et al., 1999) and further classified based on a previously described framework (Doran & Pringle, 2011, Holzemer 1994). The subcategories included: setting- related outcome variables (QIs) and patient safety related outcome (Heslop & Lu, 2014), as shown in Table 2.

RESULTS

Search outcomes

The search yielded 83 article titles of which only five articles were selected for further analysis based on the methodological assessment. Full text was obtained for all five articles and eight additional studies were identified, either from the reference lists, or classified by the database as related articles to those already obtained. A total of 13 studies were included in this review (Figure 1). The studies refer to 45 QIs in total (Table 1 and 2).

Overview of the included studies

There is a growing interest worldwide regarding patients' outcomes that are affected by the nursing care provided. The included studies originated from Asia (Cho et al., 2008), Switzerland (Bracco et al., 2001), Scotland (Tarnow-Mordi et al., 2000), Austria (Metnitz et al., 2008), one was a multi-centered worldwide study (Valentin et al., 2006) and the remaining eight studies originated from the USA.

Across the selected studies, the respective ICUs differed in type and included surgical, medical and mixed ICUs. The number of participating ICUs ranged from eight (Alonso- Echanove et al., 2003) to as many as 205 (Valentin et al., 2006). The number of involved hospitals and their capacity also differed, while, as shown in Table 1, a number of studies did not report the type or number of included hospitals (Kendall-Gallagher and Blegen, 2009, Metnitz et al., 2008, Valentin et al., 2006).

Quality appraisal

All included studies used an observational design. Six studies used prospective data (Alonso- Echanove et al., 2003, Bracco et al., 2001, Garcia and Fugulin, 2012, Metnitz et al., 2008, Robert et al., 2000, Valentin et al., 2006) and seven studies collected retrospective data (Amavardi et al., 2000, Cho et al., 2008, Dang et al., 2002, Kendall-Gallagher and Blegen, 2009, Stone et al., 2007, Tarnow-Mordi et al., 2000, Whitman et al., 2002). Data collection methods included: 1. Questionnaires regarding ICU and/or hospital characteristics which were completed by the medical director of the unit (Amavardi et al., 2000, Dang et al., 2002, Metnitz et al., 2008) or the head nurse of the unit (Tarnow-Mordi et al., 2000) of ICUs, 2. Forms specifically designed by the research teams which were completed by MDs and nurses (Alonso- Echanove et al., 2003; Bracco et al., 2001; Robert et al., 2000; Valentin et al., 2006) or infection control practitioners (Alonso-Echanove et al., 2003). One study (Whitman et al., 2002) used a combination of qualitative and quantitative data collection through interviews and special forms (Table 1).

All of the studies included a focused aim or a research question (Table 1). Only three studies used QIs already recognized as nursing specific (Bracco et al., 2001; Valentin et al., 2006; Whitman et al., 2002). The remaining ten studies clearly aimed to explore the association between structural variables and patient outcome(s).

Sample sizes of the included studies ranged from 28 (Robert et al., 2000) to 83259 (Metnitz et al., 2008) patients. Two studies do not clearly report specific inclusion and exclusion criteria for the sample (Garcia and Fugulin, 2012, Kendall-Gallagher and Blegen, 2009). The majority of the sample employed multivariable analyses (Alonso -Echanove et al., 2003; Amavardi et al., 2000; Bracco et al., 2001; Kendall-Gallagher & Blegen, 2009; Metnitz et al., 2008; Stone et al., 2007; Tarnow-Mordi et al., 2000).

Five studies report funding (Cho et al. 2008, Kendall-Gallagher and Blegen, 2009, Stone et al., 2007, Valentin et al., 2006, Whitman et al., 2002), whereas ethical approvals were sought and granted in six of the selected studies (Amavardi et al., 2000; Bracco et al., 2001; Garcia & Fugulin, 2012; Kendall-Gallagher & Blegen, 2009; Metnitz et al., 2009; Whitman et al., 2002).

Table 3 shows the scores of the QIs based on AIRE (De Roo et al., 2013). The highest scores were obtained for items 18 (97%) and 10 (96%) indicating that the QIs had been tested in daily practice and were evidence-based, respectively. Most of the sets achieved the highest scores (89%) for category III "Scientific evidence" and the lowest (51%) for the category II "Stakeholder involvement" (Smeulers et al., 2015). Only Dang et al. (2002) and Amavardi et al. (2000) reported the development process and recruited a panel to identify ICD-9-CM codes for the QIs. The remaining eleven studies applied QIs that have been widely used in previous studies. All of the included studies provide the definitions or the formulas for calculation of QIs. None of the included studies provided full description of terminology, rationality or justification, source of the data and type of the parameter.

Quality indicators identified

Findings of the included studies regarding rate measures of QIs and main associations identified in each study are presented in Table 1. The QIs identified were grouped and classified in subgroups (Table 2). The domain that appears to be mostly covered is safety (Doran & Pringle, 2011). Negative performance QIs were most common, such as adverse events, infections and complications (Mitchell, 2008). Most commonly used QIs are mortality and blood stream infections (BSIs).

There are QIs with a variety of names that examine the same numerators and denominators such as decubitus ulcers (Stone et al., 2007) and skin break down (Kendall-Gallagher and Blegen, 2009). However, in the case that different numerators and denominators are used for seemingly identical QIs, these were regarded as different outcomes. Likewise, there are similar QIs that may be considered part of a more general QI, such as device related catheter-associated urinary tract infection (CAUTI) and urinary tract infection (UTI). Identified definitions are provided in Table 1.

Valentin et al. (2006) and Bracco et al. (2001) used sentinel QIs (undesirable events that trigger further investigation) whereas the remaining studies applied rate-based QIs. In some studies, QIs were restricted to specific patient groups of the ICU. Robert et al. (2000) and Alonso-Echanove et al. (2003) focused on patients with central venous catheter (CVC). Amavardi et al. (2000) examined patients with esophageal resection and Dang et al. (2002) was interested in patients who underwent abdominal aortic surgery. Stone et al. (2007) focused on elderly patients.

