Selection, Development and Measurement of Nursing – Sensitive Quality KeyPerformance Indicators for Critically Ill Patients: A Delphi Study

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Abstract

Background: The use of suitable and pertinent Key Performance Indicators (KPIs) for nursing provides an opportunity to determine the unique contribution of nurses in the caring for critically ill patients. There is a wide heterogeneity in the way indicators are defined and interpreted. **This study aimed** to select, develop and measure Nursing – Sensitive Quality Key Performance Indicators (KPIs) for Critically Ill Patients in all critical care units, at Alexandria Main University Hospital. **Research design**: A descriptive methodological research design was used. **Setting and Subjects:** Purposive sample of more than five years experienced staff was selected (N= 31). They were classified as follows: head nurses (n = 3), charge nurses (n=3), senior shift nurses with experience more than five years (n=15) and Intensive Care Unit physicians with experience more than five years (n=10). Three rounds of e-Delphi technique were used to seek opinions from those staff about important and relevant KPIs. **Tools**: Tool I: KPIs selection questionnaire by expert panel**.** Tool II: KPIs measurement audit sheet. **Results:** The final decision for the set of indicators based on consensus agreement between expert panel were 11 indicators. **Conclusion**: The results provide 11 KPIs perceived to be more sensitive to measure outcomes of nursing care of critically ill patients. **Implications for Nursing Management:** The proposed nurse-sensitive indicators provide an opportunity for recognizing gaps, developing targeted interventions for investment and improving care and mechanisms to help governance and accountability mechanisms that improve quality in health systems.

Introduction

Evaluation of the performance of healthcare organizations is of paramount importance because of the healthcare organizations' impact on the efficacy and usefulness of overall healthcare systems [(1,2)]. Performance evaluation of nursing care is receiving increasing verification all over the world [(3)]. Nurses, the largest component and constitute of the health professional workforce, are crucial to the delivery of safe and effective care [(4,5)].Whilst nurses comprise the largest workforce and are considered the 'glue' that holds the health care system together, they are too often unappreciated and their contribution to the quality of care agenda underestimated [(6)].This is probably because most of what they do is rarely measured where most measures of quality of care provided focus almost exclusively on more medical aspects of care [(7,8)]. The quality of nursing care is an important part of the overall quality of health services, and its assessment is the central factor assuring that patients are provided with adequate and necessary care. Assessment of the quality of

nursing care is typically done by using different indicators reflecting different aspects of the nursing performance defined as Key Performance Indicators (KPIs) [1,9]. Nursing quality indicators reflect elements of patient care that are directly affected by nursing practice. The main property of a perfect performance evaluation system is the accuracy of its outcomes. Thus, it is important to choose the reasonable indicators that reflect the purpose of the performance evaluation of nursing care [9].

The electronic Delphi technique (e-Delphi) is extensively used to collect data from respondents within their area of expertise. It is a group communication process in which a panel of experts answers questionnaires about a topic, a facilitator summarizes the results, and the panel again reviews the questions for as many rounds as it takes to reach a consensus. The technique has been used to assess quality indicators in a variety of healthcare settings [10].

As patients admitted to different departments of healthcare organization often differ in disease characteristics, severity, and complications, nursing KPIs are expected to be different depending on the particular disease and severity. Nursing KPIs have gained importance in the care of critically ill patients due to the vulnerable nature of those patients, complexity of their care delivery processes, operating activities, and significant economic and workforce burden to caregivers [2,11].

In a healthcare delivery system, there is a concern that demands critically ill patients exceed already overburdened healthcare resources [3]. These demands are further compounded by the perpetual challenge of achieving high quality care without excessive resource utilization. Approaches and indicators to measure and increase the provision of best care practices in critically ill patient disease processes management have been developed and to some extent also measure the function of the operating health system [4,12]. However, a more comprehensive description and balanced assessment of KPIs of nursing performance of critical care is required in order to build a safer healthcare system [13].

Significance of the study

Although there were numerous studies reporting nurse-sensitive indicators, there were inconsistencies in the terms/definitions used to describe nursing quality indicators including: nursing key performance indicators, nurse-sensitive indicators, nurse-sensitive quality indicators and nursing metrics [14-16]. In addition, definitions used for indicators varied by tool and data source despite the indicators aiming at assessing the similar outcome [16-20] . Accordingly, there is extensive overlap in measurement methods and limited standardization of indicators between organizations or hospitals. It will be imperative that a consistent and standardized approach to indicator definition and measurement is developed to support the evaluation of nursing care in the study settings.

