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S.M. Jakob
H.U. Rothen

Intensive care 1980–1995: change in patient characteristics, nursing workload and outcome

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S.M. Jakob · H.U. Rothen (✉)
Division of Intensive Care,
Department of Anesthesia and Intensive Care, Inselspital, CH-3010 Berne, Switzerland
FAX: +41 (31) 632 9644

Abstract *Objective*: To assess temporal changes in patient characteristics, nursing workload and outcome of the patients and to compare the actual amount of available nursing staff with the estimated needs in a medical-surgical ICU.
Design: Retrospective analysis of prospectively collected data.
Setting: A medical-surgical adult intensive care unit (ICU) in a Swiss university hospital.
Patients: Data of all patients staying in the ICU between January 1980 and December 1995 were included.
Interventions: None.
Measurements and results: The estimated number of nurses needed was defined according to the Swiss Society of Intensive Care Medicine (SGI) grading system: category I = one nurse/patient/shift (= 8 h), category II = one nurse/two patients/shift, category III = one nurse/three patients/shift. An intervention score (IS) was obtained, based on a number of specific activities in the ICU.
There was a total of 35,327 patients (32 % medical and 68 % postoperative/trauma patients). Over time, the number of patients per year increased (1980/1995: 1,825/2,305, $p < 0.001$) and the length of ICU stay (LOS) decreased (4.1/3.8 days, $p < 0.013$). There was an increase in the number of patients aged > 70 years (19 %/28 %, $p < 0.001$), and a decrease in the number of patients < 60 years (58 % /41 %, $p < 0.001$). During the same time period, the IS increased two-fold. Measurement of nursing workload showed an increase over time. The number of nursing days per year increased (1980/1995: 7454/8681, $p < 0.019$), as did the relative amount of patients in category I (49 %/71 %, $p < 0.001$), whereas the portion of patients in category II (41 %/28 %, $p < 0.019$) and category III (10 %/0 %) decreased. During the same time period, mortality at ICU discharge decreased (9.0 %/7.0 %, $p < 0.002$).
Conclusions: During the last 16 years, there has been a marked increase in workload at this medical-surgical ICU. Despite an increase in the number of severely sick patients (as defined by the nursing grading system) and patient age, ICU mortality and LOS declined from 1980 to 1995. This may be ascribed to improved patient treatment or care. Whether an increasingly liberal discharge policy (transfer to newly opened intermediate care units, transfer of patients expected to die to the ward) or a more rigorous triage (denying admission to patients with a very poor prognosis) are confounding factors cannot be answered by this investigation.
The present data provide support for the tenet that there is a trend toward more complex therapies in increasingly older patients in tertiary

care ICUs. Calculations for the number or nurses needed in an ICU should take into account the increased turnover of patients and the changing patient characteristics.

Key words ICU management · ICU mortality · Intervention scoring system · Nursing workload · Personnel management · Nursing staff · Nursing care · Survival rate · Severity of illness index

Introduction

Today up to one-fourth of acute care hospital costs and close to 10% of all health care costs are consumed in critical care units [1]. In the USA, this results in expenditures up to 1% of the gross national product [2]. Even though, probably based on a slightly different medical system, the costs of critical care may be less in European ICUs, such units still consume an important proportion of a hospital budget [3]. Despite such high costs, astonishingly little is known about temporal trends of patient structure, patient outcome and nursing workload in the ICU.

Typically, an ICU is characterized by both a high workload per patient (being a main factor of high cost) and high mortality (mortality may be considered as one extreme of output measure). Estimates of nursing workload include, e.g. the therapeutic intervention scoring system (TISS and TISS-28 [4, 5]) and the time-oriented score system (TOSS [6]). Since its introduction in 1974, the TISS has been used to classify patients in ICUs: for the severity of illness, for establishing the patient-nurse ratios [7], for assessing current utilization of hospital's intensive care beds, and for establishing future needs and numbers of ICU beds. In Switzerland, a more simple system assigning one of four different categories to each patient is used. For about 20 years, application of this system has had one prerequisite, as required for by the Swiss Society of Intensive Care Medicine to recognize a unit within a hospital as an ICU. This system allows for classification of patients with regard to estimated nursing workload [8]. Based on that system, the total amount of nurses needed per time unit may be calculated easily.

