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Health Services Research

Quality measurement at intensive care units: which indicators should we use?

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Abstract

Objective: This study was conducted to develop a set of indicators that measure the quality of care in intensive care units (ICU) in Dutch hospitals and to evaluate the feasibility of the registration of these indicators.

Methods: To define potential indicators for measuring quality, 3 steps were made. First, a literature search was carried out to obtain peer-reviewed articles from 2000 to 2005, describing process or structure indicators in intensive care, which are associated with patient outcome. Additional indicators were suggested by a panel of experts. Second, a selection of indicators was made by a panel of experts using a questionnaire and ranking in a consensus procedure. Third, a study was done for 6 months in 18 ICUs to evaluate the feasibility of using the identified quality indicators. Site visits, interviews, and written questionnaires were used to evaluate the use of indicators.

Results: Sixty-two indicators were initially found, either in the literature or suggested by the members of the expert panel. From these, 12 indicators were selected by the expert panel by consensus. After the feasibility study, 11 indicators were eventually selected. “Interclinical transport,” referring to a change of hospital, was dropped because of lack of reliability and support for further implementation by the participating hospitals in the study. The following structure indicators were selected: availability of intensivist (hours per day), patient-to-nurse ratio, strategy to prevent medication errors, measurement of patient/family satisfaction. Four process indicators were selected: length of ICU stay, duration of mechanical ventilation, proportion of days with all ICU beds occupied, and proportion of glucose measurement exceeding 8.0 mmol/L or lower than 2.2 mmol/L. The selected outcome indicators were as follows: standardized mortality (APACHE II), incidence of decubitus, number of unplanned extubations. The time for registration varied from less than 30 minutes to more than 1 hour per day to collect the items. Among other factors, this variation in workload was related to the availability of computerized systems to collect the data.

Conclusion: In this study, a set of 11 quality indicators for intensive care was defined based on literature research, expert opinion, and testing. The set gives a quick view of the quality of care in individual ICUs. The availability of a computerized data collection system is important for an acceptable workload.
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1. Introduction

Interest in measuring the quality of health care is increasing among both health care professionals as well as managers. To quantify the desired (positive) and undesired (negative) consequences of activities in health care, measurement of outcome is essential [1]. Indicators may provide insight in the structure and process aspects of care that are related to outcome [2].

A quality indicator is a screening tool to identify potential suboptimal clinical care [3]. Quality indicators provide a measure of quality of structure, process, and outcome of care [4], and can serve as instruments to improve health care [5]. Structure indicators are related to the resources and means to be able to give treatment and care. Process refers to the activities related to treatment and care. Outcome is defined as changes in the state of health of a patient that can be attributed to an intervention or to the absence of an intervention. The classification has been proven feasible and easy to apply in the clinical situation for both workers in the medical field as well as for research professionals and managers [5]. However, the condition of the patient at admission has to be considered separately, because of its great impact on patient outcome [5]. In this study, the focus is on internal indicators, which are used by professionals and managers of the intensive care units (ICU) to monitor quality of care [6]. The focus is not on performance indicators to evaluate the hospital achievements for, for example, care consumers.

The ICU is an area in a hospital that constitutes substantial risk of morbidity and mortality [7]. The underlying disease of intensive care patients may partly determine outcome of care, but also treatment at the ICU will have an effect on outcome. To reduce the risks of iatrogenic and organizational adverse effects on patient outcome, quality management is important in the ICU. Indicators can provide insight in quality of care and guide improvement of care on ICUs. It is important that an indicator meets several criteria: reliability, validity, responsiveness, relevance, significance, and utility [8].

The purpose of this study is to develop a comprehensive set of structure, process, and outcome indicators that measures aspects of all domains of the quality of care at ICUs and to evaluate the feasibility of the registration of these indicators.

2. Methods

The whole process of defining a set of indicators was carried out by an expert panel, which included physicians and researchers. This expert panel defined the aim of the indicators and the procedure for selection. Indicators were selected based on several criteria: its relation with quality of care (valid), the reproducibility of the measurement (reliable), the responsiveness of the indicator (also including variability among hospitals), and the feasibility of the

registration. These criteria were used in 3 steps: literature search, consensus procedure, and feasibility study.