Aim of the study

This study aimed to select, develop and measure Nursing – Sensitive Quality Key Performance Indicators (KPIs) for Critically Ill Patients in all critical care units, at Alexandria Main University Hospital.

Research design

A descriptive methodological research design was used. Three rounds of e-Delphi technique were used to seek opinions from expert panel

about what are important and relevant KPIs. The e-Delphi technique is an effective technique for group-based judgement and consensus making. Responses obtained during each round are analyzed, summarized and returned to the panel of experts as a new list of KPIs to judge. The face-to-face Delphi meetings was not used because of the COVID-19 restriction.

Recruitment of the experts

Purposive sample of more than five years ICU experienced staff was selected. The researchers chose those staff heterogeneously, to represent the variety of perspectives. The expert panel for selection and development of KPIs were 31. They were classified as follows: head nurses (n = 3), charge nurses (n=3), senior shift nurses with experience more than five years (n=15) and Intensive Care Unit (ICU) physicians with experience more than five years (n=10).

Those experienced staff were invited to participate in the study via what's app invitation. The invitation letter indicated the importance of the research and its implication to nursing care quality improvement. The invitation was sent to 50 experts. Eleven of them did not respond, and eight of them apologized to participate. The remaining 31 expert express their willing to participate in the full rounds of the Delphi study.

Setting for KPIs selection and measurement

The study was conducted in four ICUs, at Alexandria Main University Hospital namely; First, Second, Third and Fourth Units. It is a main hospital, affiliated to Alexandria University and is equipped with 1,825 beds. The capacity of critical care units includes 46 beds in the previously mentioned four units. Alexandria Main University Hospital is the major teaching hospital at Alexandria city. It provides widespread range of health care services to all populations from Alexandria and nearest governorates.

Identification of existing KPIs from literatures

The review process was conducted by the researchers using keywords: Key performance indicators, quality of nursing care measurement, critically ill patient care indicators, intensive care unit indicators, critical care unit performance measurement, quality measures, quality management and quality indicators. Review identified 47 commonly used KPIs measuring quality of nursing care for critically ill patients.

Instrument development

Tool one: KPIs selection questionnaire by expert panel:

It was developed by the researchers from review of the related literature. The questionnaire consists of 47 KPIs, each indicator was scored by the experts according to a five-point Likert Scale (from "very important" to "unimportant").

Tool two: KPIs measurement audit sheet:

This sheet was developed by the researchers through review of related literature. It aimed to elicit documentation of basic data of critically ill patients as written by staff nurses or physicians in patient file and also, data about the finally selected 11 KPIs as documented in critical care unit's records as patient admission and discharge records, incident reports, nursing assignment record.

Data collection

- An official approval was obtained from the ethical committee and the Dean of Faculty of Nursing, Damanhur University and from the

director of Alexandria Main University Hospital and the head of departments to conduct the current study. Researchers introduced the research purposes to nursing administrators for better cooperation, and to encourage nurses to actively participate in the study.

- The data collection and the provided intervention took a period of six months starting from the first of August to end of January 2020.
- Subsequently, the study was conducted through two stages KPIs selection and KPIs Measurement.

Round 1:

The role of the expert panel was to discuss and analyze the evidence-based KPIs relative to the quality of nursing care for critically ill patients that were identified in literature review (KPIs = 47 indicators), reach a preliminary agreement on the KPIs, KPIs are reduced to 30 indicators after the first round of Delphi. The selection criteria of critical care indicators selected were safety, timeliness, effectiveness, efficiency, patient/family satisfaction, and staff work life.

Round 2:

The indicators were further reselected by the panel through second round of Delphi discussion using structured interview method, KPIs were revised and clarified to take into account the hospital context. They reached consensus on 18 indicators. Expert panel two rounds of discussion occurred in the time period of three months starting from September to November 2018.

The selection of the most important and applicable KPIs was followed by further selection from the expert panel through ranking based on the necessity and priority to monitor specific aspects of nursing care in the hospital. The experts were asked to rank the indicators separately according to their degree of recommendation for use and feasibility for evaluation and measurement.