Even though mortality as an outcome measure has often been challenged [9], this measure remains one of the key parameters. The reasons are the simplicity of its definition and the ease of obtaining results (at least with respect to ICU or hospital mortality). Furthermore, mortality is very often the only outcome variable that has already been registered for more than 10 years.

Combining both nursing workload and outcome may result in a simple measure of performance of an ICU. It may be hypothesized that an increase in workload, combined with an unchanged or even decreased mortality, reflects improved performance. Although such a comparison certainly reflects only an initial approach to an estimation of efficiency and effectiveness [10] or change in quality of care [11], we considered it worthwhile to look at, because it reflects one of the few possibilities to analyse temporal changes in the ICU over the last 15 to 20 years.

Investigations showing such temporal trends in terms of patient characteristics, patient outcome, and nursing workload are, however, rare. Most of them deal with data covering 10 years at best. In contrast, we were able prospectively to collect data over an observation period of 16 years. Thus, the objective of our analysis was to evaluate temporal changes in patient characteristics, ICU mortality and nursing workload between 1980 and 1995. Furthermore, we determined whether the number of nurses working at our adult medical-surgical ICU changed in accordance with the increase in nursing workload.

Materials and methods

This ICU is located in a tertiary care, 900 bed university hospital. The ICU consists of three surgical units and one medical unit with 6 beds for adults each. Since 1978, a minimal data set has been collected routinely by the nurses. This set includes patient's age, length of stay (LOS), ICU mortality, and a number of diagnostic and therapeutic measures (Table 1). A severity of illness score (SAPS-II, [12]) has only been calculated routinely since 1995, however.

Each patient is categorized daily according to the grading system of the Swiss Society of Intensive Care (SGI): category I = one certified nurse/patient/shift (= 8 h), i.e. three nurses/patient/day, category II = one nurse/two patients/shift, category III = one nurse/three patients/shift. In 1991 another category (Ia = 4 nurses/patient/day, i.e. 1.3 nurses/patient/shift) was added by the SGI to take into account an increase in nursing workload for some patients. A number of specific activities in the ICU were weighted according to the TISS [4]. The sum of these TISS points per year was calculated. It is called Intervention score (IS). The original TISS could not be calculated because not all variables of the TISS had been recorded on a regular basis in this ICU. IS had so far not been evaluated. Although there should be an adjustment in the relative weights of the individual variables if the number of items of a specific score is changed, we decided not to do so in order to have at least some comparability with TISS.

Furthermore, the annual number of nurses was recorded. This information was used to calculate the total amount of nursing days available per year. For this purpose, a total of 220 working days per year was assumed per certified nurse. For nurses in training, 178 working days per year were used for further calculations. This second, smaller number reflects a correction factor of 0.8 due to training activities [8]. In our unit, there are on average 47% non-certified nurses.

The number of nurses needed per year was calculated as the sum of estimated nursing days per year (according to the numbers of patients in the different SGI categories), divided by 220 (number of working days per year).

Table 1 Interventions recorded and their weighting according to TISS [4]. *Note:* tracheostomy includes surgical and percutaneous dilatative procedures, as well as minitracheostomies

Intervention	Points
Total parenteral nutrition	2
Chest tube	2
Haemodialysis	2
Invasive arterial monitoring	3
Tracheostomy	3
Ventilator	3
Pulmonary arterial catheter	4
Intracranial pressure	4
Defibrillation	4
Intra-aortic balloon pump	4
Peritoneal dialysis	4

The occupancy rate (calculated as patient days/yearly available beds) increased from 85 % (1980) to 100 % (1995). We calculated the nursing days per patient as sum of days in the ICU (inluding both the day of admission and of discharge) minus one; if the day of admission was also the day of discharge, the LOS was calculated as 1 day. The mean LOS/year was calculated as number of patient days/number of patients.

