Journal of Critical Care 54 (2019) 205–211

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

# Measuring the nursing workload in intensive care with the Nursing Activities Score (NAS): A prospective study in 16 hospitals in Belgium

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ARTICLE INFO

*Keywords:*
Nursing activities score
Workload
Intensive care unit
Shift

ABSTRACT

*Purpose:* The evaluation of nursing workload is a common practice in intensive care units (ICUs). It allows the calculation of an optimal nurse/patient ratio (N/P) which is a major challenge to ensuring the quality of care while controlling the costs of health care. The objectives of this study were, therefore, to evaluate the N/P ratio and to study nursing activities in intensive care in French-speaking Belgium.
*Methods:* The Nursing Activities Score (NAS) was prospectively recorded by shift for two periods of one month each in 16 French-speaking Belgian hospitals for a total of 316 ICU beds in 24 ICUs.
*Results:* We included 3377 patients in the study, of which 64% were medical (versus surgical). The results for 24-hour NAS (68.6%) were significantly different from the NAS per shift (Morning: 61.3%, Afternoon: 58.4%, Night: 55.0%). Outliers were significantly more prevalent among men and patients who died and outliers had longer stays in the ICU. Finally, mobilization-positioning and clinical-administrative tasks took, on average, more time for nurses in the ICU.
*Conclusions:* There is a significant difference in N/P ratio between the Belgian regulation (1/3) and the one calculated by the NAS (1/1.5). A systematic objective assessment of shift workload should be done to avoid N/P ratio differences in intensive care.



## 1. Introduction

In Europe, intensive care units represent 4.5% of hospital beds but consume 15% to 20% of total hospital expenditure. Nursing staff account for 60% of the direct costs of the Intensive Care Unit (ICU) budget [1]. Thus, an objective strategy to evaluate nursing activities is essential to optimize the use of resources and to avoid overstaffing, especially with current budget constraints [2-4].

In fact, insufficient nurse staffing is detrimental to the outcomes of intensive care patients [5,6]. Studies have demonstrated an association between inadequate nurse-to-patient ratio (N/P) and high mortality [6-11]; an increase in complications and adverse events [6,10,12-14]; an increase in nosocomial infections [12,15-18]; poor satisfaction of relatives and families of the patient [12,19,20]; an increase in pressure ulcers [12,21,22]; missing care [23]; poor pain management [24]; increased length of stay due to surgical complications [25]; and more musculoskeletal injuries and burnout injuries in nurses [26]. In addition, these factors increase hospital costs.

However, the optimal N/P ratio in intensive care has not been fully established and depends mainly on expert opinion [27,28] even though a 1/2 ratio was determined to be a threshold limit according to a recent observational study [11]. This ratio, however, varies from one country to another because it is dependent upon the organization of ICUs and the triage practices for admission [29]. In addition, in recent decades, ICUs have been constantly evolving by admitting older patients with multiple comorbidities [30,31]. This leads to more complex care and procedures with closer monitoring, leading to an increase in the nursing workload [32]. In Belgium, a 1998 federal law set arbitrarily, and without foundation, a minimum N/P ratio of 1/3 [33]. It is, therefore, important to evaluate the needs of the patient to allow for an adequate assessment of the optimal N/P ratio.

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https://doi.org/10.1016/j.jcrc.2019.08.032
0883-9441/

In recent decades, several tools for measuring the workload in critical care nursing have been published. Scales (e.g. TISS, TISS-28, NEMS) mainly evaluate the severity of disease and the complexity of therapeutic procedures [34-36] which are poorly correlated with the workloads of nurses [37]. There are also other scales (e.g. PRN, TOSS, OMEGA, NIC, SoPRA, VACTE, NRC11) that are only national instruments, with subjective weighting of items, and are seldom published [38-45]. The Nursing Activities Score (NAS) covers 81% of nursing activities and is independent of disease severity. In addition, the remaining 19% of activities (personal activities of nurses) are accounted for in the score. This retrospective scale specific to intensive care can be encoded by shift or by day (24 h). This tool has been validated in no <99 ICUs from 15 countries and is included in a large number of international publications [46]. It allows for an approach to the nursing workload that measures the nursing time consumed per patient. Comprised of 23 items, it includes both direct and indirect care. Each item representing a nursing activity is subject to a binary choice (for 18 items) or multiple choice (for 5 items). The score (per patient) is expressed as a percentage and varies from 0% to 177%. This represents the proportion of nursing time needed to provide care to the patient (100% = 1 nurse). The weighting of the items was done according to the "worksampling" method which is a reliable method resulting from industrial engineering, making it possible to measure action times without the inconvenience of timing.

The objectives of this study were, therefore, to evaluate the real N/P ratio and that obtained by the NAS, to compare the NAS score per 24 h and per shift, and to analyze the variability of nursing activities according to shift in intensive care units in French-speaking Belgium.

## 2. Patients, materials, and methods

### 2.1. Setting and patients

This was a prospective observational study that was conducted in 16 university and general hospitals in French-speaking Belgium for a total of 316 mixed ICU beds (surgical, medical, pediatric) [Appendix A]. All patients admitted during two 1-month periods: January 15 to February 15, 2018 (P1) and May 1 to May 31, 2018 (P2) were evaluated. These periods were chosen to compare data between winter and spring and outside school holidays in Belgium.

### 2.2. Instrument

The NAS scale used in this study has been translated, and adapted to Belgium, for use by shift. This version of the scale was published in a previous study by Bruyneel et al. and validated by Professor Miranda (author of the NAS scale) [47]. The score was encoded via a computer tool (Epimed Monitor®) at the end of each shift by nurses at the bedside. In our sample, nurses worked either in two shifts, 12 h during the day or 12 h at night, or in three shifts, mainly 8 h in the morning, 8 h in the afternoon, or 11 h at night. The score was encoded as soon as the patient was admitted to the unit until they were discharged.

### 2.3. Training of the nursing staff

The nurses were trained (theory and practical exercises) by the research team for one hour between March 2017 and November 2017 on the use of the validated scale [47]. Trainers used the same training materials for training at each site and a reference person from the study was available by phone 24/7. The tool and tutorial were distributed to all nurses and explanatory videos were available. In addition, a dozen nurses per hospital underwent further training to facilitate the implementation of the NAS and check the correct recording of data on a daily basis.

### 2.4. Included NAS data

The NAS score per 24 h was obtained by taking the maximum of each item recorded by shift [46]. Given the limited NAS data collected in Pediatric Intensive Care Units (PICUs), and to allow comparisons, we have grouped the NAS data from the morning and afternoon shifts into a single NAS day for these pediatric patients. Indeed, 82% of PICU NAS data were encoded in two shifts.