KPIs measurement (the finally selected 11 KPIs):

- The researchers used concurrent audit through KPIs measurement audit sheet to check and revise patients' files, assignment sheet time schedule record and patient admission and discharge records.
- At admission, patient-specific diagnostic data and data necessary for calculating severity of illness were captured and entered in the patient file by ICU medical staff. Ventilation and procedural and safety data were entered daily by nursing staff. At discharge, outcomes were captured by senior nursing staff. Microbiological data (as incidence of Urinary Tract Infection and Blood stream infection), were independently extracted from the patient file. Nurses' time schedules were used to calculate nurse to patient ratio.

Round 3:

The final decision for the set of indicators was made on the basis of **consensus agreement** between expert panel members. (KPIs finally agreed by expert panel after retaining, addition and deletion is 11 indicators)

Ethical considerations:

The ethical committee of the Faculty of Nursing, Damanhur University approved the study protocol. Data confidentiality and anonymity were assured through assigning a code number for each patient file instead of patient names to protect patients' privacy. Head of departments were assured that data are used only for research purposes and that the study

procedures could not induce any actual or potential harm to the participants.

Data Statistical Analysis:

Data were coded and fed to the statistical package of social science (IBM SPSS), version 25. Frequency and percentages (descriptive statistics) were used for presenting patients' demographic characteristics. Arithmetic mean and standard deviation (SD) were used for quantifying the studied variables. The Kendall coefficient of concordance was used to evaluate the agreement among raters. All statistical analysis was done using alpha error of 0.05.

Results

Table 1 reveals the final decision for the set of indicators that was made on the basis of consensus agreement between expert panel members. KPIs finally agreed by expert panel after retaining, addition and deletion is 11 indicators as follows: the standardized mortality rate (SMR), incidence of ventilator associated condition (VAC), incidence of central line associated blood stream infection (CLABSI), incidence of catheter associated urinary tract infection (CAUTI), incidence of pressure ulcers, nurse-patient ratio, incidence of falling out of bed, rate of readmission to the ICU within 24/48, incidence of reintubation, incidence of pneumothorax and length of patient stay in ICU (LOS). Agreement of experts regarding the importance and relevance of data in KPIs categories was determined using the Kendall coefficient of concordance (Kendall's W) for each category **in table 2**. The agreement value of the two rounds ranged from 0.24 to 0.59 (all $p < 0.001$), which is excellent agreement between the expert. **Table 3** shows that there were 180 admissions to the ICU department in the study period. The interquartile range of their age was 32-69 years. They were classified into 78 female patients and 102 male patients. The majority of studied patients (94.6%) were admitted from emergency department. 71.65 % of them were survived. **Table 4** summarizes KPIs over 3 monthly periods. Nurse to patient ratio is 1:2. Patient LOS in ICU ranged from 4 to 11 days, with mean 6 days. The SMR was 1.1 (95% confidence interval 0.9-1.3). There are no pneumothoraxes or patient readmission or patient fall over the 3 monthly periods. There are 82 Pressure ulcers with quarterly incidence ranging from 30 to 37 per 1000 admissions. Only 0.05 % of patients were reintubated within 48 hours of extubation. VACs were calculated per 1000 ventilator days (vd) and there were 22 VACs. There were 9 and 14 CLABSI and CAUTI per 1000 catheter days (cd), respectively. **In table 5** a clear definition was given for the numerator and denominator of these indicators, and thereby their values could be calculated objectively or used objectively or on a timely basis to evaluate the quality of nursing car

Table 1: Selection and development of KPIs:

