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ORIGINAL

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Measuring the nursing workload per shift in the ICU

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Abstract *Purpose:* In the intensive care unit (ICU) different strategies and workload measurement tools exist to indicate the number of nurses needed. The gathered information is always focused on manpower needed per 24 h. However, a day consists of several shifts, which may be unequal in nursing workload. The aim of this study was to evaluate if differences in nursing workload between consecutive shifts can be identified by a nursing workload measurement tool. *Methods:* The nursing activities score (NAS) was registered per patient for every shift during a 4-week period in a prospective, observational research project in the surgical-pediatric ICU (SICU-PICU) and medical ICU (MICU) of an academic hospital. *Results:* The NAS was influenced by the patient characteristics and the type of shift. Furthermore, the scores were lower during night shifts, in weekends and in MICU patients. Overall, the mean NAS per nurse per shift was 85.5 %, and the NAS per 24 h was 54.7 %. *Conclusion:* This study has shown that the nursing workload can be measured per working shift. In the ICU, the NAS differentiates the nursing workload between shifts, patients and units.

Keywords Nursing · Workload · Shift · Intensive care unit · NAS

Introduction

The nursing shortage is a global problem and challenge. Health authorities make considerable efforts to resolve this major and perilous condition [1]. In addition, the overall expenditure of health care continues to increase and personnel costs contribute considerably towards this expense. Particularly in the Intensive Care Unit (ICU), the cost of the nursing workforce is substantial, largely outnumbering the investment in technology and equipment. Health care organizations are increasingly focusing on cost control and efficiency, and therefore, staffing levels in ICUs are in the spotlight and carefully analyzed. However, nurse staffing requirements are difficult to define. Every patient requires different nursing needs, which may change rapidly in time. During the day, the activity in the unit peaks, but staffing cannot be easily reduced at night because of the same patient load and the possibility of emergency admissions.

Furthermore, understaffing, a lower nurse to patient (N/P) ratio and high workload in the ICU may result in augmented cross-transmission of nosocomial pathogens

among patients [2, 3], growing MRSA spread [4, 5], more postoperative complications, raised resource use, increased length of stay (LOS) [6–10] and higher mortality rates [11, 12]. In addition, not only patients may be harmed, but also the nursing staff may suffer from burnout [13, 14], affecting the intent to leave and staff turnover [13]. Nevertheless, overstaffing can lead to a dissipation of funds, which is unacceptable in times of rising demand for efficiency savings. Obviously, determining the right level of staffing in the ICU is delicate and challenging.

Over the past 30 years, several patient-classification or nursing workload measurement tools (NWMT) have been implemented, with the goal to optimize the utilization of nursing resources and to enhance comparisons between various ICUs [15–26].

The Therapeutic Intervention Scoring System (TISS) is the most frequently referenced NWMT and was published in 1974 [27]. This original TISS with 57 items was modified and updated twice (TISS-76 and TISS-28) [15, 20], and evolved from a severity of illness estimate to a NWMT with clear N/P ratios.

Nevertheless, TISS has constantly been criticized because weighting was based upon consensus and because of the assumed correlation between the type and number of therapeutic interventions in the ICU, severity of illness and nursing workload.

The Nursing Activities Score (NAS), partially originating from TISS-28, faces these criticisms [26]. The NAS consists of 23 items, with 5 items being divided into 2 to 3 subitems. All weights are based on the real-time assessment of duration of the nursing activities. Hence, the score is independent of the severity of illness. The NAS is a percentage and expresses the time spent by nurses in their care of the patients. The sum of scores of the 23 items ranges from 0 to 177 % (or about 1.8 nursing full-time equivalents per 24 h). The NAS is validated for measuring the nursing workload per 24-h period, but the daily score of certain items depends on their performance per shift. It is therefore recommended to record these items during each shift to estimate the total score of these items over 24 h since retrospective scoring may prove to be difficult [26].

Overall, all NWMTs are established for daily use. However, nursing workload often differs in the consecutive shifts throughout a day. In many ICUs N/P ratios are fixed per shift. Morning shifts usually count the most nurses, whereas the fewest nurses are present at night. Receiving information from a NWMT per day is not really helpful for the allocation of nursing staff shift by shift.

To our knowledge, the NAS is the only workload indicator with the ability to assess the nursing workload per shift. The aim of this study is to evaluate whether differences in nursing workload between consecutive shifts can be identified using the NAS.