118 NAS records were excluded because the scores were not completely encoded.

### 2.5. Statistical analyses

For comparisons of asymmetric variables, the Mann-Whitney and Kruskal-Wallis tests were used. For symmetric variables, we used the ANOVA test and the chi-squared test for proportion comparisons. Statistical analyses were performed with Software for Statistics and Data Science (14.0, Texas) and XLSTAT (Addinsoft 2019, Long Island in NY, USA). A $p$ value <.05 was considered statistically significant.

Each NAS item is associated with a weighting defined in the original study (e.g., medication: 5.6%). In Table 2, average times per activity according to frequency and weighting are shown. This calculation also makes it possible to summarize the multi-choice items.

To calculate outliers (high NAS), two methods were used because no consensus has been found in the literature. First, the median was used as a reference. Second, the formula (75th percentile +1.5 * inter-quartile range) described by Pirson et al. was also calculated to determine large outliers [50]. The analysis of the variables influencing the workload of ICU care staff was conducted step-by-step to determine which variables had independent effects. Variables were selected from the recorded data and a previously published study [48,51].

### 2.6. Ethical considerations

A unique, anonymous number was randomly assigned for each patient and hospital institution included in the study. We obtained permission from all nursing directorates for the implementation and extraction of data. In addition, the company, Epimed Monitor, signed confidentiality agreements with all the hospital departments. Finally, all of the hospital ethics committees were consulted and we obtained the authorization of the local committees for the hospitals that requested it (P17/82_20/12; B325201734614). Due to the observational nature of the study and the anonymization of the data, the written consent of patients or relatives was not required.

## 3. Results

### 3.1. Sociodemographic characteristics

This study included 3377 patients, including 144 (4%) pediatric cases. The occupancy rate was 77.8% in winter and 70.8% in spring. The median (P25-P75) length-of-stay (LOS) was 2 days (1–5) during both periods of the study. On average, a nurse cared for 2.5, 2.8, and 3.0 intensive care beds in the morning, afternoon, and night shifts, respectively. All ICUs in this study were medical-surgical ICUs with half of the beds dedicated to cardiac surgery and 42% to neurosurgery (Table 1).

### 3.2. Nursing activities score

#### 3.2.1. By patient and shift

A total of 31,815 recordings by shift were encoded and 13,937 NASs per 24 h were calculated. All NAS medians by shift, except that of the NAS day, varied significantly from the NAS per 24 h (68.6%) (Fig. 1). The median NAS was significantly different for the three shifts (61.3%, 58.4%, 55.0%). For NASs in two shifts, the median varied significantly

**Table 1**
Sociodemographic description of the sample ($n = 3377$, 16 hospitals, and 24 ICU's).

| | Period 1 ($n = 1795$) | Period 2 ($n = 1582$) | All periods (n = 3377) |
|---|---|---|---|
| Sex (% ♂/♀) | 60/40 | 60/40 | 60/40 |
| Age (years), mean ± SD | 62.0 ± 19.6 | 60.4 ± 21.2 | 61.3 ± 20.4 |
| Pediatric cases (>15 years), n (%) | 62 (4) | 84 (5) | 146 (4) |
| Length of stay (days), median (IQR)[a] | 2 (1–6) | 2 (1–5) | 2 (1–5) |
| Occupancy rate, mean ± SD | 77.8 ± 16.4 | 70.8 ± 19.0 | 73.8 ± 18.2 |
| Orign, % | | | |
| Emergency surgery | 11.1 | 11.3 | 11.2 |
| Scheduled surgery | 24.5 | 25.5 | 24.4 |
| Medical | 64.5 | 63.4 | 64.4 |
| Destination (%) | | | |
| Deceased | 9.1 | 8.2 | 8.6 |
| Ward | 82.7 | 83.4 | 83.1 |
| Other hospital | 4.1 | 2.7 | 3.6 |
| Home | 3.5 | 3.2 | 3.3 |
| Other | 0.6 | 2.5 | 1.4 |
| Description of hospitals | | | |
| Number of hospitals, n | 16 | 16 | 16 |
| Number of ICUs, n | 24 | 24 | 24 |
| Number of beds, n | 316 | 316 | 316 |
| Number of beds, medical-surgical, n (%) | 316 (100) | 316 (100) | 316 (100) |
| Number of PICU beds, n (%) | 24 (7.6) | 24 (7.6) | 24 (7.6) |
| Number of beds, neuro surgery, n (%) | 135 (42.7) | 135 (42.7) | 135 (42.7) |
| Number of beds, cardiac surgery, n (%) | 157 (49.7) | 157 (49.7) | 157 (49.7) |
| Ratio ICU bed/nurse, mean ± SD | | | |
| Morning | 2.5 ± 0.8 | 2.7 ± 0.6 | 2.5 ± 0.68 |
| Afternoon | 2.7 ± 0.9 | 2.9 ± 0.8 | 2.8 ± 0.9 |
| Night | 3.1 ± 1.0 | 2.9 ± 0.8 | 3.0 ± 0.9 |

Legend: SD = standard deviation; ICU=Intensive Care Unit.
[a] 1 month

between day (68.3%) and night (56.7%). A slight difference of 0.9% in NAS per 24 h was observed between the two periods. Regarding the PICU data, day and night NAS scores were significantly different with scores of 60.4% and 58.4%, respectively. The scores were lower for the day, and more importantly, for the night compared to adults.

### 3.2.2. By NAS item

For multiple-choice items, the "normal" items were chosen in the majority of cases (+/− 70%). However, for the *Mobilization and positioning* items, 70% of the items were encoded "more than normal". The choice "much more than normal" was rarely recorded (<5%). The intensity selection for *Monitoring and titration* did not vary between day and night. On the other hand, the *Mobilization and positioning* and *Administrative and managerial* task items were valued more during the day than at night. *Specific interventions* inside and outside the ICU, items 22–23, were encoded in 10% to 22% of cases during the day and only 1% to 7% at night. The patients included in the study were intubated or tracheotomized in 31% to 38% of cases, under vasoactive drugs in 18% to 25% of cases, on hemofiltration in 4% to 8%, and 2% had an external ventricular bypass catheter. No cardiac massage was performed during either registration period (Appendix B).

The items *Mobilization and positioning* and *Administrative and managerial tasks* are those that take the most time in the daily care of a patient. In three-shift situations, the *Mobilization and positioning* item took longer, on average, and represented about 10% of a nurse's working time compared to the average NAS (68%). A significant decrease in this task was observed at night during three work shifts but not in two-shift situations. *Administrative and managerial tasks* took longer in two-shift situations and was more important during the day (15%) than at night (8%). *Monitoring and titration* tasks were as intense during the day than at night in two-shift workplaces but varied significantly over three shifts. Seven items (1–3–4-6-7-8-17) accounted for 75% to 89% of the time consumed for a patient, depending on the shift. The intensity of items between shifts was significantly different when working in three shifts. When working in two shifts, this was observed for only eight items (Table 2).