KPIs identified from literature review (45 KPIs) + (2KPIs were added)	Expert panel decision after first round of discussion (30 KPIs)	Expert panel decision after second round of discussion (18 KPIs)	Expert panel final consensus agreement on KPIs to be measured (11 KPIS)
1. SMR: the standardized mortality rate	Retained	Retained	Retained
2. Incidence of ventilator associated condition (VAC)	Retained	Retained	Retained
3. Rate of unplanned extubation	Retained	Retained	Removed
4. Incidence of central line associated blood stream infection (CLABSI)	Retained	Retained	Retained
5. Incidence of catheter associated urinary tract infection (CAUTI)	Retained	Retained	Retained
6. Incidence of pressure ulcers	Retained	Retained	Retained
7. Nurse-patient ratio	Retained	Retained	Retained
8. Rate of bed occupancy in the ICU	Retained	Retained	Removed
9. Ratio of reaching the standard in the management of blood glucose level	Retained	Removed	Removed
10. Rate of patient/family satisfaction	Retained	Removed	Removed
11. Incidence of falling out of bed	Retained	Retained	Retained
12. Rate of readmission to the ICU within 24/48	Retained	Retained	Retained
13. Rate of finishing the daily target to-do checklist	Removed	Removed	Removed
14. Physician-patient ratio	Retained	Retained	Removed
15. Incidence of transfer adverse events	Removed	Removed	Removed
16. Incidence of medication errors	Retained	Removed	Removed
17. Incidence of reintubation	Retained	Retained	Retained
18. Incidence of needle-stick injuries	Retained	Removed	Removed

19. Incidence of pneumothorax	Retained	Retained	Retained
20. Implementation rate of placing patients on mechanical ventilation in a semi-recumbent position (30–45°)	Retained	Removed	Removed
21. Implementation rate of monitoring for sedation	Removed	Removed	Removed
22. Implementation rate of monitoring for pain	Retained	Removed	Removed
23. Implementation rate of monitoring for delirium	Removed	Removed	Removed
24. Implementation rate of protective ventilation strategies	Retained	Removed	Removed
25. Implementation of early and appropriate broad-spectrum antibiotics within 1 hr. after definite diagnosis	Retained	Removed	Removed
26. Implementation of hypothermia treatment following cardiac arrest	Removed	Removed	Removed
27. Implementation rate of standard enteral nutrition management	Removed	Removed	Removed
28. Implementation rate of hand hygiene	Retained	Removed	Removed
29. Implementation rate of daily multi-professional rounding	Removed	Removed	Removed
30. Implementation rate of prevention of ventilator-related pneumonia	Retained	Retained	Removed
31. Rate of completing comprehensive family/relative communication records	Removed	Removed	Removed
32. Incidence of acute renal failure	Removed	Removed	Removed
33. Rate of overall employee satisfaction	Retained	Retained	Removed
34. Incidence of aspiration during enteral nutrition	Removed	Removed	Removed
35. Incidence of multi-drug resistant infections (e.g., methicillin-resistant Staphylococcus aureus)	Retained	Retained	Removed
36. Rate of ICU staff who had completed advanced cardiac life support training	Removed	Removed	Removed
37. Rate of survival after cardio-pulmonary resuscitation	Retained	Retained	Removed
38. Rate of achieving monitoring mean arterial blood pressure (MAP)>60 mmHg	Removed	Removed	Removed

39. Rate of using restraints	Removed	Removed	Removed
40. Implementation rate of deep vein thrombosis prevention	Retained	Removed	Removed
41. Rate of carrying out early mobilization	Retained	Removed	Removed
42. Incidence of incontinence-associated dermatitis	Removed	Removed	Removed
43. Incidence of outgoing transport-associated accidents	Removed	Removed	Removed
44. Rate of evaluation for sedation	Removed	Removed	Removed
45. Rate of evaluation for analgesia	Removed	Removed	Removed
46. Rate of evaluation for delirium	Removed	Removed	Removed
47. Percentage of nurses who had worked in ICU for more than 3 years	Removed	Removed	Removed
48. Length of patient stay in ICU (LOS)	Added	Retained	Retained
49. Incidence rate of errors in patient identification	Added	Removed	Removed

Table 2: Agreement of participants regarding the importance and relevance of data inKPIs

Rounds	**Importance of KPIs of data**			**Relevance of KPIs of data**		
	W-value	X^2	***P*-Value**	**W-value**	X^2	***P*-Value**
First round	0.55	146.98	<0.001	0.59	155.11	<0.001
Second round	0.43	121.63	<0.001	0.36	111.23	<0.001
Third round	0.24	91.64	<0.001	0.25	88.15	<0.001

W, Kendall coefficient of concordance, X^2: Chi square

Table 3: Details of patients admitted to Intensive Care Unit (n =180)

Variables	**Values**
Total number of patients	180
Age, years (IQR)	49 (32-69)
Gender (female/male)	78/102

Source of admission (%)	
Emergency	94.6
Inpatient	1.35
Operation theater	4.05
Outcome (%)	
Survived	71.65
Died ICU	27
DAMA	1.35

SD: Standard deviation; ICU: Intensive Care Unit; IQR: Interquartile range;

DAMA: Discharge against medical advice.