For all calculations, the SYSTAT computer software package (SYSTAT 5.0, SYSTAT, Evanston, Ill., USA) was used. The Pearson correlation coefficient was used to analyse changes of individual variables over time.

Results

A total of 35,327 patients (32 % medical and 68 % postoperative/trauma patients) were included in this analysis. For 1995, this correponds to 3.8 % of all ICU admissions and 4.8 % of all ICU nursing days in Switzerland (J.C. Chevrolet, personal communication). Over time, there was an increase in the number of patients per year (1980/1995: 1825/2305, $p < 0.001$ and a decrease in LOS (4.1/3.8 days, $p < 0.013$) (Fig. 1). In 1995, the hospital as a whole as well as the ICU treated aproximately 33 % more patients than in 1980. The number of nursing days decreased in the hospital (–3 %), whereas it increased in the ICU (+ 10 %), indicating a significantly more decreased LOS of the patients in the hospital, compared to the one of the patients in the ICU. In 1980, the number of patients admitted to the ICU was 7.4 % of the total number of hospitalized patients. This figure increased slightly to 7.7 % in 1985, 7.9 % in 1990, and it again decreased to 7.6 % in 1995. There was an increase in patients aged > 70 years (19 %/28 %, $p < 0.001$), and a decrease in patients < 60 years (58 %/41 %, $p < 0.001$) (Fig. 2). For comparison, note that the age distribution of the Swiss population did not change markedly throughout the years (1980: > 70 years: 9.5 %, < 60 years: 81.6 %; 1995: > 70 years: 10.4 %, < 60 years: 80.5 %). During the same time period, ICU mortality decreased (9.0 %/7.0 %, $p < 0.002$) (Fig. 1). The total hospital mortality was not recorded.

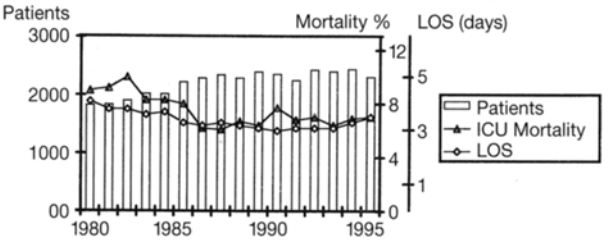

Fig. 1 Number of patients, mortality and LOS in 1980–1995

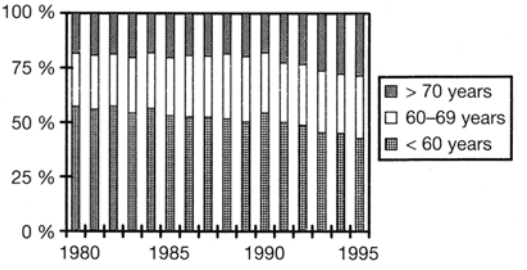

Fig. 2 Distribution of patient ages during 1980–1995

The number of the nurses increased from 86 (1980) to 121 (1995). The number of patients/nurse per year decreased slightly (1980/1995: 21.2/19.1). Measurement of nursing workload showed an increase over time. The number of patient days per year increased (1980/1995: 7454/8681, $p < 0.019$), as did the relative amount of the patients in category I (49 %/71 %, $p < 0.001$), whereas the amount of patients in category II (41 %/28 %, $p < 0.019$) and category III (10 %/0 %) decreased (Fig. 3).