2.1. Literature search

To obtain relevant literature about quality indicators for intensive care, a literature search was performed using Medline. The search strategy was based on a review of ICU quality indicators performed by Berenholtz et al [7], who included publications published from January 1965 to July 2000. The present study is an update from the literature search from Berenholtz et al [7], and we adopted this search strategy for articles published between July 2000 and July 2005. The Medical Subject Headings used were critical care, ICUs, mortality, morbidity, length of stay, quality indicators (health care), and quality of health care. The search was restricted to the English and the Dutch language and adult age category (18 years and older). The search was limited to meta-analyses, reviews and randomized controlled trials. To obtain observational studies, the Medical Subject Headings case-control studies and retrospective studies were added.

A limited set of additional articles was included, which was suggested by experts [9-16]. Also, the Cochrane Library Issue [17] was searched by using the keywords intensive care, critical care, ICU, and quality of health care.

Studies were included that described a process or structure measure associated with improved outcome (morbidity, mortality, quality of life, or patient satisfaction) in a population of patients admitted to ICU hospital care.

Studies about pediatric or neonatal ICUs were excluded, because we focused on indicators for adult ICUs. Articles with a specific patient population, for instance, burn injury or HIV-infected patients, were excluded. Studies performed in non-Western societies were excluded.

Two researchers independently checked all articles on relevance. Relevant articles were subsequently discussed in an expert panel until consensus was reached.

2.2. Expert opinion

To select a balanced set of indicators meeting the criteria, experts were consulted. The Dutch National Society of Intensive Care Medicine established a multidisciplinary expert panel, aiming to develop a set of indicators that can be used to provide information for improvement of the care in the ICU. The expert panel included 7 physicians with different backgrounds: internal medicine, anesthesiology, and surgery. In addition, 1 ICU nurse and 2 scientific researchers took part in this panel. From February 2004 onward, the expert panel met monthly to discuss the literature and select the indicators. First, the expert panel extracted structure, process, and outcome indicators from the selected articles. Second, additional indicators based on expert opinion were taken into account. The final step to select indicators was made by using a procedure similar to that used by the Agency for Healthcare Research and Quality [3]. A questionnaire using Likert scales was used to make a first

selection of the indicators [8]. One ICU nurse and 7 physicians from the expert panel completed the questionnaire. The questionnaire measured for each indicator on a 5-point scale the degree of the following: relevance for quality of care, the potential to use the indicator to guide improvement of quality of care, and the feasibility of the registration of the indicators. If there was no clear conclusion to either include or exclude the indicator, the decision was made on the basis of discussion until consensus was reached.

A further selection of remaining indicators was made through ranking. The expert panel was asked to rank the potential structure, process, and outcome indicators separately on their degree of recommendation for use. The final decision for the current set of indicators was made on the basis of consensus between panel members. This method is similar to the one used in the development of indicators for acute myocardial infarction care in Canada [18].

The set of indicators was constructed in a way that all quality domains as described by the Institute of Medicine were addressed [19].

2.3. Feasibility study

A feasibility study was carried out to evaluate the use of the identified quality indicators. Intensive care units in the Netherlands were asked by the expert panel if they would be willing to participate in this study. Out of 97 hospitals, 33 initially agreed to participate. Clusters were made to get a balanced selection of categorical hospitals, teaching, and nonteaching hospitals. By random selection in each category of hospitals, 18 hospitals were included in the study: 1 categorical hospital, 7 teaching hospitals, and 10 nonteaching hospitals. Physicians and nurses were trained to collect uniformly all data for the 12 indicators. A data

dictionary was available with detailed definitions and examples. Data were collected for 6 months in collaboration with the National Intensive Care Evaluation (www.stichting-NICE.nl). In the Netherlands, approximately half of the ICUs provide monthly data for this database. Intensive care units that did not use this registration system either used another system or developed a special input module.