Authors, publication date, country	Research aim(s)	Methods: study design, population, tools used study duration	QIs and formula or definition identified	Nurse staffing variables and definition identified	Results
Kendall-Gallagher & Blegen, 2009, USA	To explore: • the relationship between the proportion of certified staff nurses and the risk of harm of patients • the organizational and nursing characteristics associated with rates of adverse events	• Correlational, cross-sectional, unit level design, • Secondary data analysis of 48 adult ICUs from 29 hospitals randomly selected • Quarterly collected data using two questionnaires • One year study	• Falls: annual rate per 1000 patient days • Medication administration errors (MAEs): annual rate per 1000 patient days • Skin break down: annual rate per 1000 patient days • Urinary tract infection (UTI): annual rate per 1000 patient days • Central catheter line infection (CCLI): annual rate per 1000 patient days • Bloodstream infection (BSI): annual rate per 1000 patient days	• Registered nurses (RNs) education level: percentage of RNs with bachelor of science or higher education in nursing • RN years of experience: mean years of experience of RNs • Total hours of nursing care per day: mean total working hours of all nursing staff per day • RN skill mix: percentage of nursing staff who are registered nurses • RN work group competence: percentage of certified staff RNs	• Expected rate of falls was 1.1 per 1000 patient days • Expected rate of UTI was 2.29 per 1000 patient days • Expected rate of BSI was 1.7 per 1000 patient days • Expected rate of MAEs was 4.82 per 1000 patient days • The proportion of certified RNs at the unit was inversely related to the rate of falls (p = 0.04) • UTI decreased by 0.19 (expected rate = 2.29 per 1000 patient days) for each 1 SD change in the proportion of certified staff nurses in the unit (p = 0.07) • The total hours of nursing care was positively related to MAE (p = 0.006). • Mean years of experience by staff nurses was inversely related to UTI (p = 0.01) • Every additional patient per RN was associated with 9% increase in the odds of death (OR = 1.09, 95% CI 1.04-1.14) • Nurse education was negatively related to skin break down (-0.44, p = 0.05) • Nurse experience was positively related to MAE (0.31, p = 0.05) • Total hours of Nursing care to patient day was positively correlated with CLBSI (0.62, p = 0.01) and catheter infections (0.63, p = 0.01) • Nurse skill mix was correlated positively with MAEs (0.31, p = 0.05) and negatively with UTI (0.64, p = 0.05)
Cho et al., 2008, Korea	To examine the relationship between nurse staffing and patient mortality in ICUs	• Correlational study collecting data from administrative databases • 27,372 ICU patients discharged from 42 tertiary and 194 secondary hospitals (total 236 hospitals) aged > 15 years old with 26 primary diagnoses • 3 data sources were used: ICU survey data (hospital and ICU characteristics); Medical claims data (patients clinical and utilization information); and NHI (enrollee database for death day) • 3 months	• Mortality: deaths that occurred in the hospital or on the date of hospital discharge	• Nurses' years of work experience: the years of RNs' license to the time yr of data collection • Staffing of RNs: ratio of average daily census to the total number of full time equivalent RNs in ICUs (ADC/RN ratio)	• The overall mortality rate was 17% in tertiary and 22% in secondary hospitals • There was a greater likelihood of dying to patients admitted to mixed ICU in tertiary hospitals (OR = 1.61, p = 0.011) and in hospitals where there was not a board- certified physician present for 4 or more hrs per day (OR = 1.56, p = 0.002) • Patients at secondary public hospitals who located in metropolitan cities had greater probability of dying (OR = 1,38, p = 0.005) • The ADC/RN ratio was significantly related with mortality in secondary hospitals (OR = 1.43, 95% confidence interval [CI] 1.16-1.77, p = 0.001) • Every additional patient per RN in secondary hospitals was associated with a 9% increase in odds of dying (OR = 1.09, 95% CI 1.04-1.14). • Every additional patient per RN was associated with 9% increase in the odds of death (OR = 1.09, 95% CI 1.04-1.14)