Patients, materials and methods

Setting and patients

A prospective, observational research project was performed in the surgical-pediatric ICU (SICU-PICU) and medical ICU (MICU) at Ghent University Hospital. All patients admitted during a 4-week period in 2004 were included. The MICU has 14 beds. The surgical-pediatric ICU consists of four subunits with 28 beds. The pediatric patients are predominantly cohorted in unit four, but depending on the inflow, more children can be hospitalised. The N/P ratio is constant throughout the three consecutive shifts, which is one nurse for two patients, regardless the occupancy rate or the care demand. One nurse could look after two adult patients, two pediatric patients or one of each.

Instrument

The authors of the NAS have described three conditions that need to be fulfilled to complete the NAS per shift instead of per day. Firstly, a large number of shifts should be included; secondly, data should be collected and analyzed per shift, independently from the other shifts, and thirdly, the definitions of the items cannot be altered.

All three conditions are met. However, we must remark that some wording has been modified to obtain a better understanding and correct registration. This happened in close consultation with the first author of the NAS (DRM). The following phrases were adjusted: The description of time “in any shift” is replaced by “per shift” in every subitem. Subitem 6b, “Performing procedure(s) more frequently than three times per 24 h,” is replaced by “more frequently than one time per shift.” Item 13, “Fluid administration >3 l/m^2/day,” is replaced by “Fluid administration >1 l/m^2/shift.” All other (sub)-items remained untouched, as did the weights of the individual items.

Twenty-four hours were divided into three shifts. The morning shift began at 07:00 hours and lasted till 14:00 hours, then the evening shift started and ran on until 22:00 hours into the night shift, which ceased at 07:00 hours. Although these shifts have slightly different durations, this was considered irrelevant for analysis.

Nurses on duty started scoring upon arrival of the patient. In every shift a new scoring form had to be completed until the patient was discharged. The score of the 23 items was calculated per patient during each shift unless the patient was present less than 4 h in the first/last shift. The rationale behind this is that patients who were present for less than a complete shift, but more than 4 h, counterbalance the excluded ones that were only in the unit a couple of hours. No correction factor was applied when patients went to the operating room temporarily.

The mean workload/nurse is based on the total NAS points achieved in the unit and the number of nurses. This mean NAS/nurse/shift takes into account all valid NAS scores and the number of empty beds. Each nurse can receive 100 NAS points, which means a 100 % consumption of the nurse's time.

The original NAS or NAS/24 h was derived from the available NAS forms per shift of each patient. The 24-h period started at 7:00 hours. NAS/24 h could only be computed if the patient stayed at least 12 h. The three individual shift scores were not just summed up to the overall 24 h score, but determined by counting the original NAS weights of the highest performed (sub)items, as described in the original publication.

Training of the nursing staff and support

The NAS was registered by the nurse responsible for that particular patient. The weights of each (sub)item were concealed to avoid bias. All nurses attended a training session prior to the study or were supervised during their first NAS registration.

During the first week of the study, the responsible research fellow (DD) was in the hospital to support the nurses' cooperation. Moreover, he was available by telephone 24/7.

Severity of illness

Acute Physiology and Chronic Health Evaluation II (APACHEII) and Simplified Acute Physiology Score II (SAPSII) were recorded for adult patients after 24 h of admission. Severity of illness (PRISM/PIM2) was not routinely estimated for pediatric patients.

Statistical analysis

Statistical analyses were undertaken with the Statistical Package for the Social Sciences (version 16.0, SPSS Inc., Chicago, IL) using non-parametric tests. For comparison between two unpaired groups, the Mann-Whitney *U* test was used; among three unpaired groups, the Kruskal-Wallis test. The significance level was set at $\alpha = 0.05$. A p value <0.05 was considered statistically significant.

Ethical committee

Permission to conduct this study was obtained from the local ethics committee.

Results

Response rate

A total of 3,486 shifts were monitored. The response rate was 93 %, of which 3.7 % were invalid.

Nursing staff

The number of FTE nurses per ICU bed was 2.9.

Occupancy rate

The overall occupancy rate was 93.5, 92.5 % in the MICU and 93.9 % in the SICU-PICU, respectively.