Between 1980 and 1995 the IS/patient increased (Fig. 4). Considering the specific interventions, there was an increase mainly in activities concerning invasive cardiovascular monitoring and respiratory therapy. As an example, the number of arterial canulas inserted increased from 1980 to 1995 by 400 % and the number of pulmonary arterial catheters by 600 % (Table 2). The tracheostomies performed (including minitracheostomies) increased from 1980 to 1995 by 230 % and the ventilator days from 1980 to 1995 by 150 % (Table 2). In 1980, about the same number of patients was treated by (intermittent) hemo- and peritonealdialysis (23 vs 27). In 1995, the number of patients treated by hemodialysis had increased to 94, whereas peritonealdialysis was performed in 12 patients only. In the same time period, the number of patients on total parenteral nutrition (TPN) decreased from 341 to 226.

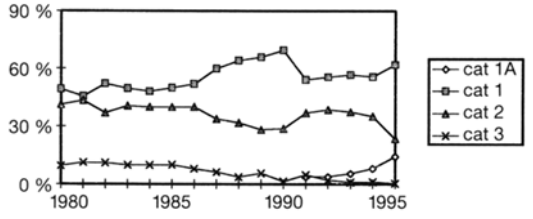

Fig. 3 Distribution of SGI categories from 1980 to 1995

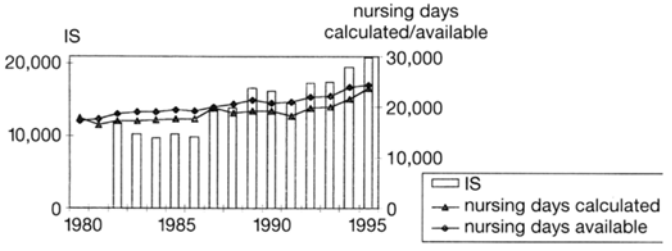

Fig. 4 IS, nursing days available and calculated, respectively, in 1980–1995

Table 2 Interventions 1980–1995. *Note:* tracheostomy includes surgical and percutaneous dilatative procedures, as well as minitracheostomies

Year	1980	1985	1990	1995
Invasive arterial monitoring	475	639	869	1498
PA catheters	34	29	55	204
Tracheostomies	71	57	114	165
Ventilator days	2494	2332	3842	4461
ICP	13	65	56	30
Haemodialysis and peritoneal dialysis	50	28	38	105

Discussion

The main finding of this study is a marked increase in nursing workload during the last 16 years. From 1980 to 1995, the number of patients per year increased, the age of patient increased, and the number of nursing days increased. Interestingly, the mortality at ICU discharge slightly decreased during the same time period.

There are several possibilities to measure the nursing workload in the ICU: concerning nursing categories, as used in this study, the nurses decide how time consuming a patient is. Thus, the problem with nursing categories is threefold: (a), this system results in relative units which are not easily comparable between ICUs of different size and hospitals; (b), the categories can change during the day, so each patient should be classified several times a day; and (c), with increasingly complex patients, the introduction of higher categories (i.e. Ia) becomes necessary, the definition of which can be difficult. The therapeutic intervention scoring system (TISS) and similar scores claim to measure the nurses' work directly. Activities such as organizational activities, indirect patient care, etc. are, however, not included in such measures. Moreover, the recorded activities may consume different amounts of time in different ICUs. A solution of this problem could be the time-oriented scoring system (TOSS [6]). This scoring system assigns time to the different activities of the TISS. A more extensive measure of the nursing workload would include all the time-consuming factors of patients on ICUs: severity of illness/nursing category, LOS (the shorter the time the patients are in the ICU, the more admissions and discharges occur), TISS, TOSS or other interventions scores.