Robert et al., 2000, USA	To determine the risk factors for primary BSI, including the effect of RNs' levels	• Nested case control study • 28 patients with primary BSI (case) compared with 99 randomly selected patients (control) hospitalized for more than 3 days of a 20-bed Surgical ICU in a 1000 bed university- affiliated inner city teaching public hospital • A standardized form was used for data collection, as well as the relative microbiological data • 1-year study period	• Primary BSI: BSI were defined according to the CDC criteria per 1000 patient days	• Composition of nursing staff (pool versus regular nurses): • Regular staff: nurses permanently assigned to the unit • Pool staff: nursing staff that are members of the hospital pool service or agency nurses who work at the hospital • Mean of nurse to patient ratio (N/P) is expressed as the maximum number of nursing hours per SICU-patient day	• Overall primary BSI was 4.6 per 1000 patient days • There was a decreased regular N/P ratio (9.1 hrs/ patient, p < 0.001) and an increased pool-nurse-to-patient ratio (4.4 hrs/ patient, p < 0.001) during the period of 5 months with decreased regular nurse to patient ratio • BSI were significantly more frequent during periods with decreased regular nurse to patient ratio than period with high patient ratio (7.6 vs 2.8 BSI/1000 patient days, respectively (p = 0.004) • BSI were significantly more frequent in the period of decreased regular nurse to patient ratio (9.1 hours/ patient, p < 0.001) and increased pool-nurse-to-patient ratio (4.4 hrs/ patient, p < 0.001) • Regular N/P ratio for the 3 days before the index date was significantly lower for case patients than for controls (median 8.8 vs 9.9 nursing hours / patient day, p < 0.001) • Pool N/P ratio was significantly higher for case patients than for controls (median 3.2 vs 2.8 nursing hours / patient day, p < 0.001)
Dang et al., 2002, USA	To isolate the effects of nurse staffing on patient's outcomes (medical complications associated with mortality and are nurse sensitive) by examining the association between ICU nurse staffing and the likelihood of medical complications for patient undergoing abdominal aortic surgery	• Retrospective study with secondary analysis of hospital discharge data • 2606 patients aged 30 years or older with principal procedure code for abdominal aortic surgery, • 38 ICUs in one state • Data were obtained by: Health discharge data set was used for patient information; A questionnaire was used for nurse staffing data; An instrument of 32 items was used for the organizational characteristics; and a panel of experts including 4 physicians who identified the ICD-9-CM codes for the potential complications	• Complications related to mortality and are nurse sensitive: • Cardiac complications: - acute MI (ICD-9-CM code: 410); arrest (ICD-9-CM code: 4275) • Complications after a procedure (ICD-9-CM code: 9971) • Respiratory complications: pulmonary insufficiency after a procedure (ICD-9-CM codes: 5184, 5185, 5188); reintubation (ICD-9-CM code: 9604); aspiration ICD-9-CM codes: 507, 9973; ventilation > 96 hrs ICD-9-CM code: 9672 • Others complications: acute renal failure ICD-9-CM code: 584; septicemia: ICD-9-CM code: 038; platelets transfusion ICD-9-CM code: 9905	• Intensity of nursing staff: the average N/P ratio at day and night • Low, medium and high intensity nurse staffing at day and night was calculated	• The intensity of nurse staffing was significantly associated with all the complications examined • Patients treated on units with medium intensity staffing were more likely to have cardiac complications (OR = 1.78, 95% CI = 1.16-2.72, p = 0.29) and other complications (OR = 1.74, 95% CI = 1.15-2.63, p = 0.49) comparing with those treated in units with high intensity • Patients cared in units with low intensity staffing were more than twice as likely to have respiratory complications than patients treated in units with high intensity staffing (OR = 2.33, 95% CI 1.50-3.60, p = 0.14) • Patients cared in units with medium intensity staffing were more than twice as likely to have cardiac complications after a procedure, than patients treated in units with high intensity staffing (OR = 2.10, 95% CI 1.26-3.50) • Patients were more than 5 times as likely to develop pulmonary insufficiency after surgery (OR = 5.11, 95% CI 2.89-9.04), as well as more than twice as likely to be mechanically ventilated after 96 hours (OR = 2.39, 95% CI 1.55-3.69) and reintubated (OR = 2.09, CI 1.47- 3.03) on units with low intensity staffing compared with units with high intensity