### 3.2.3. Related variables of high NAS

Results from the outlier calculations were variable. For example, 44% of outliers were observed on the basis of the median compared to only 2.1% for the formula from Pirson et al. However, for both methods, the proportion of high NAS was significantly higher in men and in deceased patients. Lastly, outliers had longer hospital stays than the general population (Table 3).

## 4. Discussion

In this study, the demographics, with an average age of 61 years and a death rate of 8.6%, are similar to previous studies on critical care workload [11,37,49-52].

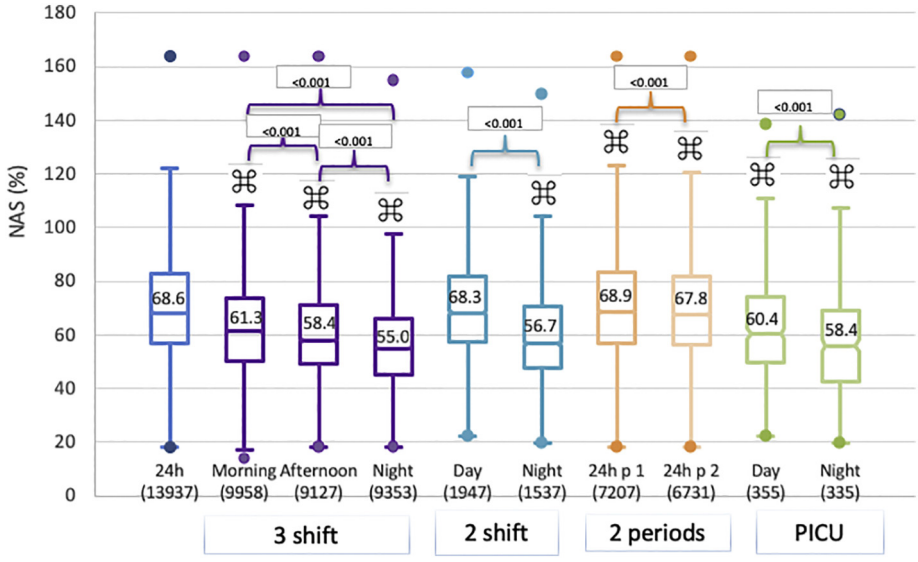


**Fig. 1.** Box plots representing the median NAS divided by shift and 24 h. P1 = period 1, P2 = period 2; PICU = NAS afternoon and morning are combined into one day; ⌘: comparison NAS 24 h with p value <.001 (Test Kruskall Wallis for multiple comparison and Mann Whitney for simple comparison).

**Table 2**
Average time per activity obtained according to item frequency and weighting of the original NAS scale (expressed as a percentage).

| Activity | 3 Shift | | | | 2 shift | | |
|---|---|---|---|---|---|---|---|
| | Morning (n = 9856) | Afternoon (n = 9126) | Night (n = 9352) | *p value* | Day (n = 1945) | Night (n = 1536) | p value |
| 1. Monitoring and titration | 7.0 ± 3.9 | 7.1 ± 4.0 | 6.3 ± 4.2 | *0.026* | 7.4 ± 4.4 | 6.9 ± 4.2 | *<0.001* |
| 2. Laboratory, biochemical investigations | 3.4 ± 1.8 | 3.3 ± 1.8 | 3.6 ± 1.6 | *0.085* | 3.7 ± 1.5 | 3.7 ± 1.5 | *<0.001* |
| 3. Medication, vasoactive drugs excluded | 5.3 ± 1.3 | 5.2 ± 1.4 | 4.7 ± 2.0 | *<0.001* | 5.4 ± 1.0 | 5.3 ± 1.3 | *<0.001* |
| 4. Hygiene procedures | 7.4 ± 5.7 | 6.7 ± 5.4 | 5.8 ± 5.6 | *0.003* | 8.6 ± 6.2 | 7.3 ± 5.8 | *<0.001* |
| 5. Care of drains, all (except gastric tube) | 1.4 ± 0.8 | 1.3 ± 0.8 | 1.2 ± 0.8 | *0.837* | 1.1 ± 0.9 | 1.1 ± 0.9 | *<0.001* |
| 6. Mobilization and positioning, including procedures | 10.5 ± 3.5 | 10.4 ± 3.5 | 8.8 ± 4.8 | *0.429* | 11.0 ± 3.5 | 10.7 ± 3.4 | *<0.001* |
| 7. Support and care of relatives and patient | 5.3 ± 6.7 | 5.9 ± 7.6 | 3.7 ± 5.5 | *<0.001* | 6.3 ± 7.9 | 5.1 ± 6.7 | *<0.001* |
| 8. Administrative and managerial tasks | 10.0 ± 8.9 | 8.7 ± 8.3 | 6.3 ± 6.9 | *<0.001* | 15.1 ± 9.6 | 8.3 ± 8.1 | *<0.001* |
| 9. Respiratory support | 1.1 ± 0.6 | 1.1 ± 0.6 | 1.0 ± 0.6 | *0.009* | 1.1 ± 0.6 | 1.1 ± 0.6 | *<0.001* |
| 10. Care of artificial airways | 0.7 ± 0.9 | 0.7 ± 0.9 | 0.6 ± 0.9 | *0.204* | 0.6 ± 0.8 | 0.6 ± 0.9 | 0.03 |
| 11. Treatment for improving lung function | 2.8 ± 2.1 | 2.7 ± 2.1 | 2.4 ± 2.2 | *0.881* | 2.0 ± 2.2 | 2.0 ± 2.2 | 0.008 |
| 12. Vasoactive medication | 0.3 ± 0.5 | 0.3 ± 0.5 | 0.3 ± 0.5 | *0.179* | 0.2 ± 0.5 | 0.2 ± 0.5 | 0.001 |
| 13. Intravenous replacement of large fluid losses | 0.1 ± 0.5 | 0.1 ± 0.6 | 0.1 ± 0.5 | *0.27* | 0.2 ± 0.6 | 0.2 ± 0.6 | *<0.001* |
| 14. Left atrium monitoring: pulmonary artery catheter | 0.2 ± 0.5 | 0.2 ± 0.5 | 0.1 ± 0.5 | *0.401* | 0.1 ± 0.3 | 0.1 ± 0.3 | *<0.001* |
| 15. Cardiopulmonary resuscitation after arrest | – | – | – | – | – | – | – |
| 16. Hemofiltration techniques, dialysis techniques | 0.6 ± 2.0 | 0.6 ± 2.0 | 0.4 ± 1.8 | *0.153* | 0.3 ± 1.6 | 0.4 ± 1.6 | *<0.001* |
| 17. Quantitative urine output measurement | 6.1 ± 2.4 | 6.0 ± 2.4 | 5.4 ± 2.9 | *<0.001* | 6.5 ± 1.9 | 6.6 ± 1.6 | *<0.001* |
| 18. Measurement of intracranial pressure | 0.0 ± 0.2 | 0.0 ± 0.2 | 0.0 ± 0.2 | *0.191* | 0.0 ± 0.2 | 0.0 ± 0.2 | *<0.001* |
| 19. Treatment of complicated metabolic acidosis/alkalosis | 0.1 ± 0.4 | 0.1 ± 0.4 | 0.1 ± 0.3 | *0.622* | 0.1 ± 0.3 | 0.1 ± 0.3 | *<0.001* |
| 20. Intravenous hyperalimentation | 0.2 ± 0.6 | 0.2 ± 0.6 | 0.1 ± 0.6 | *0.272* | 0.1 ± 0.6 | 0.1 ± 0.6 | *<0.001* |
| 21. Enteral feeding through gastric tube | 0.4 ± 0.6 | 0.4 ± 0.6 | 0.4 ± 0.6 | *0.141* | 0.4 ± 0.6 | 0.4 ± 0.6 | *<0.001* |
| 22. Specific intervention(s) in the intensive care unit | 0.4 ± 1.0 | 0.3 ± 0.9 | 0.2 ± 0.6 | *<0.001* | 0.6 ± 1.2 | 0.2 ± 0.7 | *<0.001* |
| 23. Specific interventions outside the intensive care unit | 0.2 ± 0.6 | 0.1 ± 0.5 | 0.0 ± 0.2 | *<0.001* | 0.2 ± 0.6 | 0.0 ± 0.2 | *<0.001* |