Table 4: Quarterly data of finally selected Key Performance Indicators

Quality indicators	Values
1. Nursing ratio (nurses/patients)	1:2
2. Length of stay (median, IQR)	6 (4-11)
3. Standardized mortality ratio (mean, 95% CI)	1.1 (0.9-1.3)
4. Pneumothorax (n, per 1000)	0
5. Pressure ulcer (n, per 1000)	82 (30-37)
6. Readmission (%)	0
7. Falls (n, per 1000)	0
8. Reintubated/ intubated (%)	2/41 (0.05)
9. VAC (n, per 1000)	22 (24.18)
10. CLABSI (n, per 1000)	9 (6.67)
11. CAUTI (n, per 1000)	14 (10.37)

VAC: Ventilator-associated condition; CLABSI: Central line-associated bloodstream infection;

CAUTI: Catheter-associated urinary tract infection

Table 5: Key definition of each selected Key Performance Indicators

Quality indicators	Ratio formula (%)	Numerator	Denominator
1. Nursing ratio (nurses/patients' beds)	Number of ICU nurses registered during the period of research ÷ICU Beds at the same period) ×100	Number of ICU nurses registered during the period of research	ICU beds at the same period

2. Length of stay (median, IQR)	Length of stay is calculated as the difference between the admission Date/Time and the Physical Departure Date/Time.	----------	----------
3. Standardized mortality ratio (mean, 95% CI)	Death rate (No. of actual death in ICU / Total no. of discharge including death) ÷ Average of expected mortality rate (from APACHE version 4)	Death rate (No. of actual death in ICU / Total no. of discharge including death)	Average of expected mortality rate (from APACHE version 4)
4. Pneumothorax (n, per 1000)	Incidence (‰) = (Number of patients who had a Pneumothorax ÷ Number of ICU patients' total days of hospitalization) ×1000	Number of patients who had Pneumothorax during the Period of research	Number of ICU patients' total hospitalization days Patients who had "Pneumothorax" before being admitted to the ICU were excluded from the numerator and denominator.
5. Pressure ulcer (n, per 1000)	Incidence (‰) = (Number of patients who had a pressure ulcer ÷ Number of ICU patients' total days of hospitalization) ×1000	Number of patients who had pressure ulcer during the Period of research	Number of ICU patients' total hospitalization days Patients who had "pressure ulcer" before being admitted to the ICU were excluded from the numerator and denominator.
6. Readmission (%)	Total Number of readmitted within 48 hours ÷ total number of discharged patients ×100	Total Number of readmitted within 48 hours	total number of discharged patients

7. Falls (n, per 1000)	Number of patient falls occurred within a month÷ Total number of inpatients days per month ×1000	Number of patient falls occurred within a month.	Total number of inpatients days per month
8. Reintubated/ intubated (%)	Total Number of reintubations within 48 hours ÷ total number of intubated patients ×100	Total Number of reintubations within 48 hours	total number of intubated patients
9. VAC (n, per 1000)	Incidence (‰) = (Number of patients who had ventilator-related pneumonia÷ Total days of ventilator use) ×1000	Number of patients who had ventilator-related pneumonia	Total days of patients using the ventilator
10. CLABSI (n, per 1000)	Incidence (‰) = Number of patients who had intravascular catheter related infections÷ Total number of days of central venous catheter use) ×1000	Number of ICU patients who had intravascular catheter related infection	Total days of ICU patients using the central venous catheter
11. CAUTI (n, per 1000)	Incidence (‰) = (Number of patients who had urinary catheter-related urinary tract infections ÷ Total number of days of urinary catheter use) ×1000	Number of patients who had urinary catheter-related Urinary tract infection	Total days of patients using the urinary catheter

Discussion

Globally, there is a growing concern about the need for quality health care, with a view that poor-quality care provision is not only wasteful but also ineffective and unethical [21,22]. Measurement of quality indicators is central to improvement efforts aimed to promote accountability in healthcare and professional practice [23-25]. Quality indicators arise from the increasing demand for measures of quality across the healthcare continuum ranging from the community to tertiary level [26]. Therefore, measuring what nurses do is important in maintaining standards, supporting nursing management and understanding outcomes and their variation that is linked to nursing.