Table 1. Characteristics of the included studies

Authors, publication date, country	Research aim(s)	Methods: study design, population, tools used study duration	QIs and formula or definition identified	Nurse staffing variables and definition identified	Results
Amavardi et al., 2000, USA	To determine if the presence of N/P ratio at night time (NNPR) of one nurse caring for one or two patients vs one nurse caring for three or more patients in the ICU is associated with clinical and economic outcomes following esophageal resection	• Statewide observational cohort study • 353/366 adult ICU surgical patients aged 18 years and older in 32/35 acute care hospitals with primary procedure code of esophageal resection/ • Data were obtained from: the hospital discharged database; a previously validated questionnaire with 32 organizational characteristics; ICD-9-CM codes including primary diagnosis, 14 secondary discharge diagnoses and 14 secondary procedures; a panel of 2 ICU physicians for selected secondary outcomes that reflect post- operative complications/ • 4-year study	• Primary: mortality; hospital LOS; cost • Secondary: post-operative infection (ICD-9-CM code:9985); aspiration (ICD-9-CM codes: 507, 9973); reintubation (ICD-9-CM code: 9604); pulmonary insufficiency (ICD-9-CM codes: 5184, 5185, 5188); pneumonia (ICD-9-CM codes: 480-487); septicemia ICD-9-CM code: 038; cardiac complications (ICD-9-CM code: 9971); cardiac arrest (ICD-9-CM code: 4257); acute MI (ICD-9-CM code: 410); renal failure (ICD-9-CM code: 584); reoperation for bleeding (ICD-9-CM codes: 3941, 3949, 3998); surgical complications (ICD-9-CM codes: 9981, 9982, 9983)	• N/P ratio at night shift (NNPR): • Nurse caring for > 1: 2 means that 1 nurse is caring for 1 or 2 patients • Nurse caring for < 1: 2 means that 1 nurse is caring for 3 or more patients	• The overall unadjusted in hospital mortality rate for esophageal resection was 8.1% • Unadjusted mortality for patients with NNPR < 1: 2 vs NNPR > 1: 2 was 15% vs 5.6% (p = 0.009) • No significant difference was found n the risk of in hospital mortality between patients with a NNPR > 1: 2 and those with NNPR < 1: 2 (OR = 0.7, 95%, CI 0.3-2.0) • Median LOS for patients with NNPR < 1: 2 vs NNPR > 1: 2 was 15 days vs 9 days (p < 0.001). • There was 39% increase in LOS for patients when NNPR < 1:2 (95% CI, 19-61%, p < 0.001) • Increased LOS was associated with low surgeon volume (p < 0.001), age (p = 0.004) and emergency admission (p < 0.001). • Total hospital cost for patients with NNPR < 1: 2 vs NNPR > 1: 2 was $24,915 vs $15,209 (p < 0.001). • There was a 32% increase in direct hospital cost ($4810) for patients with NNPR < 1: 2 (95% CI,14-52%, p < 0.001) • Morbidity and resource utilization were increased for patients treated by nurse caring for more than three ICU patients at night. • - Patients with NNPR < 1: 2 had increased risk of reintubation (OR 2.6, 95% CI, 1.4-4.5, p = 0.001), pneumonia (OR 2.4, 95% CI 1.2-4.7, p = 0.012) and septicemia (OR 3.6, 95% CI 1.1-12.5, p = 0.04)
Alonso-Echanove et al., 2003, USA	To evaluate the role of the patient, CVC and nurse staffing factors in the risk of CVC-associated BSI	• Prospective, observational multicenter, cohort study conducted in a non- research setting • 4535 adults in 8 ICUs at 6 district hospitals representing 8593 CVCs and 56627 catheter days • Data collection was based on NNIS system and then transmitted to CDC • 3 data collection forms were developed: patient admission form; daily log form; CVC log form	• CVC associated with BSI: according to the NNIS system definition per 1000 CVC days	• Nurse staffing factors: float nurse: a nurse normally assigned elsewhere in the hospital or from an outside agency, among others • Median N/P ratio: number of registered nurses for each patient • Median patient care assistant to patient ratio: number of patient care assistants per shift per 100 patients	• 27 of 60 potentially risk factors were significantly associated with CVC associated BSI (p < 0.05) • 2.8% of CVCs were associated with CVC-associated BSI • Factors associated with CVC-BSI were: TPN with non-impregnated CVC (95% CI 1.69-2.88, p < 0.0001), absent of antibiotics for 48 hours after insertion of CVC (95% CI: 1.39-2.72, p = 0.0001), patient unarousable ≥ 70% (CI: 1.38-2.36, p < 0.0001). • The proportion of float nurse-days > 60% found to be independent risk factor (p = 0.0019) • Risk for CVC-associated BSI was lower with antimicrobial-impregnated CVCs • The risk of CVC-BSI was not associated with N/P ratio or the patient-care assistant-to- patient ratio • The risk of CVC BSI was 2.6 times higher for CVCs inserted in patients cared for by float nurse more than 60% of time (7 of 884, 7.92 BSIs per 1000 CVC days, p = 0.01).
Whitman et al/ 2002, USA	To describe the rates of selected nurse sensitive patient outcomes and to determine if there are differences in rates across units	• Secondary analyses of monthly prospective observational data • 95 patient care units across 10 adult acute care hospitals • Data collection methods were different for each NSO (monthly surveillance data from infection control staff, monthly system wide 1 day prevalence, pharmacy and risk management reports, patient' interviews one day every month, finance office reports)/ • 1 year study	• CLBSI: number of CLIs/ number of central line days in place • PU: number of hospital acquired PUs (grade II or greater)/number of patients assessed for skin break down • Medication errors: number of reported medication errors/ number of dispensed doses • Falls: number of unplanned descents to the floor/ number of patient days • Patient satisfaction with pain management: percentage of patients responding very satisfied • Restraint application: number of hours in restraints/ number of total hours available to restrain patients	• Describes and compares the rates of already recognized nurse sensitive patient outcomes by ANA	• CL infection and PUs were higher in non-cardiac ICUs (p = 0.037) • Falls rates were higher in MS units comparing with NCICUs and cardiac ICU (CICUs) (p = 0.035 and p = 0.003, respectively) • Satisfaction with pain had minimal variability ranging from 0.48 to 0.57 • Restraint application duration was higher in NCICUs and CICUs (p=0.001) • Medication errors were ranging from 0.1 to 0.5 • Significant differences were found with respect to mean CLI rates (F[4.59] = 6.25, p = 0.001), pressure ulcer rates (F[4.87] = 5.04, p = 0.001), fall rates (F[4.90] = 4.94, p = 0.001) and RADRs (F[4.75] = 12.6, p = 0.001) • No significant differences were observed in medication error rates (F[4.59] = 6.25, p = 0.001) and satisfaction with pain management by nurse rates (F[4.77] = 0.49, p = 0.7)