Example: Monitoring and titration (4.5% in 1a, 12.1% in 1b, and 19.6% in 1c according to the original NAS scale) takes 6.3% of the nurse's time at night in 3 shifts compared to average NAS per patient (55%).
Summary of Nursing Activities Score, available scale in publication of Miranda Crit Care Med 2003; 31:374–382 [46].
Mean ± standard deviation; *p* value: ANOVA Test.

The implementation of the NAS by shift allowed us to accurately calculate nursing time per patient expressed as a percentage. In our study, the organization of work was either three shifts (8–8-11 h) or two shifts ($12h$). In total, we collected nearly 32,000 records with a majority of NASs (88%) encoded in three shifts. To our knowledge, only one study also evaluated the NAS score in three shifts. In comparison to this study, also done in Belgium [49], we note that our results (morning: 61.3%, afternoon: 58.4, and night: 55.0%) were about 15% higher.

The PICU NAS results (morning: 60.4% and night: 58.4%) are substantially similar to other studies in pediatric intensive care units [53,55].

Relative to the NAS per 24 h, significant differences are observed when compared to the NAS per shift except for the NAS daytime. In view of the results, it is therefore better to encode the NAS by shift to determine a precise N/P ratio. With an average score of 68.6%, we have a result very similar to Greece (64.6%) [50], Brazil (66.4%) [51], and Italy (65.9%) [54] but lower, by report, than Norway (96.2%) [56]. The differences can be explained by the organization (e.g. triage of ICU patients, presence of intermediate unit) of health care in different countries [50]. Currently, in Belgium, a 1998 regulation imposes a minimum of two nurses for every six beds, but our results suggest that an optimal N/P ratio would be rather 1/1.5.

For both methods of calculating outliers, gender, ICU death, and length of stay in ICU show a significant relationship when analyzing the variables influencing the high NAS. For the latter two variables, these patients were probably more unstable and required more surveillance. The objective of the study was not to perform benchmarking between hospitals, however, there is a high variability in the number of outliers between them. These results are completely identical to two previous studies on the analysis of factors associated with NASs [37,51].

We choose the NAS as it is more cited in the literature, a review of 2015 had found 36 articles referring to the score [4]. In addition, the

**Table 3**
Analysis of variables related to high NAS compared with low values according to two formulas: the median and the medico-economic formula.

| | | Outliers Median | p value | Outliers P75 + 1.5 IQR | p value |
|---|---|---|---|---|---|
| Proportion of outliers by hospital, % | Med [P25-P75] | 44.0 [35.4–55.0] | <0.001 [a] | 2.1 [1.1–2.6] | <0.001[a] |
| Outliers NAS by Sex, % | F | 47.8 | 0.005 [a] | 2.0 | 0.027[a] |
| | M | 50.2 | | 2.6 | |
| Outliers NAS by period, % | 1 | 50.4 | 0.007 [a] | 2.3 | 0.733[a] |
| | 2 | 48.1 | | 2.4 | |
| Outliers NAS by shift, % | 2 | 54.0 | <0.001 [a] | 2.4 | 0.876[a] |
| | 3 | 48.5 | | 2.3 | |
| Outliers NAS by ICU discharge, % | Alive | 46.2 | <0.001 [a] | 1.5 | <0.001[a] |
| | Dead | 72.7 | | 9.4 | |
| Length of stay outliers and inliers | Outliers NAS, % | 42.3 | <0.001[b] | 2.1 | 0.005[b] |
| | Outliers Med [P25-P75], Day | 7 [3–17] | | 8 [3–15] | |
| | Inliers Med[P25-P75], Day | 5 [2—11] | | 6 [2–14] | |
| Age | Outliers NAS, % | 49.3 | 0.389 [b] | 2.4 | <0.001[b] |
| | Med outliers [P25-P75], Years | 65 [55–75] | | 62 [52–72] | |
| | Med inliers [P25-P75], Years | 66 [54–75] | | 66 [54–75] | |

Legend: a: chi squared, b: Mann Whitney, Med = median, p25 = percentile 25th, P75 = percentile 75th, IQR: interquartile range,F=Female, M = Male.

tool is used worldwide [45,49,50,56] and is not very time consuming [47]. Finally, the authors of a recent literature review report that the NAS is the best instrument for defining ICU nursing endowment. Indeed, NAS is the most extensively.

examined workload tool, with generally reliable results. It is also a system that focuses on the whole of the critical care nurse's workload [5].

Administrative tasks represent a large part of the nursing activity. These tasks are proportionally more important when the shifts are in 12 h because the day nurses make the majority of admissions and discharges of patients. Administrative staff could reduce the weight of this item to nurses and free up time for direct care. The second most important item is "mobilization and positioning". Indeed, 2% to 6% of our patients require three or more nurses to mobilize them, which is explained by the instability and the equipment of the patients.