Demographics

During the study period, 36 pediatric, 91 medical and 128 surgical patients were admitted. The demographics are described in Table 1. The median LOS in the ICU was 2.4 (0.1–121.1), 2.1 (0.1–108.9) and 2.0 (0.1–57.1) days for PICU, MICU and SICU patients, respectively. Patients were predominantly admitted and discharged during the evening shift. Four medical PICU patients were admitted via the operation room after they had received a minor intervention (e.g., a Hickman line). Despite this surgical treatment, their type of admission was classified as medical.

Severity of illness

SICU patients had a mean APACHE II/SAPS II of 14.4/29.1 (±6.2/13.8). MICU patients had a mean APACHE II/SAPS II of 17.9/35.0 (±8.9/17.6). Mortality was highest among MICU patients (13.2 %), followed by PICU (8.3 %) and SICU (7.0 %) patients.

Nursing activities score

Per patient per shift

The mean NAS/shift was 47.0, 46.3 and 41.6 %, respectively, for the morning, evening and night shift. The NAS was significantly lower during the night shift in comparison to the morning and evening shift ($p < 0.001$). Similar findings were found when SICU and MICU patients were analyzed separately. In pediatric patients, only the NAS during the morning shift differed significantly from the night shift ($p = 0.002$).

Table 1 Demographic characteristics of the study population

	PICU ($n = 36$)	MICU ($n = 91$)	SICU ($n = 128$)
Sex (% ♂/♀)	50/50	60.4/39.6	64.8/35.2
Age (in years)			
Mean	60.6[a]	56.9	58.1
Length of stay (days)			
Median (IQR)	2.4 (0.1–121.1)	2.1 (0.1–108.9)	2.0 (0.1–57.1)
Origin (%)			
Operating room	38.9	9.9	72.7
Ward	11.1	37.4	9.4
A and E	11.1	34.1	7.0
Different ICU	0	9.9	1.6
Other hospital	38.9	8.8	9.4
Type of admission (%)			
Elective surgery	25.0	3.3	43.8
Emergency surgery	5.6	7.7	32.0
Medical	69.4	89	24.2
Destination (%)			
Ward	86.1	76.9	86.7
Different ICU	NA	2.2	3.9
Other hospital	2.8	6.6	2.3
Deceased	8.3	13.2	7.0
Home	2.8	1.1	0

PICU Pediatric Intensive Care Unit, *MICU* Medical Intensive Care Unit, *SICU* Surgical Intensive Care Unit, *A and E* accident and emergency, *NA* not applicable

[a] In months

Per nurse per shift

Overall, 85.5 % of the the nurse's time is consumed. The mean NAS/nurse differs significantly between the two ICUs (SICU-PICU 87.8 %, MICU 82.5 %, $p = 0.001$). When comparing the use of the nursing time between shifts, no differences could be found between the morning and the evening shift (89.9 vs. 87.6 %, $p = 0.430$), but both shifts differed significantly from the night shift (78.9 %, $p < 0.001$). These findings were identical for both ICUs (Fig. 1).

When comparing the two ICUs with regards to the mean NAS/nurse, no difference was noted within the morning and the evening shift, but the MICU had a significantly lower mean NAS/nurse during the night shift (SICU-PICU 81.0 %, MICU 71.8 %, $p < 0.001$) (Fig. 2).

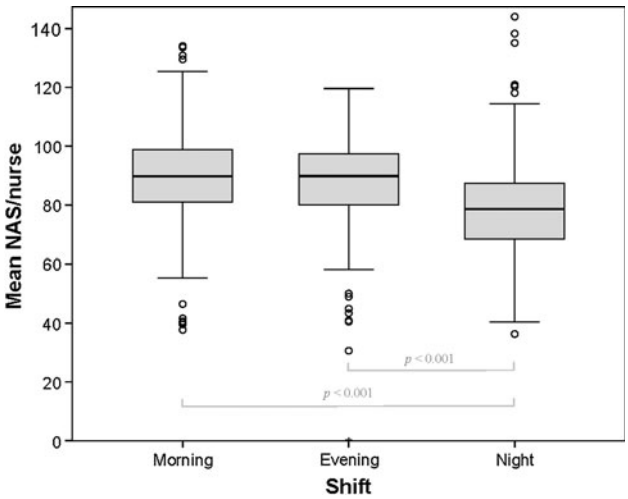

Fig. 1 Box plots representing the mean NAS per nurse per shift. *NAS* Nursing activities score

Week versus weekend

If the mean NAS/nurse during the week was compared with the scores during the weekend, we determined a significantly higher score on weekdays for morning (90.6 vs. 85.0 %, $p = 0.041$) and evening shifts (90.4 vs. 79.9 %, $p < 0.001$). The difference between the night shifts was not statistically significant (78.4 vs. 73.5 %, $p = 0.085$) (Fig. 3).