Several very time consuming activities are neither reflected by TISS, TOSS, nor nursing categories (e.g. basic nursing activities in multiple-trauma patients who have to be cared for with special elevators, etc., transport to CT scans or MRI, and social contacts with the patients or their relatives). Despite that, TISS may correspond well to hospital costs, as has been recently published as preliminary data [13]. Another approach to this problem has been proposed by Miranda and coworkers [5]. They divide the work of the nurses into six categories: (a) activities concerning a simplified TISS (TISS-28 items); (b) patient care activities not in TISS-28; (c) indirect patient care; (d) organizational activities; (e) personal activities; (f) other. With increasing values of TISS-28 there was an increase in the acitivities of the category (a) and a decrease in activities of the category (e). In patients with the lowest TISS-28 values, more time was spent for activities of the category (b). In the evening shift, more time was spent for patient care activities and less time for activities of the category (e). Moreover, there was no correlation between the time needed for work concerning categories (c) and (d) (22–26.7 % of the total work) and TISS 28. Other authors have found a linear relationship between the total nursing time and the TISS [14], however.

Our data show that on average, the number of available nurses is very close to the number of nurses needed according to the patients treated (Fig. 4). On the days when there is a high turnover of patients and during holidays, there may be too few nurses available, although compared to others our patient/nurse ratio may be rather low [8]. Moreover, the twofold increase in the Intervention score, the decrease in LOS and the increased age of the patients all suggest that the workload per unit of time has increased significantly. The above-mentioned factors should be taken into account when the number of nursing personnel necessary for an ICU is calculated.

In our unit, the recorded interventions have increased as a whole and per patient (Table 2, Fig. 4). The activities that increased most were invasive cardiovascu-

lar monitoring and respiratory care. Other interventions such as peritoneal dialysis or total parenteral nutrition decreased. This may reflect new therapeutic approaches (e.g. continuous haemodialysis/haemofiltration, early enteral nutrition). Factors that correspond to the outcome of critically ill patients are the underlying disease [4, 15–18], the severity of illness [12], the amount of time for patient care [4], and patient age [4, 15–18].

One of the few outcome measures available from our data is ICU mortality. This measure significantly decreased over time. A similar pattern was found in LOS. In contrast, the mean age of the patients increased. This may be ascribed to improved patient treatment/care. Whether an increasingly liberal discharge policy (transfer to newly opened intermediate care units, transfer of patients expected to die to ward) or a more rigorous triage (denying admission to patients with a very poor prognosis) are confounding factors cannot be answered by this investigation. Other outcome measurements, such as infection rates, readmissions, late mortality (30 days, 6 months, 1 year), quality of life or "clinical performance" [19] were not recorded in this study.

When comparing our ICU to the average of the Swiss university ICUs [20], there was a shorter LOS (3.2 vs 4.4 days), although the ratio of ventilator days/patient days was higher (0.31 vs 0.26). Comparing our ICU to the average of more than 2870 ICUs in the United States [21], our patients are younger (37 % over 65 years vs 58 %), and there are marked differences in several diagnostic or therapeutic interventions (haemodialysis – without continuous modes – 2 vs 3.9 %, pulmonary arterial catheters 1.3–2.3 % until 1994, 8.9 % in 1995 (mainly due to changed policy in cardiac anaesthesia) vs 20 %, invasive arterial monitoring 59 vs 39 %). Such differences may be explained by both a different patient mix and different diagnostic or therapeutic approaches.

Our study has several limitations: (1) the percentage of work of a certified nurse that can be done by a non-certified one has been taken from the literature [8] and has not been validated in our ICU; the values of the calculated available nursing days are therefore only estimates; (2), the recorded interventions are only part of the original TISS, which means that it may not reflect nursing workload. A direct comparison with other units is not possible. However, because the same data were collected throughout the years, we believe that the interpretation of our data is still meaningful.

In summary, we conclude that the nurses' workload has increased significantly over the last 16 years. Furthermore, the basis today of calculating the number of nursing personnel needed in our ICU only partly takes their performance into account. We suggest that a severity of illness score, an intervention score, and the LOS should be included in a measure of performance of a distinct ICU. Finally, the data presented provide support for the tenet that there is a trend toward more complex therapies in increasingly older patients [22].

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