Seven of the 23 items alone account for 75% to 89% of the nursing time consumed per patient. The encoding of only these items could reduce the encoding time and provide a relatively representative score of the time consumed per patient. However, this could lead to significant approximations as has been described for NEMS [36]. In particular, these items allow for comparison of NAS scores by pathology.

This study has some limitations. First, we did not record a disease severity score in our sample. However, these scores (e.g. SOFA and APACHE II) are weakly or moderately correlated with NAS [37]. In addition, the results of the SAPS 2 and SAPS 3 studies did not always reflect nursing needs [57]. Nevertheless, some NAS items allowed us to describe our sample from a medical point of view (e.g. vasoactive drug, intubation). This study was conducted on only two distinct periods of one month. However, current literature does not prevent us from generalizing our results over the year. Third, the encoding was not verified by the authors at the bedside of the patient in all hospitals. However, all nurses at the participating centers received one hour of training for coding and reference nurses in each center were trained more thoroughly. Finally, for pediatric outcomes, we have very few NASs encoded compared to adult NAS. Further study of pediatric cases may be needed to evaluate the optimal Pediatric N/P ratio.

This study demonstrates that it is feasible to implement the NAS scale in a large number of ICUs. In addition, these results demonstrate a significant gap between legislation and the real N/P ratio and the importance of evaluating the workload in ICU. Further studies on the analysis of the impact of this N/P ratio gap on the quality of patient care in the ICU would be interesting. This article could add a new approach to scientifically define N/P ratio legislation through health policies. Finally, given the variability of outliers by hospital, the use of the NAS would allow the financing of the nursing staff per hospital according to their case-mix of intensive care.

## 5. Conclusions

This study demonstrates that it is feasible to implement the NAS scale in a large number of ICUs.

The NAS per 24 h is significantly higher than that per shift. There is a difference between the ratio calculated by the scale (1/1.5) and the legislation in Belgium (1/3). An objective measure of the daily workload with validated tools and by shift seems recommended in order to avoid these differences.

## Declaration of Competing Interest

The authors have no conflicts of interest to declare.

## Acknowledgments

The authors would like to acknowledge the contributions of Sébastien Canipel, Jacques Delaunoy, Declaye Joséfine, Sabine Evrard, Pascal Ennafla, Yannick Hansenne, Isabelle Heulers, Géraldine Ketels, Marie Leterme, Yves Maule, Tulay Ozeyilmaz, and Miguel Waterkeyn. The authors acknowledge the contribution of a medical writer, Sandy Field,

PhD, for English language editing of the manuscript.

## Appendix A. Hospitals participating in the study

| Hospital | ICU Beds |
|---|---|
| CHU Marie Curie, Hôpital Civil - Charleroi | 32 |
| CHU Ambroise Pare - Mons | 14 |
| Clinique de l'Europe, site Saint Michel - Bruxelles | 8 |
| CHwapi - Tournai | 36 |
| CHC Clinique Notre-Dame - Waremme | 6 |
| CHR de la Citadelle - Liège | 48 |
| CHR East Belgium - Verviers | 18 |
| CHU Brugmann site Victor Horta et Paul Brien - Bruxelles | 35 |
| Clinique Saint-Jean - Bruxelles | 15 |
| CHC Clinique de l'Espérance - Montegnée | 10 |
| CHC Clinique Notre-Dame - Hermalle | 6 |
| CHC Clinique Saint-Joseph - Liège | 22 |
| HIS Hopitaux Iris SUD, site Bracops - Bruxelles | 12 |
| Hôpital de Jolimont, La Louvière | 22 |
| Hôpital Universitaire des Enfants Reine Fabiola - Bruxelles | 18 |
| CHU Tivoli - La Louvière | 14 |
| Total | 316 |