Workload per 24 h

A total of 1,280 original NAS scores could be derived from all records. On average, the NAS was 54.7 % per patient. Splitting up according to patient category resulted in a NAS of 57.0, 53.5 and 54.6 % for PICU, MICU or SICU patients respectively. There was only a significant difference between the PICU and MICU NAS ($p = 0.042$).

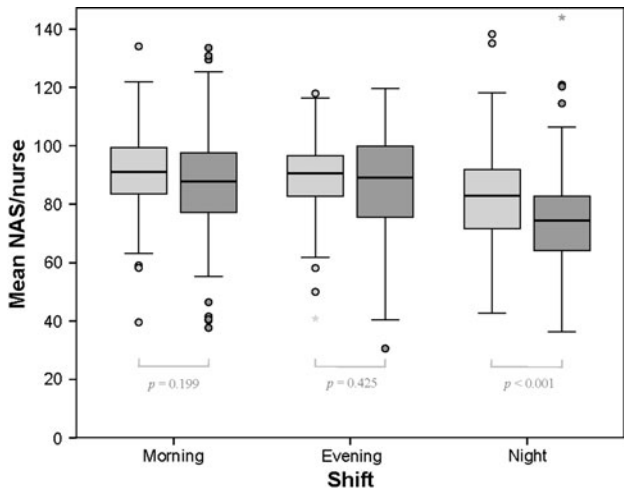

Fig. 2 Box plots representing the mean NAS per nurse per shift for the SICU-PICU (*light grey*) and MICU (*dark grey*). *NAS* Nursing activities score

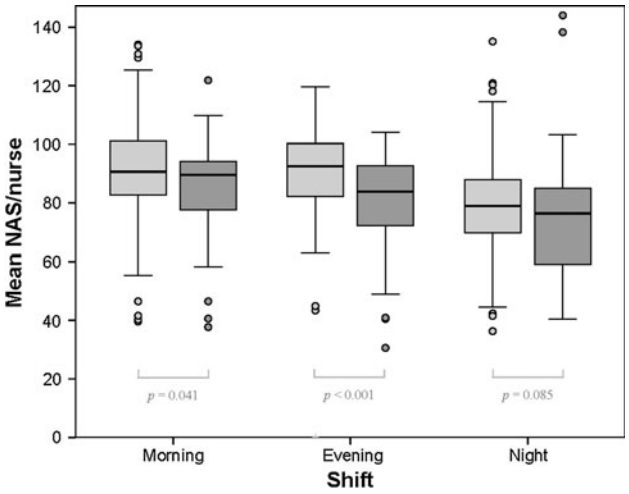

Fig. 3 Box plots representing the mean NAS per nurse per shift: week (*light grey*) versus weekend (*dark grey*). *NAS* Nursing activities score

Discussion

In this study, demographics and clinical findings were similar to previously published articles in the ICU and PICU field [28–32]. The mortality rates in the MICU and SICU are comparable to those in other studies [28, 29]. The severity of illness scores are in line with those in the literature [28, 30, 33]. Additionally, MICU patients were noted to have higher SAPSII scores, but generated a lower amount of nursing workload expressed by the TISS-28 [33] or NAS, supporting that illness severity measures should not be used for the purpose of assessing nursing workload.

This study is the first that has attempted to quantify the nursing workload per shift using the NAS and has proven its feasibility, respecting the three conditions, although NAS weightings are computed for 24-h periods [34].

The NAS measures the consumption of nursing time in the ICU. Some ICUs admit patients with mixed pathologies, whereas other ICUs have a uniform population: surgical, medical, neurosurgical, liver failure, burns or pediatrics. The NAS is composed of different (sub)items, reflecting the ICU nurse's job in all aspects (e.g., monitoring, administration of medication, hygiene procedures, support of patient and relatives, etc.). It is plausible that some (sub)items are more frequently scored in one type of patient, although this was not analyzed in this study. The advantage of these items with subdivisions is that the nursing workload can be quantified more accurately. In the current study, we applied the NAS on both adult and pediatric patients. To our knowledge, this is the first time the NAS has been implemented in a pediatric setting.

