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Evaluation of nurses' workload in intensive care unit of a tertiary care university hospital in relation to the patients' severity of illness: a prospective study

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Summary

Backgrounds

Costs of intensive care reach up to 30% of the hospital budget with workforce expenses being substantial. Determining proper nurse – patient ratio is necessary for optimizing patients' health related outcomes and hospitals' cost effective functioning.

Objectives

To evaluate nurses' workload using Nine Equivalents of Nursing Manpower Use Score and Nursing Activities Score scoring systems while assessing correlation between both scores and the severity of illness measured by Simplified Acute Physiology Score II.

Design

A Prospective study

Settings

Cardiac Surgery Intensive Care Unit of the Clinical Hospital Centre Rijeka, Croatia, from October 2014 to February 2015. This Intensive Care Unit has 3 beds that can be expanded upon need.

Participants

The study included 99 patients treated at this Unit during the study's period. The scores were obtained by 6 nurses, working in 12 hour shifts.

Methods

Measurements were obtained for each patient 24h after admission and subsequently twice a day, at the end of the day shift (7 pm) and at the end of the night shift (7 am). The necessary data were obtained from the patient's medical records.

Results

Nursing Activities Score showed significantly higher number of nurses are required for one 12-hour shift ($Z = 3.76$, $p < 0.001$). Higher scores were obtained on day shifts vs. night shifts. (Nursing Manpower Use Score, $z=3.25$, $p<0.001$; Nursing Activities Score, $z=4.16$, $p<0.001$). When comparing Nursing Activities Score and Nursing Manpower Use Score during the

week, we calculated higher required number of nurses on weekdays than on weekends and holidays, (Nursing Manpower Use Score, $p<0.001$; Nursing Activities Score, $p<0.001$). Correlation analysis of Nursing Activities Score and Nursing Manpower Use Score with Simplified Acute Physiology Score II has shown that Nursing Manpower Use Score positively associated with severity of disease, while Nursing Activities Score shows no association.

Conclusion

Both scores can be used to estimate required number of nurses in 12-hour shifts, although Nursing Activities Score seems more suitable for units with prolonged length of stay, while Nursing Manpower Use Score appears better for units with shorter duration of stay (up to four days). Higher workload measured by Nursing Manpower Use Score scale can be predicted with higher Simplified Acute Physiology Score II. However, with low Simplified Acute Physiology Score II scores it cannot be assumed that the nursing workload will also be low. Further research is needed to determine the best tool to asses nursing workload in intensive care units.

Key words: Intensive Care Unit, Nursing Activities Score, Nursing Manpower Use Score, Simplified Acute Physiology Score II, Workload

Contribution of the paper

What is already known about the topic?

- Cost effective ICU functioning is a challenge in managing hospital's budget with overall intensive care costs reaching up to 30% of the total institutional budget and with the costs of ICU workforce often higher than the cost of equipment.
- Nursing requirements in ICUs are still difficult to define mainly due to possibility of high variation in severity of illness of ICU patients in a short period of stay, hence scores utilized to estimate the ICU related nursing workload are still a subject of discussion among scientists.
- Nine Equivalents of Nursing Manpower Use Score (NEMS) and Nursing Activities Score (NAS) scoring systems were developed to assess nurses' workload and define it quite differently with NEMS being based on the therapeutic interventions which patients receive during ICU stay, while NAS counts specific activities of nurses that are part of the total intensive care treatment and is therefore more nursing oriented.

What this paper adds?

- NEMS appears a more suitable instrument for measuring workload for patients who are extremely unstable and for patients with short length of stay in the ICU (up to three or four days), contrary to that, in patients who have a prolonged stay in the ICU and need more demanding procedures related to hygiene, administration, positioning in bed and mobilization, a more acceptable measurement tool could be NAS.
- As there is no correlation of NAS and Simplified Acute Physiology Score (SAPS II), higher workload measured by NEMS scale can be predicted with higher SAPS II, however, with low SAPS-II scores it cannot be assumed that the nursing workload will also be low, due to nursing work that may be necessary in intensive treatment and is unrelated to the severity of illness.
- For countries in transition, the numbers of nurses proposed by state legislation are often hard to achieve due to economic and organizational constraints, however, NAS and NEMS seem to provide realistic standards in nursing workload assessment.