## Appendix B. Description items of NAS by shift

| Items | 3 shift, frequency (%) | | | p value | 2 shift, frequency (%) | | p value |
|---|---|---|---|---|---|---|---|
| | Morning (n = 9856) | Afternoon (n = 9126) | Night (n = 9352) | | Day (n = 1945) | Night, (n = 1536) | |
| **1. Monitoring and titration** | **9805 (99)** | **9070 (98)** | **8426 (90)** | 0.001 | **1935 (99)** | **1520 (99)** | 0.001 |
| 1a. Hourly vital signs, regular registration and calculation of fluid balance | 6689 (68) | 6125 (67) | 5884 (63) | | 1268 (65) | 1087 (71) | |
| 1b. Present at bedside and continuous observation or active for 2 h or more in any shift | 2911 (30) | 2757 (30) | 2375 (25) | | 575 (30) | 374 (24) | |
| 1c. Present at bedside and active for 4 h or more in any shift for reasons of safety | 205 (2) | 188 (2) | 167 (2) | | 92 (5) | 59 (4) | |
| 2. Laboratory, biochemical and microbiological investigations | 7706 (78) | 7106 (78) | 7818 (84) | <0.001 | 1651 (85) | 1326 (86) | 0.229 |
| 3. Medication, vasoactive drugs excluded | 9267 (94) | 8474 (93) | 7873 (84) | <0.001 | 1875 (96) | 1454 (95) | 0.013 |
| **4. Hygiene procedures** | **9727 (99)** | **8748 (96)** | **7634 (81)** | <0.001 | **1885 (97)** | **1455 (95)** | <0.001 |
| 4a. Performing hygiene procedures such as dressing of | 7108 (72) | 6734 (74) | 5804 (62) | | 1174 (60) | 1038 (68) | |
| 4b. The performance of hygiene procedures took 2 h in any shift | 2347 (24) | 1842 (20) | 1701 (28) | | 670 (34) | 401 (26) | |
| 4c. The performance of hygiene procedures took 4 h in any shift | 272 (3) | 172 (2) | 129 (1) | | 41 (2) | 16 (1) | |
| 5. Care of drains, all (except gastric tube) 1.8 | 7399 (75) | 6785 (74) | 6333 (68) | <0.001 | 1181 (61) | 949 (62) | 0.522 |
| **6. Mobilization and positioning, including procedures** | **9725 (99)** | **8971 (98)** | **8008 (86)** | <0.001 | **1908 (98)** | **1502 (98)** | <0.001 |
| 6a. Performing procedure(s) up to three times per 24 h | 2695 (27) | 2506 (27) | 2541 (27) | | 398 (20) | 343 (22) | |
| 6b. Performing procedure(s) more frequently than 3 times per 24 h, or with two nurses, any frequency | 6679 (68) | 6208 (68) | 5312 (57) | | 1391 (72) | 1122 (73) | |
| 6c. Performing procedure with three or more nurses, any frequency | 351 (4) | 257 (3) | 155 (2) | | 119 (6) | 37 (2) | |
| **7. Support and care of relatives and patient** | **9103 (92)** | **8563 (94)** | **6560 (70)** | <0.001 | **1879 (97)** | **1370 (89)** | <0.001 |
| 7a. Support and care of either relatives or patient requiring full dedication for about 1 h in any shift | 8523 (86) | 7853 (86) | 6258 (67) | | 1711 (88) | 1284 (84) | |
| 7b. Support and care of either relatives or patient requiring full dedication for 3 h or more in any shift | 580 (6) | 710 (8) | 302 (3) | | 168 (9) | 86 (6) | |
| **8. Administrative and managerial tasks** | **9743 (99)** | **9011 (99)** | **8311 (89)** | <0.001 | **1919 (99)** | **1492 (97)** | <0.001 |
| 8a. Performing in routine | 6733 (68) | 6821 (75) | 7063 (76) | | 811 (42) | 1149 (75) | |
| 8b. Performing administrative and managerial tasks requiring full dedication for about 2 h in any shift | 2916 (30) | 2113 (23) | 1209 (13) | | 1081 (56) | 337 (22) | |
| 8c. Performing administrative and managerial tasks requiring full dedication for about 4 h or more of the time in any shift | 94 (2) | 67 (1) | 39 (0) | | 27 (1) | 6 (0) | |
| **Ventilatory support** | | | | | | | |
| 9. Respiratory support | 7476 (76) | 7011 (77) | 6566 (70) | <0.001 | 1465 (75) | 1219 (79) | 0.005 |
| 10. Care of artificial airways: endotracheal tube or tracheostomy cannula | 3733 (38) | 3483 (38) | 3189 (34) | <0.001 | 602 (31) | 536 (35) | 0.014 |
| 11. Treatment for improving lung function | 6160 (63) | 5605 (61) | 4999 (53) | <0.001 | 867 (45) | 715 (47) | 0.246 |
| **Cardiovascular support** | | | | | | | |
| 12. Vasoactive medication, disregard type and dose | 2442 (25) | 2281 (25) | 2138 (23) | 0.001 | 356 (18) | 306 (20) | 0.277 |
| 13. Intravenous replacement of large fluid losses. | 470 (5) | 532 (6) | 442 (5) | 0.001 | 122 (6) | 102 (7) | 0.66 |
| 14. Left atrium monitoring: pulmonary artery catheter with or without cardiac output measurement | 902 (9) | 839 (9) | 740 (8) | 0.002 | 68 (3) | 56 (4) | 0.813 |
| 15. Cardiopulmonary resuscitation after arrest, in the past period of 24 h | 0 | 0 | 0 | – | 0 | 0 | – |
| **Renal support** | | | | | | | |
| 16. Hemofiltration techniques, dialysis techniques | 745 (8) | 664 (7) | 523 (6) | 0.001 | 86 (4) | 73 (5) | 0.642 |
| 17. Quantitative urine output measurement (e.g., by indwelling urinary catheter) | 8577 (87) | 7843 (86) | 7200 (77) | <0.001 | 1796 (92) | 1454 (98) | 0.006 |
| **Neurologic support** | | | | | | | |
| 18. Measurement of intracranial pressure | 189 (2) | 190 (2) | 174 (2) | 0.529 | 38 (2) | 32 (2) | 0.787 |
| **Metabolic support** | | | | | | | |
| 19. Treatment of complicated metabolic acidosis/alkalosis | 851 (9) | 879 (10) | 659 (7) | <0.001 | 87 (4) | 67 (4) | 0.874 |
| 20. Intravenous hyperalimentation | 545 (6) | 517 (6) | 439 (5) | 0.006 | 83 (4) | 62 (4) | 0.735 |
| 21. Enteral feeding through gastric tube or other gastrointestinal route (e.g., jejunostomy) | 3348 (34) | 2975 (33) | 2678 (29) | <0.001 | 586 (30) | 530 (35) | 0.006 |
| **Specific interventions** | | | | | | | |
| 22. Specific intervention(s) in the intensive care unit | 1576 (16) | 1127 (12) | 504 (5) | <0.001 | 432 (22) | 114 (7) | <0.001 |
| 23. Specific interventions outside the intensive care unit: surgery or diagnostic procedures | 1037 (11) | 691 (8) | 112 (1) | <0.001 | 198 (10) | 25 (2) | <0.001 |

Summary of Nursing Activities Score, available scale in publication of Miranda Crit Care Med 2003; 31:374–382 [46]; Legend: *p* value: chi square per shift and per item.

## References


[1] Reis Miranda D, Jegers M. Monitoring costs in the ICU: a search for a pertinent methodology. Acta Anaesthesiol Scand 2012;56:1104–13. https://doi.org/10.1111/j.1399-6576.2012.02735.x.

[2] Wunsch H, Angus DC, Harrison DA, et al. Variation in critical care services across North America and Western Europe. Crit Care Med 2008;36:2787–93. https://doi.org/10.1097/CCM.0b013e318186aec8.

[3] Timmers TK, Verhofstad HJ, Moons KGM, Leenen LPH. Intensive care performance: how should we monitor performance in the future? World J Crit Care Med 2014; 3:74–8. https://doi.org/10.5492/wjccm.v3.i4.74.

[4] Lachance J, Douville F, Dallaire C, et al. The use of the nursing activities score in clinical settings: an integrative review. Rev Esc Enferm USP 2015;49:147–56. https://doi.org/10.1590/s0080-623420150000700021.

[5] Greaves J, Goodall Andrea B, et al. Nursing workloads and activity in critical care: a review of the evidence. Intensive Crit Care Nurs 2018;48:10–20. https://doi.org/10.1016/j.iccn.2018.06.002.

[6] West E, Mays N, Rafferty AM, Rowan K, Sanderson C. Nursing resources and patient outcomes in intensive care: a systematic review of the literature. Int J Nurs Stud 2009;46:993–1011. https://doi.org/10.1016/j.ijnurstu.2007.07.011.

[7] Aiken LH, Sloane DM, Bruyneel L, et al. Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. Lancet 2014;383:1824–30. https://doi.org/10.1016/s0140-6736(13)62631-8.

[8] Cho SH, Yun SC. Bed-to-nurse ratios, provision of basic nursing care, and in-hospital and 30-day mortality among acute stroke patients admitted to an intensive care unit: cross-sectional analysis of survey and administrative data. Int J Nurs Stud 2009;46:1092–101. https://doi.org/10.1016/j.ijnurstu.2009.02.001.