Some patients are not present in the unit during the entire shift. Some arrive after the start, while others are discharged before the end of a shift. In order not to lose the valuable data of these patients, a solution was found. Patients present for less than a complete shift, but more than 4 h, were considered to be there the entire shift, whereas patients present for less than 4 h in a particular shift were excluded from the analysis. In this way both groups counterbalance each other. Concern could rise about extremely unstable patients who die in their first hours after ICU admission. These patients are responsible for an enormous workload. However, in our study population nobody died within 10 h after admission.

Three NAS variations are currently operational, namely the NAS/shift, which is the NAS score produced by a patient in a particular shift, the mean NAS/nurse is the average workload per nurse in the unit, and the NAS/24 h is the original instrument reflecting the nursing workload throughout the day.

The nursing workload may fluctuate from patient to patient and from shift to shift, and so does the NAS/shift. Night shifts generate less nursing workload in comparison to morning and evening shifts. Within the night shift, a distinction has been noted between MICU and SICU-PICU. MICU patients required less nursing care at night, resulting in a lower mean NAS/nurse. Morning and evening shifts on weekends are less stressful than weekdays, possibly because elective surgery is not performed. Nevertheless, morning and evening shifts during weekends still remain busier than night shifts.

Out of the NAS/shift, the NAS/24 h was composed. The PICU, MICU and SICU NAS/24 h ranged between 53.5 and 57.0 %. On average the NAS/24 h was 54.7 %, which was lower than the NAS (66.4, 72.9 %) in two Brazilian studies [31, 35]. No straightforward explanation can be found for this difference, apart from normal variation between centers. No other studies are available for comparison.

The present study has some limitations. First, the nursing workload is monitored in two units, one of which is a combined surgical-pediatric unit. Because the focus of this study project is to quantify the workload per nurse each shift, the individual NAS/shift scores are averaged per unit. In some units, both surgical and pediatric patients are nursed. Therefore, mean scores are transcending the type of patient. As a consequence, it is not possible to explore how both patient types influence the mean NAS per shift. Second, the severity of illness score (PRISM/PIM2) was not routinely assessed for pediatric patients. Comparing the pediatric study population might therefore be harder. Third, depending on the focus of the study (unit vs. patient) and in order to prevent the loss of data (e.g., if a patient is only present for a few hours in a particular shift), it may be appropriate to use a scoring form per bed space per shift instead of changing the form between two consecutive patients within the same shift. This could result in a more complete data set. Fourth, in this study, the weights used in the analysis of nursing work per shift were those allocated per item in the original NAS study, but these were developed for use per 24 h. Therefore, the reader should be aware that the weights of the respective items cannot be simply extrapolated to the use per shift in the daily practice, before specific research has been carried out. Fifth, no staff demographics, such as age, percentage part-time nurses, proportion specialized ICU training or average years of ICU experience, were considered in the data analysis. Given the high staff turnover in ICUs [36], this might be of importance for detailed benchmarking. Finally, this study took place in a single academic hospital and may not reflect the workload of nurses in other ICUs elsewhere in the world. Data were also collected in 2004. Working conditions might have evolved since then.

Further analysis is necessary to identify which items are primarily realized in each patient category and per shift. This article could add a new approach for the measurement of the nursing workload in the ICU. The objective measurement of nursing workload per shift may be beneficial for nurse managers to adjust the staffing requirements. Therefore, the nursing workload should be recorded routinely per shift using the NAS or other appropriate NWMT. The obtained results can then be translated into staff allocation. This could be realized directly through adjusted N/P ratios or rather as a guide how to allocate floating staff for multiple requesting ICUs. Subsequently, more insight could be gained for future research and practice. Additionally, it is of utmost importance to endeavor to develop a reliable computerized NWMT that involves estimations of prospective staffing requirements.

Conclusion

The aim of this study was to analyze quantitatively the differences of nursing consumption per shift using the NAS. Depending on what focus, variations in nursing workload could be revealed between shifts, type of patient, days of the week and ICUs. The obtained results indicate that the NAS, developed for measuring the nursing consumption on a daily basis, allows for an appropriate application on a shift-by-shift basis. The identified differences in nursing workload between shifts could not have been detected with any other existing NWMT. The NAS could therefore be a guide for harmonizing nursing resources with workload on a shift-by-shift basis.

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Conflicts of interest None of the authors has any potential conflict of interest to disclose.

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