Background

Rapid technological progress combined with changes of the health care system and growing expectations of patients resulted in significant change in working conditions of the Intensive care unit (ICU) nurses over the past twenty years. Life expectancy of patients is significantly higher than in the last century and the possibility to impact natural course of many serious illnesses which until recently were incurable is growing. There is a rise in the required number of intensive treatments, as well as in material and human resources necessary for intensive care.

Croatia is a small European country that suffered significant demographic and economic losses during the war from 1991 to 1995. Furthermore, together with the rest of the world, it was severely affected by the global economic crisis of 2008, which intensified the pre-existing post-war economic problems and impacted the already strained healthcare system as well. In Croatia, the health care system is divided into primary, secondary and tertiary sector. All Croatian citizens are entitled to basic health care through mandatory health insurance, while for a minority of health services they must participate financially if they do not have the supplemental health insurance. The exceptions to this rule are senior citizens, the disabled and the unemployed. Basically, Croatia has a social Health insurance, based on solidarity. Every working citizen must contribute to the state-owned health insurance system and everybody receives basic health care services if the need arises. The country also has a largely liberal sick leave and maternity compensation packages in comparison to western European countries, so there is a possibility for abuse, resulting in the need for rationalization of the costs at all levels of health care.

Most hospitals in Croatia are owned by the State and the average lengths of stay in acute hospitals in Croatia are significantly longer than in Slovenia and Hungary (countries bordering Croatia) and most other European countries (1), The ratios between numbers of nurses per inhabitant, and nurses per physician estimated in 2011 were well below the EU average (1), and have not changed significantly since then. In 2014, according to the data presented by the Eurostat (official EU website for statistical topics), Luxembourg ranked highest in nurse/100 000 inhabitants ratio (1197/100 000), while Croatia (120/100 000) was ranked among the lowest ratio countries, together with Romania (56/100 000), Greece (182 / 100 000) and Slovenia (244/100 000) (2).

In a survey made in 2001, there were 123 ICU-s in Croatia, with 900 ICU beds altogether (3). In majority of them, nurses worked in 12 hours shifts, and on average, the nurse/patient ratio was 7:11. The ICUs were poorly equipped (only 43.6% had a perfusor pump per bed, with one pump for enteral nutrition per two beds) (3).

The European Society of Intensive Care Medicine suggests that the number of nurse full-time equivalents for running one ICU bed is 6, and that nursing shifts should be 8 hours (4).

Australian College of Critical Care Nurses (ACCCN) established standard suggests nurse/patient ratio of at least 1:1 (5), and similarly to that, the British Association of Critical Care Nurses (BACCN) proposes an ICU should not go below 1:2 nurse/patient ratio (6). In the ICU, where this research was conducted, there were 3.3 full time nurses in the period of the study.

Croatian Nursing Council was not founded until 2003, thus legislation and regulation of the rights and work duties of nurses in the ICU setting are still in development.

The educational system for nursing in Croatia is also not without its problems. Although, it is based on the Bologna Process, the Croatian basic nursing education remains at the secondary school level and the doctoral degree in nursing is still non-existent (7). Nurses were considered, and often still are, physicians' assistants and based on job complexity index of health care workers, they have three times lower salaries than physicians, even though the standard practice is that they provide most of ICU care and a lot of decision making (8). In that sense, intensive medicine in Croatia is still greatly conservative.

The overall costs of ICUs reach up to 30% of the total hospital budget (9), with the cost of ICU workforce being substantial, often higher than the cost of equipment (10). Hence, cost effective ICU functioning is a challenge in managing hospital's budget. The effect of excessive workload of nurses on patient outcomes and the total costs of treatment are already well known. Numerous studies have shown that the optimization in the number of nurses and conditions of their working environment result in higher patient safety and quality of health care (12). The understaffing of nurses is directly related to: the increasing number of infections related to medical care in the ICU (12-15) and higher number of postoperative complications and prolonged stay in the ICU (15-18). It is well known that the cost of extended treatment of patients in institutions with insufficient numbers of staff is much higher

than the costs of increased employment of nurses (19). Aside from affecting patients' outcomes, it often also leads to nurses developing „Burnout„ syndrome (20, 21).