Table 1. Continued

Authors, publication date, country	Research aim(s)	Methods: study design, population, tools used study duration	QIs and formula or definition identified	Nurse staffing variables and definition identified	Results
Bracco et al., 2001, Switzerland	To determine the occurrence of critical incidents focusing on incidents due to human factors. Secondary aim was to identify patients or situations at risk and try to determine clinical and financial consequences of human related incidents	• Prospective observational study • 1024 consecutive patients admitted in a 11- bed multidisciplinary ICU in a non- university teaching 280- bed hospital • A list including 105 items (defining critical incidents) and a standardized data sheet were used to collect data during clinical round. Incidents were analyzed within 24hrs • 1 year study	• Mortality • Readmissions • Critical incidence • Cost • LOS • Human errors: • venous lines and catheters, respiratory system, cardiovascular system, drug related complications, neurological system complications, urinary system complications, gastrointestinal system complications, skin and muscular system, management complications • All definitions of critical incidents and categorization of complications were listed including diagnostic criteria	• Human errors • Regular nursing staff amounted to 3.2 nurses per bed. • Nursing staff included: mix skilled, ICU certified nurses, certified nurses undergoing ICU training and RNs without ICU certification	• Median LOS was 1.9 days, readmission rate was 4.3% and hospital mortality was 5.9%: 1.4% among planned and 8.9% among unplanned admissions ($p < 0.0001$, OR = 6.6, 95% CI 3.7-9.4). Predicted and observed mortality were found to be 13.9% and 8.9% ($p < 0.0001$), respectively • 777 critical incidents were reported and 241 human errors occurred in 161 patients • Cost attributable to human error was estimated at 800,000 euros per year and mean daily ICU cost per patient was 1900 euros • ICU LOS was prolonged by 425 patient-days of treatment over one year, due to errors (OR = 1.26, $p = 0.0001$) • Surveillance problems occurred after a median delay of 41 hours ($p = 0.001$) , planning errors had more severe consequences than execution or surveillance problems ($p = 0.01$) • Risk of human error was correlated with severity of physiological disturbance ($p < 0.0001$) and with LOS ICU ($p < 0.0001$) • The overall risk of human error was 16% but in patients already affected by human error, the risk of a second error was increased to 30% • ICP monitoring (40.0%, RR = 2.6, $p = 0.05$), LOS (OR = 1.26, $p = 0.0001$), readmission (OR = 3.04, $p = 0.0005$) and Simplified Acute Physiology Score (OR = 1.22, $p = 0.0034$) were significantly associated with human error • Patients were at higher risk of human error when an invasive technique was used: mechanical ventilation (26.4%, Relative risk [RR] = 2.8, $p = 0.0001$), pulmonary arterial catheter (35.4%, RR = 2.7, $p = 0.0001$) and renal support (50.0%, RR = 3.4, $p = 0.0001$)
Valentin et al., 2006, world-wide	To assess the prevalence and corresponding factors of selected unintended events that comprise patient safety in ICU	• Observational, prospective, multinational study of incidents. Cross-sectional design • 1913 patients adult > 18 years old in 205/280 ICUs from 29 countries and 4 continents • Data were obtained by: a structured questionnaire was used for anonymous report of unintended events; a questionnaire for information for ICU characteristics, patient and nurses' related factors; and the nine equivalents of nursing manpower use score (NEMS) for nursing workload; patient data which were recorded using a project website and online data collection software • 24hr observation period	• Sentinel events. All sentinel events were presented as rates per 100 patient days • Medication errors: - prescription; administration; wrong dose, drug, route • Airway: unplanned extubation - artificial airway obstruction; cuff leakage; prompting reintubation • Indwelling lines: iv cannulas and the attachment fluid delivery sets; catheters: arterial line, CVP, pulmonary artery catheters, folley, dialysis; probes and drains: unplanned dislodgment, inappropriate, disconnection of chest drain and nasogastric tubes • Equipment failure: infusion devices; ventilator and accessories; renal replacement devices; power and oxygen supply • Alarms: inappropriate turn off	• Nursing workload as calculated by NEMS • N/P ratio each shift	• Median P/N ratio ranged 1.3 to 2.0 and median P/physician ratio ranged from 3.0 to 6.0 • 584 sentinel events affected 391/1913 patients • 38.8 events per 100 patient days were observed (95% CI 34.7-42.9) • 268 patients experienced only one event, 123 patients > 1 event and 1522 no event • The most frequent events were related to lines, catheter and drains occurred in 158 patients and the second most frequent events were those associated with prescription and administration of drugs • 14.5 events related to lines, catheters and drains per 100 patient day (95% CI 12.0-16.9), 10.5 events related to medication/100 patinet days (95% CI 8.6-12.4), 9.2 events related to equipment/100 patient days (95% CI 7.4-11.1), 3.3 airway related events/100 patient days (95% CI 2.4-4.3) and 1.3 alarms related events/100 patinet days (95% CI 0.6-1.9) • Higher severity of illness, higher level of care, longer LOS in ICU before observation and a longer duration of exposure were associated with elevated ORs for experiencing a sentinel event. • There was an association of trauma ICUs with lower odds for the occurrence of sentinel events (OR 0.47, 95% CI 0.22-1.00, $p = 0.04$) • P/N ratio showed a slight nonlinear influence ($p = 0.04$, quadratic term $p = 0.006$)
Tarnow-Mordi et al., 2000, Scotland	To investigate whether mortality is independently related to nursing requirement and other measures of workload	• Retrospective analysis from a prospective cohort study • 1050 adult episodes representing 1025 patients (25 readmissions) in 1 ICU • Locally agreed formula was used to calculate the number of appropriated staffed beds • Nursing requirement per shift was recorded by senior nurse at the end of each shift according to recommendations of UK intensive care society • 4 year study	• Mortality: death in the ICU or before discharge from hospital • LOS • Readmission rates in the ICU	• Measures of workload in each patient' stay per shift: occupancy per shift: the highest number of ICU beds occupied each shift • Peak occupancy: the highest occupancy per shift during the patients' stay • ICU nursing requirement per shift: the highest number of nurses required for the ICU according the recommendations of UK Intensive care society • Number of appropriately staffed beds: total whole time-equivalent nurses- • Nurse workload: the ratio of occupied to appropriately staffed beds	• 337 deaths were recorded (226 ICU, 111 before hospital discharge) and 61 readmissions in a total of 1286 admissions • Median LOS was 2.2 days (0.3-95.8) • Median ratio of occupied beds to appropriately staffed beds was 1.3 (0.4-2.2) • Median nursing requirement per shift was 9.2 (2.5-14.9). • Median nursing requirement per occupied bed per shift was 1.6 (0.7-2.3) • Adjusted mortality was related to the ratio of occupied of appropriately staffed beds per shift, peak occupancy and ICU nursing requirement per occupied bed per shift • Unadjusted mortality was greater for patients exposed to high vs moderate overall ICU workload (OR = 4.0, 95% CI 2.6-6.2) • Adjusted mortality was more than 2 times higher in patients exposed to high workload (average nursing requirement per occupied bed and peak occupancy) than those exposed to low workload (OR = 3.1, 95% CI 1.9-5.0)