Site visits were done by researchers to support the data collection where necessary. To obtain information about the process of data collection, 2 representatives from each ICU (a nurse and an intensivist), responsible for the registration, were interviewed and filled in a questionnaire. In a semi-structured interview, data were collected on perceived validity and reliability of the indicators, possible improvements in definitions, and the local process of collecting and processing the data. The questionnaire included questions on the time investment for the registration (daily, <30 minutes, >30 to <60 minutes, and >60 minutes), a 4-point Likert scale on the acceptability of the time investment and on the desirability of future implementation of each indicator.

3. Results

To achieve a limited and balanced set of quality indicators, a selection was made in several steps, resulting in a set of 11 indicators (Fig. 1).

3.1. Literature search

In the current literature study, 647 articles from the search were identified. Of these, 594 (92%) articles were rejected after review of the abstract on relevance. Fifty-three relevant articles were selected, which reported on a variety of

Fig. 1 Flow diagram for selecting the indicators.

Table 1 Indicators found in literature and indicators identified by Berenholtz et al [7]

Structure	Process	Outcome
Physician staffing [20,21]	Noninvasive ventilation [22,23]	Ventilator associated pneumonia [24-27]
Patient-to-nurse ratio [16,28-31]	SDD [32]	Deep venous thrombosis [33-35]
Mattresses or pressure-relieving beds [9]	TISS score by discharge [36]	Pulmonary embolism [33-35]
Daily sedation interruption policy [37]	Unplanned extubation [38,39]	Decubitus [9]
Use of case management approach [40]	Continuous lateral rotational therapy [24,41,42]	Stress ulcer [43]
Computerized physician order entry [44]	Interclinical transport [45-47]	Quality of life [15]
Pharmacist participation during daily rounds [16]	Red cell concentrate transfusion [48,49]	Hospital mortality rate [32,50]
Weaning following a protocol [10]	Nutrition support [51-54]	<u>Berenholtz et al:</u>
Protocol for admission and discharge [11]	Glucose regulation [55,56]	ICU mortality rate [7]
Infection control participation [12]	Autopsy discussion [57-59]	Patient/family satisfaction [7]
Organizational form IC [21,60]	Open vs closed suction system [61]	Rate of catheter-related blood stream infections [7]
Quality improvement program [13]	Daily rounds by an intensivist [14]	Rate of resistant infections [7]
	Number of patients with premature discharge [11]	
<u>Berenholtz et al:</u>	<u>Berenholz et al:</u>	
Rate of delayed admissions [7]	Effective assessment of pain [7]	
Rate of delayed discharges [7]	ICU LOS [7]	
Cancelled operating room cases [7]	Average days on mechanical ventilation [7]	
Emergency department bypass hours [7]	Suboptimal management of pain [7]	
Rate of unplanned ICU readmission [7]	Appropriate use of blood transfusions [7]	
	Prevention of ventilator-associated pneumonia [7]	
	Appropriate sedation [7]	
	Appropriate peptic ulcer disease prophylaxis [7]	
	Appropriate deep venous thrombosis prophylaxis [7]	

indicators that were associated with improved patient outcome. This resulted in the selection of 12 structure indicators, 13 process indicators, and 7 outcome indicators (Table 1). Berenholtz et al [7] also performed a review to identify quality indicators for ICUs. From this publication, 18 additional indicators were selected, consisting of 5 structure, 9 process, and 4 outcome indicators (Table 1). Furthermore, a limited set of additional articles, as suggested by experts, was taken into account and indicators from these articles are presented in Table 1 [8-15]. In addition to indicators extracted from the literature, we also included 12 indicators suggested by the experts in the panel (Table 2).

3.2. Indicator selection

From the indicators found in the literature and the indicator identified by experts in the field, a list of 62 indicators was made. These 62 indicators were reduced to 25 by using a questionnaire. Three criteria were used to select these 62 indicators: (1) at least 6 of 8 available panel members completely or partly agreed on relevance for quality of care, (2) potential use of the indicator to guide improvement of quality of care, and (3) feasibility of the registration of the indicator.