Shortage in nursing care is a global challenge for hospital management systems. Nursing requirements in ICUs are still difficult to define mainly due to the possibility of high variation in severity of illness of ICU patients in a brief period of stay. Thus, diversity of nursing care and the ICU related workload seem hard to predict.

Overstaffing in cost effective health care management is unacceptable, nevertheless determining the right nurse – patient ratio is necessary for optimizing the patients' health related outcomes as well as nurses' and health organizations' cost effective and streamlined functioning. Technology and equipment in ICU is improving and changing rapidly. Therefore, the nursing workload cannot be evaluated only in relation to the number of nurses and patients, but also diagnosis, severity of illness, certain specific activities and the amount of time that a nurse must spend with a specific patient (22).

Different scoring systems have been used to assess the severity of illness, predicting the outcome of treatment and the level of dysfunction of certain organs in patients. Severity scoring systems are often used in ICUs to estimate disease severity and predict mortality (23-25). The Simplified Acute Physiology Score (SAPS II) was developed and validated in 13 Intensive Care Units in a cohort study of over 13000 patients, and published in 1993. (26)

Therapeutic interventions scoring system (TISS) was designed and published in 1974 and it was focused on the severity of illness, however its use quickly spread to estimating nurse – patient ratio (27). It includes 57 therapeutic nursing activities which a nurse is performing throughout 24 hours. In 1983 TISS was expanded to include 76 activities, and in 1996 was simplified to include 28 activities divided into 7 groups (28). It was criticized for being time consuming and overly dependent on severity of illness, so the need for a simpler scoring system led to development of the Nine Equivalents of Nursing Manpower Use Score (NEMS) in 1997 (29). The NEMS scale consists of 9 items with weighting assigned, with score ranges 0-63 points, and it was envisaged that for 46 points one full – time nurse would be required. It is simple to complete but insensitive to the small changes in patient's condition which influence nursing care. Workload assessed by NEMS does not differ substantially from the workload assessed by TISS, and NEMS being considerably less time consuming has been widely used (30). The principles of use for both instruments are that the workload is co-

dependent only on the severity of illness and that both scoring systems should be used in a period of 24 hours. However, the relationship between the severity of illness and nurse workload is not always linear (31), and as nurses work in shifts, there was a growing need for a different and more comprehensive scoring system.

The problems encountered in TISS and NEMS were considered and Nursing Activities Score (NAS) was developed in 2003 (33). It consists of 23 items that represent specific activities performed by nurses in the ICU, with item weightings being based on time nurses need to perform these activities. Scale scores range from 0 to 178.7 points, and for 100 points one full – time nurse is required. The advantages of this instrument are its independence of the severity of illness (33) and that it can be used both for measuring workload in 24 hours and in shifts (34) with minor adjustments proposed by the authors of the score (7). Although, NEMS was developed for use in 24-hour periods, it has been reported that it too could be used for assessment of work in shifts (34, 35).

The aim of this study was to examine the workload of nurses working in shifts of 12 hours at the Department of intensive care for cardiac-surgery patients, using NEMS and NAS scoring systems and to determine the relationship between these two instruments as well as correlation of both scores with the severity of illness measured by the Simplified Acute Physiology Score II (SAPS II).

Methods

Setting

A prospective research study was performed in the Clinical Hospital Centre Rijeka in the cardiac-surgical ICU. This ICU is a subunit of the Clinic for anesthesiology and intensive care and has 3 beds, if needed it can be expanded with one or two additional beds. The study lasted 99 days (October 2014 to February 2015).

Sample

In the time frame of this study, the ICU had altogether 10 nurses, working in 12 hour shifts, usually 2 and rarely 3 in one shift regardless of the bed occupancy. There was no specific division of roles of nurses during shifts. All nurses regardless of their level of education (secondary school or bachelor degree), had the same responsibilities simply due to an overall shortage in the number of employed nurses. There were no shift supervisors. From October 2014 to February 2015 a total of 101 patients were admitted to this ICU. The study included 99 patients aged between 20 and 85 years who were treated at the ICU throughout the study's duration. Two patients were excluded due to incomplete medical records, and two patients were admitted twice which was considered as a new admission. All included patients were either patients admitted immediately after a planned cardiac surgery, before surgery as emergencies or after they had been transferred to a ward and were then readmitted for required intensive care treatment.