Table 1. Continued

Authors, publication date, country	Research aim(s)	Methods: study design, population, tools used study duration	QIs and formula or definition identified	Nurse staffing variables and definition identified	Results
Garcia & Fugulin, 2012, Brazil; USA	To analyze the time the nursing team uses to see patients in ICU, as well as to check its correlation with quality care indicators	• Quantitative descriptive correlational study in an adult ICU • All patients admitted during study period • Selected QIs of the Institution's group of QIs that were already validated and recommended in Brazilian literature • The data were monthly collected from the management instruments: "Worksheet to calculate the mean nursing care time spent" (part of head nurses' monthly reports calculated electronically by equation in excel); "Worksheet to obtain nursing quality indicators"/ • 2 year study	• NGT loss: definition of ANA, National Database of Nursing QIs • CVC loss: number of CVC losses/ number of patients with CVC per day x 100 • Incidence of pressure ulcers: definition of ANA, National Database of Nursing QI • Extubation incidence: definition of ANA, National Database of Nursing QI	• Nursing time (including nurses and nursing technicians) spent to assist each patient: mean number of nursing staff members in each professional category X mean productivity of each professional category X work journey of each professional category ÷ mean daily number of patients attended	• Mean number of nursing hours were 13.9 hours per patient per day in 2008 and 14,1hrs/pat/day in 2009 • - Mean care hours for nurses and nursing technicians remained the same in 2008 and 2009 • The proportion of nurses' care time was found to be 31%. The care time of nursing technicians was 69% • Nursing care time spent and the QI "incidence of accidental extubation" showed statistically significant correlation (r = -0.454, p = 0.026) • The mean incidence of accidental extubation was found to be 0.73 (SD 0.57) and 0.46 (SD 0.58) for 2008 and 2009, respectively • The incidence of accidental extubation decreased when the nursing care time increased (r = -0,454, p = 0.026)
Metnitz et al., 2008, Austria	To evaluate the relationship between patient volume and outcome (survival status at ICU and hospital discharge status) in a large cohort of critically ill patients	• Prospective, multicenter cohort study • 83259 patients from 40 ICUs in Austria • A questionnaire was used to examine the structural characteristics of quality of the included ICUs • ASDI prospectively collected data • 7 year study	• Fatal outcome • Observed to expected mortality: number of observed deaths per group/ the number of SAPS II predicted deaths per group • ICU LOS • Hospital LOS	• Level of the provided care (assessed by TISS 28) • P/N ratio: number of patients assigned to one nurse • The efficient use of nursing personnel was evaluated from the work utilization ratio and was calculated by specific formula • Occupancy rate: the percentage of occupied beds per day	• LOS was 3 days (median Q1-Q2, 2-7) • Observed/ expected mortality ratio was 0.90 (95% CI 0.89-0.91) • An increase in the number of patients/year/ICU bed (turnover) (OR = 0.967, 95% CI 0.956-0979) and an increase in the number of patients treated in the same diagnostic category (OR = 0.995, 95% CI 0.993-0.996) reduced the risk of fatal outcome • An increase in P/N ratio (OR = 1.082, 95% 1.019-1.149) and an increase in the number of diagnostic categories (OR = 1.065, 95% CI 1.044-1.086) were associated with worse outcomes • A significant positive correlation between later admission and survival was observed (OR per year 0.96, 95% CI 0.95-0.97) • When P/N ratio was increased by 1 and the nurse had to care for an additional patient, the risk of dying at hospital was increasing by 8% and by 30% in univariate and multivariate analysis, respectively
Stone et al., 2007, USA	To examine effects of a comprehensive set of working conditions on elderly patient safety outcomes in ICU	• Observational study • 51 adult ICUs in 31 hospitals, 15846 elderly ICU patients • Standardized data collection forms were used: data were collected by Medicare files (30 day mortality, decubiti), NNIS (for CLBSI, VAP, CAUTI), administrative data (covariates), AHA ,and RN survey (for the organizational climate by Nurse work environment scale- 42 item) • For administrative processes the monthly payroll data was used (RN hours per patient day, ratio of overtime to regular time hours of RN and average RN wages per ICU • Medicare cost reports were used to estimate profit margin • Magnet accreditation status was determined using credentialing body's website • During the year 2002	• CLBSI: according to definition and formula of NNIS protocols • VAP: according to definition and formula of NNIS protocols • UTI: according to definition and formula of NNIS protocols • 30 day mortality: the date of index admission in inpatient standard analytic file to the date of death in the denominator file, • Decubiti: according to definition and formula of AHRQ protocol	• RN hours per patient day • Ratio of overtime to regular time hrs of RNs • Average RN wages per ICU • Average RN wages per ICU • Overtime • Effective work conditions (by the organizational climate calculated by Nursing work scale (NWS)	• 30-day mortality rate was 22% • Overall rates for infection were low: CLBSI: 0.95% (61/6385), CAUTI: 1.7% (102/6031), VAP: 1.5% (81/5462). Average 30-day mortality was 22% and decubitus ulcer 2.0 • Patients admitted to ICUs in which nurses perceived more positive organizational climate had slightly higher odds for developing CLBSI (adjusted OR = 1.19, 95% CI 1.05-1.36), but were 39% less likely to develop CAUTI (adjusted OR = 0.61, 95% CI 0.44-0.83) • Patients admitted to ICU with more RN hours per patient day had significantly lower incidence of CLBSI, VAP, 30-day mortality and decubiti (p ≤ = 0.05) • In settings where nurses worked less overtime patient experienced less CLSBI (adjusted OR = 0.33, 95% CI 0.15-0.72) • In settings where nurses worked more overtime patients had increased odds in CAUTI (p<0.001) and higher rates of decubiti (adjusted OR = 1.91, 95% CI 1.17-3.11) • Hospitals with the lowest profit margin had less adverse outcomes (CAUTI, VAP, decubiti) than those more profitable (P ≤ 0.05), whereas CLBSI had negative relationship (p < 0.001) • Increased overtime was associated with patients' risk of CAUTI, decubitus ulcer. Less overtime was associated with lower incidence of CLBSI

Table 1. Continued. AHA = American Hospital Association (annual survey data), ANA = American Nurses Association, ASDI = Austrian Center for Documentation and Quality Assurance, BSI = bloodstream infection, CAUTI = catheter-associated urinary tract infection, CDC = Centers of Disease Control and Prevention, CI = confidence interval, CIMC = cardiac intermediate care units, CCLI = central catheter line infection, CLBSI = central line bloodstream infections, ICD= International Center of Disease, ICU = intensive care unit, ICP = intracranial pressure , IMC = intermediate care unit, LOS = length of stay, MAE= medication administrator error, MS = medical/surgical, NCICU = Non-cardiac ICU, NEMS = Nine Equivalents of Nursing Manpower Use Score, NNIS = National Nosocomial Infections Surveillance, NNPR = night nurse to patient ratio, N/P ratio = nurse to patient ratio, NWS = Nursing Work Scale , NNIS = nosocomial infections surveillance, OR = odds ratio, p = significance value, RADR = restraint application duration rate, RN = registered nurse, SAPS= Simplified Acute Physiology Score, UE = unplanned extubation, UTI = urinary tract infections, Yrs = Years, Vs = Versus