These 25 indicators were reduced to a set of 12 indicators (Table 3): 4 structure indicators, 5 process indicators, and

3 outcome indicators. This selection was based on ranking and further discussion until consensus was reached. Arguments in the discussion were related to the level of evidence, the availability of the data, validity, and a balanced distribution of structure, process, and outcome indicators covering the 6 quality domains from the Institute of Medicine [19]. Furthermore, the panel was reluctant to include indicators of

Table 2 Additional indicators based on expert opinion

Structure	Process
Policy to register outcome	Examination of post-ICU quality of life
Policy to prevent medication errors	Number of patient days with isolation for outbreak control
Education level IC staff	Number of refused IC admissions
Registration of complications	Number of cancelled OK admissions
Registration of absenteeism among ICU personnel	Occupation rate
	Days of 100% occupation
	Number of discharged patients in out of office time

Table 3 Selected indicators that were measured in the feasibility study

Indicator	
<i>Structure</i>	
Availability of intensivists (per hour)	The average couple of hours per day that an intensivist is available within 5 minutes at the ICU, including weekends
Patient-to-nurse ratio (measured 3 times daily)	Number of ICU patients present compared to the number of qualified ICU nurses that are available in day shift, evening shift, and night shift. Student nurses are not included
Strategy to prevent medication errors	Strategy to prevent medication errors measured by 10 items, yes or no
Measurement of patient/family satisfaction	Whether or not a registration of patient/family satisfaction is present
<i>Process</i>	
Length of ICU stay	Days of ICU stay in a particular period compared to the total number of discharged patients at the ICU in the same period
Duration of mechanical ventilation	Days of mechanical ventilation of the ICU patients compared to the total number of mechanical ventilated patients
Absolute number of interclinical transport	Total number of interclinical transported patients connected to capacity problems
Percent of days with all ICU beds occupied	Days of 100% bed occupation compared to the total number of days in the same period
Percent glucose measurements greater than 8 mmol/L or lower than 2.2 mmol/L	Number of measurements greater than 8.0 mmol/L or lower than 2.2 mmol/L compared to the total number of glucose measurements
<i>Outcome</i>	
Standardized mortality (APACHE II)	(A) Mortality rate in the ICU compared to the total number of ICU patients (B) Mortality rate in the hospital compared to the expected mortality rate based on average
Number of unplanned extubations	Number of unplanned extubations (per 100 ventilation days) in a period compared to the total days of mechanical ventilation in the same period
Incidence of decubitus	Number of ICU patients with incidence of decubitus, level 3 or 4 compared to the total number of treated patients in the same period

current medical knowledge as new scientific data are constantly released, resulting in increased time dependency of the indicator set. The only indicator that directly measures medical treatment concerns glucose regulation. Three of the selected indicators were similar to the indicators selected by Berenholtz et al [7]: ICU mortality, average ICU length of stay, and duration of mechanical ventilation.

For each indicator, a detailed description was made defining the quality target, definition, numerator and denominator, and type of the indicator. These descriptions were collected in a data dictionary available for all participants.

3.3. Feasibility study

To evaluate the registration of the 12 indicators, a feasibility study was done in 18 ICUs. The pilot study covered 7682 admissions and 31 849 treatment days (of which 16 860 ventilated).

Seventeen percent of ICUs needed more than 60 minutes per day to collect the items. These ICUs did not routinely participate in the National Intensive Care Evaluation. Thirty-seven percent of ICUs that routinely use the database needed 30 to 60 minutes per day to collect the items, and 46% less than 30 minutes per day.

More than 80% of respondents supported further implementation of 10 indicators. "Interclinical transport" and "measurement of patient/family satisfaction" were supported by less than 80% of respondents. In addition to the lack of support for implementation, "interclinical transport" was also reported in the interviews to be very unreliable to register, and was therefore dropped for the final set of indicators. The indicator "patient/family satisfaction" was consolidated in the final set because it was considered easy to register and important due to a growing interest in patient centeredness in care evaluation.