[9] Kane RL, Shamliyan TA, Mueller C, Duval S, Wilt TJ. The association of registered nurse staffing levels and patient outcomes: systematic review and meta-analysis. Med Care 2007;45:1195–204. https://doi.org/10.1097/MLR.0b013e3181468ca3.

[10] West E, Barron DN, Harrison D, Rafferty AM, Rowan K, Sanderson C. Nurse staffing, medical staffing and mortality in intensive care: an observational study. Int J Nurs Stud 2014;51:781–94. https://doi.org/10.1016/j.ijnurstu.2014.02.007.

[11] Neuraz A, Guérin C, Payet C, Polazzi S, Aubrun F, Dailler F, et al. Patient mortality is associated with staff resources and workload in the ICU: a multicenter observational study. Crit Care Med 2015;43:1587–94. https://doi.org/10.1097/ccm.0000000000001015.

[12] Schubert M, Clarke SP, Aiken LH, De Geest S. Associations between rationing of nursing care and inpatient mortality in Swiss hospitals. International J Qual Health Care 2012;24:230–8. https://doi.org/10.1093/intqhc/mzs009.

[13] Gonçalves LA, Andolhe R, Oliveira EMD, Barbosa RL, Faro ACM, Gallotti RMD, et al. Nursing allocation and adverse events/incidents in intensive care units. Rev Esc Enferm USP 2012;46:71–7. https://doi.org/10.1590/s0080-62342012000700011.

[14] Graf J, Von den Driesch A, Koch KC, Janssens U. Identification and characterization of errors and incidents in a medical intensive care unit. Acta Anaesthesiol Scand 2005;49:930–9. https://doi.org/10.1111/j.1399-6576.2005.00731.x.

[15] Daud-Gallotti RM, Costa SF, Guimarães T, Padilha KG, Inoue EN, Vasconcelos TN, et al. Nursing workload as a risk factor for healthcare associated infections in ICU: a prospective study. PLoS One 2012;7:e52342. https://doi.org/10.1371/journal.pone.0052342.

[16] Stone PW, Mooney-Kane C, Larson EL, Horan T, Glance LG, Zwanziger J, et al. Nurse working conditions and patient safety outcomes. Med Care 2007;45:571–8. https://doi.org/10.1097/MLR.0b013e3180383667.

[17] Venier AG, Leroyer C, Slekovec C, Talon D, Bertrand X, Parer S, et al. Risk factors for Pseudomonas aeruginosa acquisition in intensive care units: a prospective multicentre study. J Hosp Infect 2014;88:103–8. https://doi.org/10.1016/j.jhin.2014.06.018.

[18] Cimiotti JP, Aiken LH, Sloane DM, Wu ES. Nurse staffing, burnout, and health care–associated infection. Am J Infect Control 2012;40:486–90. https://doi.org/10.1016/j.ajic.2012.02.029.

[19] Gerasimou-Angelidi S, Myrianthefs P, Chovas A, Baltopoulos G, Komnos A. Nursing activities score as a predictor of family satisfaction in an adult intensive care unit in Greece. J Nurs Manag 2014;22:151–8. https://doi.org/10.1111/jonm.12089.

[20] Johnson D, Wilson M, Cavanaugh B, Bryden C, Gudmundson D, Moodley O. Measuring the ability to meet family needs in an intensive care unit. Crit Care Med 1998;26:266–71.

[21] Cremasco MF, Wenzel F, Zanei SS, Whitaker IY. Pressure ulcers in the intensive care unit: the relationship between nursing workload, illness severity and pressure ulcer risk. J Clin Nurs 2013;22:2183–91. https://doi.org/10.1111/j.1365-2702.2012.04216.x.

[22] Lake ET, Cheung RB. Are patient falls and pressure ulcers sensitive to nurse staffing? West J Nurs Res 2006;28:654–77. https://doi.org/10.1177/0193945906290323.

[23] Ball JE, Bruyneel L, Aiken LH, Sermeus W, Sloane DM, Rafferty AM, et al. Post-operative mortality, missed care and nurse staffing in nine countries: a cross-sectional study. Int J Nurs Stud 2018;78:10–5. https://doi.org/10.1016/j.ijnurstu.2017.08.004.

[24] Shindul-Rothschild J, Flanagan J, Stamp KD, Read CY. Beyond the pain scale: provider communication and staffing predictive of patients' satisfaction with pain control. Pain Manag Nurs 2017;18:401–9. https://doi.org/10.1016/j.pmn.2017.05.003.

[25] Dang D, Johantgen ME, Pronovost PJ, Jenckes MW, Bass EB. Postoperative complications: does intensive care unit staff nursing make a difference? Heart Lung J Acute Critical Care 2002;31:219–28. https://doi.org/10.1067/mhl.2002.122838.

[26] Frade MM, Vinagre RG, Zaragoza IG, Viñas SS, Antúnez EM, Alvarez EG, et al. Burnout syndrome in different intensive care units. Enferm Intensiva 2009;20:131–40. https://doi.org/10.1016/S1130-2399(09)73221-3.

[27] EFCCN. Position statement on workforce requirements within European critical care nursing. Eur Feder Crit Care Nursing Assoc: Available from: http://www.efccna.org/images/stories/publication/2007_ps_workforce_requirements_neu.pdf [Accessed 23 july 2007].

[28] Bray K, Wren I, Baldwin A, St Ledger U, Gibson V, Goodman S, et al. Standards for nurse staffing in critical care units determined by: the British Association of Critical Care Nurses, The Critical Care Networks National Nurse Leads, Royal College of Nursing Critical Care and In-flight Forum. Nurs Crit Care 2010;15:109–11. https://doi.org/10.1111/j.1478-5153.2010.00392.x.

[29] Valentin A, Ferdinande P, ESICM Working Group on Quality Improvement. Recommendations on basic requirements for intensive care units: structural and organizational aspects. Intensive Care Med 2011;37:1575. https://doi.org/10.1007/s00134-011-2332-z.

[30] Sprung CL, Artigas A, Kesecioglu J, Pezzi A, Wiis J, Pirracchio R, et al. The Eldicus prospective, observational study of triage decision making in European intensive care units. Part II: intensive care benefit for the elderly. Crit Care Med 2012;40:132–8. https://doi.org/10.1097/CCM.0b013e318232d6b0.

[31] Vincent JL, Lefrant JY, Kotfis K, Nanchal R, Martin-Loeches I, Wittebole X, et al. Comparison of European ICU patients in 2012 (ICON) versus 2002 (SOAP). Intensive Care Med 2018;44:337–44. https://doi.org/10.1007/s00134-017-5043-2.

[32] Laerkner E, Egerod I, Hansen HP. Nurses' experiences of caring for critically ill, non-sedated, mechanically ventilated patients in the intensive care unit: a qualitative study. Intensive Crit Care Nurs 2015;31:96–204. https://doi.org/10.1016/j.iccn.2015.01.005.