Category of outcome variables	Sub-category of outcome variables	QIs identified	Studies identified												
			Kendall-Gallagher & Blegen, 2009	Cho et al., 2008	Robert et al., 2000	Dang et al., 2002	Amavardi et al., 2000	Alonso-Echanove et al., 2003	Whitman et al., 2002	Bracco et al., 2001	Valentin et al., 2006	Tarnow-Mordi et al., 2000	Garcia & Fugulin, 2012	Metnitz et al., 2008	Stone et al., 2007
Primary QIs	Setting related	Mortality (adjusted and unadjusted, observed and expected- SMR)/fatal outcome		X			X			X		X		X	
Primary QIs	Setting related	30 day mortality													X
Primary QIs	Patient related use of health care	ICU LOS				X	X			X	X	X		X	
Primary QIs	Patient related use of health care	Hospital LOS				X	X							X	
Primary QIs	Setting related	Cost					X			X					
Primary QIs	Patient related use of health care	Readmission								X		X			
Secondary QIs – Infections	Patient related safety	UTI	X												X
Secondary QIs – Infections	Patient related safety	CVC-associated BSI/ CLBSI	X					X	X						X
Secondary QIs – Infections	Patient related safety	BSI	X		X										
Secondary QIs – Infections	Patient related safety	Postoperative septicemia				X	X								
Secondary QIs – Infections	Patient related safety	Postoperative infection					X								
Secondary QIs – Infections	Patient related safety	Post-operative pneumonia					X								
Secondary QIs – Infections	Patient related safety	VAP													X
Secondary QIs – Adverse events	Patient related safety	Medication errors	X						X		X				
Secondary QIs – Adverse events	Patient related safety	Skin break down, pressure sores	X						X				X		X
Secondary QIs – Adverse events	Patient related safety	Falls	X						X						
Secondary QIs – Adverse events	Patient related safety	Reintubation				X	X								
Secondary QIs – Adverse events	Patient related safety	Extubation incidence/unplanned extubation									X		X		
Secondary QIs – Adverse events	Patient related safety	Aspiration				X	X								
Secondary QIs – Complication after OR	Patient related safety	Acute MI				X	X								
Secondary QIs – Complication after OR	Patient related safety	Cardiac arrest				X	X								
Secondary QIs – Complication after OR	Patient related safety	Complications after procedure				X									
Secondary QIs – Complication after OR	Patient related safety	Pulmonary insufficiency after procedure				X									
Secondary QIs – Complication after OR	Patient related safety	Ventilation > 96 hours				X									
Secondary QIs – Complication after OR	Patient related safety	Renal failure				X	X								
Secondary QIs – Complication after OR	Patient related safety	Platelets transfusion				X									
Secondary QIs – Complication after OR	Patient related safety	Cardiac complications					X								
Secondary QIs – Complication after OR	Patient related safety	Reoperation for bleeding					X								
Secondary QIs – Complication after OR	Patient related safety	Surgical complications					X								
Secondary QIs – Complication after OR	Patient related safety	Critical incidence								X					

Table 2. Categorization of quality indicators identified in the included studies

Category of outcome variables		Sub-category of outcome variables	QIs identified	Studies identified												
				Kendall-Gallagher & Blegen, 2009	Cho et al., 2008	Robert et al., 2000	Dang et al., 2002	Amavardi et al., 2000	Alonso-Echanove et al., 2003	Whitman et al., 2002	Bracco et al., 2001	Valentin et al., 2006	Tarnow-Mordi et al., 2000	Garcia & Fugulin, 2012	Metnitz et al., 2008	Stone et al., 2007
Secondary QIs	Errors	Patient related safety	Human errors related to venous lines and catheters								X					
			Human errors related to respiratory system								X					
			Human errors related to cardiovascular system								X					
			Human errors related to drug related complications								X					
			Human errors related to neurological system complications								X					
			Human errors related to urinary system complications								X					
			Human errors related to Gastrointestinal system complications								X					
			Human errors related to skin and muscular system								X					
			Human errors related to management complications								X					
Secondary QIs		Patient related perception	Patient satisfaction with pain management							X						
		Patient related safety	Restraint application							X						
Secondary QIs	Sentinel/unintended events	Patient related safety	Sentinel events related to medication (prescription, administration)									X				
			Sentinel events related to airway									X				
			Sentinel events related to indwelling lines (lines, catheters, drains, arterial lines CVP lines, pulmonary artery catheters, folley catheters, dialysis catheters, chest drain, nasogastric tubes)									X		X		
			Sentinel events related to equipment									X				

Table 2. Continued

DISCUSSION

The current review builds on previous research pooling patients' outcomes associated with the quality and quantity of nursing care in the ICU. This review examines the methodological quality of QIs identified, through a relative new instrument (AIRE) (De Roo et al., 2013). To the authors' knowledge, this is the first time that the AIRE instrument is used for the methodological quality assessment of NQIs in the ICU.

The QIs identified concerned a specific health care setting (ICU), even though they were previously used for other health care settings as well. The heterogeneity was evident both with regards to the number of QIs, which ranged from 1 to 15, as well as to the type of QIs measured (Tables 1 and 2). The observed variation across QIs indicates that the selection of QIs depends to some extent on the type and needs of each ICU, as well as the purpose the QIs are selected to serve. The composition of involved stakeholders and the defined criteria may also affect the selection of QIs. The geographical origin, the main causes of mortality of the population under study and the available means need to be taken into consideration (Mainz, 2003). Additionally, critically ill patients' outcomes are not equally sensitive to nursing care (Whitman et al., 2002). The examination of a specific group in the ICU, as well as the diagnostic related group are factors that may affect the sensitivity to nursing care and the selection of QIs.

QIs that describe the positive effect of nursing care delivered by measures of improved health status, such as symptom control (e.g. dyspnea, nausea) were not identified. This finding may suggest that this type of information is not recorded and documented in administrative databases (Savitz et al., 2005). Only Whitman et al. (2002) reported rates of "patient satisfaction with pain management". Likewise, there seems to be a lack of patient- reported outcome QIs, which should be addressed in future studies.

Methodological characteristics of the identified QIs varied considerably across the included studies (Table 3). The high scores obtained in the category "scientific evidence" were indicative of the fact that generally valid and widely used QIs were included in these studies. On the other hand, low scores in the remaining categories suggest that future studies should pay more attention to reporting the involvement of relevant stakeholders as well as to providing full descriptions of the QIs used.

Structure variables associated with patient outcomes differ among included studies (Table 1). This was also highlighted in previously published reviews (Numata et al., 2006; Penoyer, 2010; West et al.,