This requires development of sensitive, nursing-specific indicators [27,28]. The use of appropriate and pertinent nurse-sensitive indicators offers an opportunity to demonstrate the unique and exclusive contributions of nurses to patient outcomes [25,27,29].

The result of this study revealed the final decision for the set of indicators was made on the basis of consensus agreement between expert panel members.

The selected KPIs to be measured were agreed by expert panel after retaining, addition and deletion during the two rounds of discussion. This result is consistent with those of Chrusch and Martin (2016), who aimed to develop and implement quality indicators for comparing ICU characteristics and performance. Detailed operational definitions were then developed for the selected quality indicators [30].

On the other hand, this result differed from that conducted by Guo and Zhou (2011) as they built an indicator system (Lima & Barbosa, 2015) [31,32]. including specific functions formed by a number of inter-related care duties. All indicators related to the quality of nursing care were selected and scored using the Delphi technique according to the experience of the expert panel. However, no clear definition was given for the numerator and denominator of these indicators, and thus their values could not be calculated or used objectively or on a timely basis to estimate the quality of nursing care [31,32].

The result of this study showed that some indicators were deleted. This is due to their low incidence in clinical practice, less control by nursing staff, or overlap with other indicators. It was surprising that; incidence of transfer adverse events was deleted. Expert panel stated that adverse events that occur during patient transfer had low rates. This contradicts with Parmentier-Decrucq et al. (2013) who confirmed that patients who require critical care are at high risk of adverse events during transfer such as cardiopulmonary arrest. Thereby, ICU patient out-transfer accident incidence rate" serve as a sensitive indicator of ICU nursing quality [33].

The results of this study confirmed that nurse-patient ratio is retained indicator that is finally selected by expert panel. This could be attributed to the supposition that using "nurse-to-bed ratio" as an index of nursing quality, allows the hospital manager to position an appropriate number of nursing staff based on the disease severity of ICU patients and the associated nursing workload, to satisfy the requirements and needs of patient care.

In the current study, the indicator "incidence of medication errors" was deleted. This may seem counterintuitive as nurses are responsible for administering medications, and a large number of medications are administered in the ICU. This might be explained by the fact that incidence of medication errors has been used as a general indicator of hospital-wide monitoring, because this indicator is more closely related to general patient safety. Presently, the ICU department reports to the hospital quality team the absolute value of the number of wrong medications given through incidence report for each medication administration error. Nurses did not document the total frequency of medications prescribed to patients, and in the ICU this issue is

particularly prominent, such as temporary medications for intravenous injection or the number of long-term pump-related drug administrations. These data are hard to obtain for the ICU due to the huge number of medications used, thus it is difficult to measure. Therefore, it is not consistent with the criteria that an indicator has generalized applicability.

Strength and Limitation

- The strength of this study is measurement of the selected KPIs in the clinical area to ensure by the panel of experts that they are important and relevant.
- Limitation of this study is selection of panel of experts from one hospital and not involving experts from other ICUs in other hospitals.

Conclusion

- Not all KPIs are important and relevant to measure quality of care provided to the critically ill patients. They can be differed from setting to another because they may be influenced by other extraneous factors other than the quality of care provided to critically ill patients.

Implications for Nursing Management

- It is hoped that this study will provide an ICU database with consistent definitions and terminology of KPIs. This would provide a mechanism for comparing characteristics and performance between units and regions over time. Furthermore, the proposed nurse-sensitive indicators provide an opportunity for recognizing gaps, developing targeted interventions for investment and improving care and mechanisms to help governance and accountability mechanisms that improve quality in health systems. This contributes to provision of information globally and locally for monitoring quality of nursing care. Finally, measures of nursing quality might strengthen and reinforce the voice of nurses in policy and practice, promotion of patient safety and emphasize their position in planning and management roles where the nursing voice is often lacking. This build improvement in nursing networks to promote nurse-led initiatives.

Conflicts of Interest Disclosure

The authors declare that there is no conflict of interest.

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