4. Discussion

In the current study, a set of quality indicators for intensive care was defined, which after implementation in clinical practice may beneficially influence the quality of care at ICUs. The indicators identified on the basis of the literature study were evaluated, and additional indicators were selected by a panel of experts. This expert panel selected a set of 12 indicators on the basis of a questionnaire and consensus. A feasibility study was done to evaluate the registration of these indicators. Finally, a set of 11 indicators was identified.

The search strategy we used was based on a review of ICU quality indicators performed by Berenholtz et al [7]. In the current study, we found additional indicators. These additional indicators resulted from new reports after the publication year 2000, and from meta-analyses that were excluded by Berenholtz et al [7]. Another difference between the selection made in this study as compared to the set used by Berenholtz et al [7] is that the panel also took operational, logistic, and national arguments into consideration. A process of selection was performed to limit the number of indicators to make the registration feasible and the set applicable.

The set of indicators should be dynamic; an indicator that does not seem to provide opportunities for improvement in time can be dropped, whereas other indicators that seem more favorable can be added. In addition, if an indicator does not show variability (anymore), the indicator can be exchanged for a new indicator.

Several studies showed that the use of indicators and quality programs significantly improve the quality of health care [62,63]. Monitoring indicators implies an administrative burden for physicians and should be worth the effort. Lagoe and Westert [62] described the impact of the exchange of daily, weekly, and quarterly information among a full range of health care administrators and practitioners on the accessibility and efficiency of care. These efforts resulted in increased accessibility of hospital emergency departments and greater efficiency of acute and long-term care. Another study developed and reported clinical indicators as measures of the quality of care received by patients with acute coronary syndromes or congestive heart failure [63]. The study showed that clinical indicators can be used by clinicians to monitor practice standards and to effectuate change in system of care and clinician behavior. However, other studies showed that some indicators, frequently used as a measure of quality, have no relationship with quality, and that ranking of hospitals does not quantify the potential gains that could be achieved [64-66].

The main goal is to use the indicators for internal comparison and internal use, by comparison within an ICU over time and by comparing with other ICUs on a national level. However, this benchmarking will be performed for a particular ICU compared to anonymous other ICUs and data will not be available for the public. Next to this internal use of indicators, some of the indicators may be suitable for external reporting. The Dutch Health Care Inspectorate has defined a hospitalwide set of performance indicators in 2003 [67]. Two indicators in the Dutch set match those used in this study: "duration of mechanical ventilation" and "availability of intensivists." Hospitals are asked to report about these indicators in 2004 over the past year. The Health Care Inspectorate uses these indicators as an instrument for their supervision and monitoring of health care.

The indicator set currently identified can be used both to measure and to improve quality of care delivered in ICUs. Feedback of information on the indicators aims to

guide management of care. Feedback on the indicators and comparison with other sets in time may stimulate improvement in quality of care for doctors, nurses, and other health care workers. Comparison within an ICU over time will be more easy to interpret and less susceptible to bias and differences in case mix. For comparison between ICUs, case mix plays a major role. For example, a method to make differences in mortality rate easier to interpret is to correct for severity of illness by using standardized mortality ratios. With other indicators, case mix should also be considered.

At present, analyses are being developed to relate the results of different indicators and to improve insight in the validity of the final set. The set of indicators gives a relatively quick view of the quality of care in individual ICUs. However, computerized assistance is necessary to limit the registration workload.

This study reflects the first step of a promising initiative to use quality indicators in improving the quality of care in Dutch ICUs. For effective monitoring of intensive care quality and to identify areas of improvement, we aim to implement this set of indicators in all Dutch ICUs. Because there is no legal obligation to register indicators in the ICUs, this registration should be highly supported in the field of ICUs to obtain maximal effect. This set is developed in close cooperation with the Dutch National Society of Intensive Care Medicine, which promotes support for further implementation of the set.

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