Items	Dimension	Studies identified													Item score (average ratio) % (min: 25, max:100)	Category score % (min: 25, max: 100)	Standardized category score % (min: 0 , max: 100)
		Kendall-Gallagher & Blegen, 2009	Cho et al., 2008	Robert et al., 2000	Dang et al., 2002	Amavardi et al., 2000	Alonso-Echanove et al., 2003	Whitman et al., 2002	Bracco et al., 2001	Valentin et al., 2006	Tarnow-Mordi et al., 2000	Garcia & Fugulin, 2012	Metnitz et al., 2008	Stone et al., 2007			
Purpose, relevance and organizational context	The purpose of the indicator is described clearly	11	15	16	12	12	15	15	14	14	15	16	14	11	87	81	75
	The criteria for selecting the topic of the indicator are described in detail	10	11	13	11	14	14	15	13	13	14	14	13	12	80		
	The organizational context of the indicator is described in detail	8	9	10	11	9	10	9	12	13	9	10	11	12	64		
	The quality domain the indicator addresses is described in detail	13	6	16	16	15	15	12	15	15	15	12	11	14	83		
	The health care process covered by the indicator is described and defined in detail	14	13	15	14	14	15	15	15	15	15	15	16	16	92		
Stake holder involvement	The group developing the indicator includes individuals from all relevant professional groups	4	4	4	9	10	4	4	4	4	6	4	4	4	31	51	35
	Considering the purpose of the indicator, all relevant stakeholders have been involved at some stage of the development process	4	4	4	16	9	8	4	4	4	5	4	4	4	36		
	The indicator has been formally endorsed	16	4	16	16	15	14	4	15	15	13	16	12	16	88		
Scientific evidence	Systematic methods were used to search for scientific evidence	11	11	14	12	13	15	13	13	13	14	14	13	16	83	89	85
	The indicator is based on recommendations from an evidence based guideline or studies published in peer-reviewed scientific journals	16	16	16	11	16	16	15	15	15	16	16	15	16	96		
	The supporting evidence has been critically appraised	16	16	15	11	14	14	15	14	14	13	14	14	15	89		
Additional evidence, formulation, usage	The numerator and denominator are described in detail	6	15	16	10	10	15	14	10	10	14	13	13	12	75	86	82
	The target patient population of the indicator is defined clearly	11	15	16	15	16	16	11	12	12	13	12	14	16	86		
	A strategy for risk adjustment has been considered and described	8	16	14	16	14	14	10	13	13	13	10	13	15	81		
	The indicator measures what it is intended to measure (validity)	14	14	16	12	14	16	12	14	14	16	14	12	16	88		
	The indicator measures accurately and consistently (reliability)	14	14	15	12	14	16	15	14	14	16	14	11	16	89		
	The indicator has sufficient discriminative power	14	12	14	15	11	14	13	12	12	13	11	14	15	82		
	The indicator has been piloted in practice	16	16	16	16	16	16	16	14	14	16	14	15	16	97		
	The efforts needed for data collection have been considered	14	15	15	16	15	15	16	14	14	14	14	14	15	92		
	Specific instructions for presenting and interpreting results	11	16	15	12	14	15	14	14	14	14	13	13	15	87		

Table 3. Quality assessment of the quality indicators identified through research and evaluation (AIRE) instrument (De Roo et al., 2013). Category score = (sum of individual authors' scores for the items in a category) / (maximum possible score for that category); Standardized category score (range 0-100%) = (total score per category - minimum possible score per category) / (maximum possible score per category - minimum possible score per category)

2009). Almost half of the studies examined N/P ratio. Nevertheless, it should be noted that, even when the same nurse staffing variable was considered, it was measured in different ways, for example N/P ratio in the morning versus night shift (Amavardi et al., 2000; Dang et al., 2002). It is evident that there are many different ways of measuring nurses' contribution to patient care. However, this variability makes comparison among the studies difficult. It is of note that in more than half of the studies, it is not clear if nurses are registered nurses (RNs) or if other levels of nursing personnel were included.

A wide variability regarding mortality and morbidity rates was also observed (Table 1). This variation may be related to differences regarding organizational and structural factors of the ICUs, including available resources, capacity, type of each ICU, as well as care processes and policies, for instance admission and discharge criteria (Pronovost et al., 2003). Furthermore, it is of note that there are no universally applied systems that enable constant collection of QIs. Similarly, there are no uniform definitions and descriptions of QIs (Whitman et al., 2002). Thus, similar QIs may lead to different calculations because the formulas as well as inclusion and exclusion criteria provided by different organizations may vary (AHRQ 2006).

The findings of this review suggest that the increased ratio of average daily census to the total number of full time equivalent RNs (ADC/RNs) and N/P ratio at day and night, overtime, workload, use of float or pool nurses and the low intensity staffing are all strongly associated with higher rates of adverse events, mortality, infections and complications in adult ICUs (Table 1). These findings are consistent with previous results in acute and critical care populations (Griffiths et al., 2008, Numata et al., 2006, Penoyer, 2010, Van den Heede et al., 2007, West et al., 2009).

Sets that assess ICU performance have been previously described (Najjar-Pellet et al., 2008). Furthermore, there are sets of QIs that focus on specific populations of the ICU: neurological (Russell et al., 2002), end-stage (Clarke et al., 2003), palliative care (Mularski et al., 2006), medical and surgical (Pronovost et al., 2003) and cardiology patients (Idemoto and Kresevic, 2007). The current literature review did not reveal a complete set of QIs according to structure-process-outcome, which can quantify nursing care in the ICU. However, the NQIs identified are evidence-based and valid. Thus, they could be used in the context of the development of a unique set of NQIs specific to the ICU. To achieve this end-goal, a well-defined multi-level and structured research approach is needed that combines the available evidence with expert opinion.

Limitations

The use of MESH terms probably limited retrieval of results (Pronovost et al., 1999). In particular, using the general term QI as a key word probably restricted the articles yielded. Furthermore, the review did not employ any method for retrieving grey literature. Even though a number of additional studies from European countries (Isfort, 2013) and Korea (Choi et al., 2008) were identified in the search, those were not published in the English language, and were thus excluded. To the authors' knowledge, the AIRE instrument has not been used previously in the context of assessing QIs in the ICU. Thus, no comparisons could be drawn. Lastly, the inclusion of articles published after 2000 may have limited the number of articles examined; however, the review has covered a relatively long time period.

CONCLUSIONS

ICU patients may be at greater risk when the overall nursing staff performance is disturbed (West et al., 2009). Mishaps indicate poor quality of the care provided. Continuous assessment of measures, which quantify the level of nursing quality and nursing contribution to patients' care outcomes is pivotal. The NQIs pooled in this review could be used for the development of a unique set specific to the ICU. Monitoring of validated NQIs may improve critically ill patients' outcomes that are mostly affected by nurses. This would also allow the comparison between ICU settings. A set of NQIs specific for the ICU may influence clinical nursing practice, guide improvements of the care delivered and contribute to the transformation and improvement of the health care system (De Vos. et al., 2007, Numata et al., 2006, Penoyer, 2010). Lastly, monitoring of NQIs in a unit recognizes that the critically ill patient remains the focus of the care process.

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