[33] Arrete royal fixant les normes auxquelles une fonction de soins intensifs doit répondre pour être agréée([M.B. du 19/06/1998, p. 20073). 27 Avril 2018].

[34] Cullen DJ, Civetta JM, Briggs BA, Ferrara LC. Therapeutic intervention scoring system: a method for quantitative comparison of patient care. Crit Care Med 1974;2:57–60.

[35] Miranda DR, De Rijk A, Schaufeli W. Simplified therapeutic intervention scoring system: the TISS-28 items–results from a multicenter study. Crit Care Med 1996;24:64–73.

[36] Miranda DR, Moreno R, Iapichino G. Nine equivalents of nursing manpower use score (NEMS). Intensive Care Med 1997;23:760–5. https://doi.org/10.1007/s001340050.

[37] Altafin JAM, Grion CMC, Tanita MT, Festti J, Cardoso LTQ, Veiga CFF, et al. Nursing Activities Score and workload in the intensive care unit of a university hospital. Revista Brasileira de Terapia Intensive 2014;26:292–8. https://doi.org/10.5935/0103-507X.20140041.

[38] Chagnon M, Audette L, Lebrun L, Tilquin C. A patient classification system by level of nursing care requirements. Nurs Res 1978;27:107–112.

[39] Équipe de Recherche Opérationnelle en Santé (EROS): PNR 80. La mesure du niveau des soins infirmiers requis. Bibliothèque nationale du Québec et du Canada, Montréal; 1981.

[40] Italian Multicenter Group of ICU Research (GIRTI), Iapichino G. Time oriented score system (TOSS): a method for direct and quantitative assessment of nursing workload for ICU patients. Intensive Care Med 1991;17:340–5.

[41] Commission d'Évaluation de la Société de Réanimation de Langue Français. Utilisation de l'indice de gravité simplifié et du système OMEGA. Réan Soins Int, Méd d'Urg 1986;2:219–21.

[42] Butcher HK, Bulechek GM, Dochterman JMM, Wagner C. Nursing interventions classification (NIC)-E-book. Elsevier Health Sciences; 2018.

[43] Marcos BB, Del campo ugidos RM, Méndez EF, et al. Propuesta de unanueva escala de valoración de cargas de trabajo y tiempos de enfermería (VACTE©). Enferm Intensiva 2007;18:115–25. https://doi.org/10.1016/S1130-2399(07)74393-6.

[44] Walther SM, Jonasson U, Karlsson S, Nordlund P, Johansson A, Mälstam J, et al, South-eastern Intensive Care Network Of Sweden. Multicentre study of validity and interrater reliability of the modified Nursing Care Recording System (NCR11) for assessment of workload in the ICU. Acta Anaesthesiol Scand 2004;48(6):690–6. https://doi.org/10.1111/j.0001-5172.2004.00397.x.

[45] Esmaeili R, Moosazadeh M, Alizadeh M, Afshari M. A systematic review of the workload of nurses in intensive care units using NAS. Acta Medica Mediterranea 2015;31(7):1455–60.

[46] Miranda DR, Nap R, De Rijk A, Schaufeli W, Iapichino G. Nursing activities score. Crit Care Med 2003;31:374–82. https://doi.org/10.1097/01.CCM.0000045567.78801.CC.

[47] Bruynel A, Guerra C, Tack J, Droguet M, Maes J, Miranda RD. Traduction sémantique en français et implémentation du Nursing Activities Score en Belgique. Médecine Intensive Réanimation 2018;27:260–72. https://doi.org/10.3166/rea-2018-0029.

[48] Pirson M, Dramaix M, Leclercq P, Jackson T. Analysis of cost outliers within APR-DRGs in a Belgian general hospital: two complementary approaches. Health Policy 2006;76:13–25. https://doi.org/10.1016/j.healthpol.2005.04.008.

[49] Debergh DP, Myny D, Van Herzeele I, Van Maele G, Miranda DR, Colardyn F. Measuring the nursing workload per shift in the ICU. Intensive Care Med 2012;38:1438–44. https://doi.org/10.1007/s00134-012-2654-5.

[50] Padilha KH, Stafseth S, Solms D, Hoogendoom M, Monge FJC, Gomaa OH, et al. Nursing activities score: an updated guideline for its application in the intensive care unit. Rev Esc Enferm USP 2015;49:131–7. https://doi.org/10.1590/s0080-62342015000070001 spe.

[51] Padilha KG, De Sousa RMC, Queijo AF, Mendes AM, Miranda DR. Nursing activities score in the intensive care unit: analysis of the related factors. Intensive Crit Care Nurs 2008;24:197–204. https://doi.org/10.1016/j.iccn.2007.09.004.

[52] Carmona-Monge FJ, Rodríguez GMR, Herranz CQ, Gómez SG, Marín-Morales D. Evaluation of the nursing workload through the nine equivalents for nursing manpower use scale and the nursing activities score: a prospective correlation study. Intensive Crit Care Nurs 2013;29:228–33. https://doi.org/10.1016/j.iccn.2013.03.003.

[53] Nieri AS, Manousaki K, Kalafati M, Padilha KG, Stafseth SK, Katsoulas T, et al. Validation of the nursing workload scoring systems “nursing activities score” (NAS), and “therapeutic intervention scoring system for critically ill children” (TISS-C) in a Greek paediatric intensive care unit. Intensive Crit Care Nurs 2018;48:3–9. https://doi.org/10.1016/j.iccn.2018.03.005.

[54] Lucchini A, De Felippis C, Elli S, Schifano L, Rolla F, Pegoraro F, et al. Nursing activities score (NAS): 5 years of experience in the intensive care units of an Italian university hospital. Intensive Crit Care Nurs 2014;30:52–158. https://doi.org/10.1016/j.iccn.2013.10.004.

[55] Campagner AOM, Garcia PCR, Piva JP. Use of scores to calculate the nursing workload in a pediatric intensive care unit. Revista Brasileira de Terapia Intensive 2014;26:36–43. https://doi.org/10.5935/0103-507X.20140006.

[56] Stafseth SK, Solms D, Bredal IS. The characterisation of workloads and nursing staff allocation in intensive care units: a descriptive study using the nursing activities score for the first time in Norway. Intensive Crit Care Nurs 2011;27:290–4. https://doi.org/10.1016/j.iccn.2011.07.003.

[57] Perren A, Previsdomini M, Perren I, Merlani P. Critical care nurses inadequately assess SAPS II scores of very ill patients in real life. Crit Care Res Prac 2012;2012. https://doi.org/10.1155/2012/919106.