The first readmission was after an elective cardiac surgery and the second was due to life-threatening postoperative complication which occurred after the patient was discharged from ICU to a cardiac surgery hospital ward. Two patients were present in the ICU for only 4 hours, but were resuscitated once or several times in that period, representing a significant workload for nurses during those 4 hours. Therefore, they were included in the study. In case where patients were temporarily going to an operating room, no alternations were applied in the score.

Data collection

Demographic and clinical data of patients were collected for the purposes of this study. NAS and NEMS were scored twice a day, at the end of the day shift (7 pm) and at the end of the night shift (7 am) for each patient treated in our ICU in the period of the study. The data necessary for calculating the length of ICU and hospital stay were obtained from the patients'

medical records. The type of admission and the destination of discharge were also obtained from the patients' medical records in order to better represent the characteristics of the study population.

Instruments

NEMS score (Table 1. in supplementary data) was used in its original form as recommended and was translated to Croatian language by the authors of the study and then back into English for checking. It was also piloted for contents and linguistic clarity. The workload was calculated based on the total NEMS points scored in that shift and a number of nurses. One full – time nurse can receive up to 46 points in one shift or in other words, 46 NEMS points represent 100% consumption of time of one nurse.

Adjusted form of NAS, one designed for use in shifts was translated into Croatian language, checked and piloted for contents and linguistic clarity (Table 2. in supplementary data). Three conditions that authors of the NAS have described for the score to be used in shifts were met; inclusion of many shifts, collection and analysis of data per shift, and inability of items' change. One full- time nurse can receive up to 100 NAS points per shift. Scoring was performed by 6 nurses who attended a training session for use of the scoring systems prior to participating in the study. All 6 nurses scored the same patient separately to account for the level of subjectivity. They all scored almost identically, except for the item 8, which was later discussed until we found that all included nurses were assigning the same weighting to the item 8.

Simplified Acute Physiology Score II was recorded for all included patients within 24 hours after admission. The score contains 17 variables: age, type of admission, 12 physiological variables, and three variables associated with patient disease, all with assigned weighting. The score is calculated in the first 24 hours of ICU admission and it is used to predict the in-hospital mortality risk (26). In some respects, it evaluates the performance of ICUs. However, scores utilized to estimate the ICU related workload are still a subject of discussion among scientists.

Data analysis

Statistical analyses were performed using data analysis software system Dell Statistica (version 12., 2015).

Continuous variables are presented as mean value (standard deviation) or median (with interquartile range) and categorical variables with frequency or percentage. For comparison between normally distributed variables (normality distribution was analysed with Kolmogorov-Smirnov test) parametric tests were used (t-test or analysis of variance, ANOVA), and non-parametric tests were used otherwise (Mann Whitney U test or Kruskal Wallis ANOVA). The statistical relationships between value of NEMS, NAS and SAPS II were presented by Pearson's correlation coefficient r and coefficient of determination R2 (proportion of variance explained). The level of significance was set to $p<0.05$.

Informed consent

The study protocol was conducted according to the World Medical Association outlined in the declaration of Helsinki and was approved by the local ethics committee (Clinical Hospital Center Rijeka ref.no. 2170-29-02/1-14-2).

Results

A total of 197 shift records were collected. In the period of the study, mortality rate was 6%. Demographic characteristics of the study population are presented in Table 3.

Patients were predominantly admitted and discharged during the day shift. The totals of 559 measurements were collected in 99 day shifts and 98 night shifts during the study's duration. For every patient, as long as they were in the ICU, NAS and NEMS were calculated twice a day, along with SAPS II which was calculated for every patient 24 hours after admission. The average values of NAS and NEMS per individual patient were calculated in day shifts and in night shifts. The mean value of NAS per patient in day shift was 77.3 (SD 13.6) with a median value of 75, 2 and in night shifts 67.5 (SD 13.7) with a median of 68.3.

The cumulative mean value of NAS in day shifts was 251.1 (SD 110.5) with a median of 239.6 (IQR 166.6-332.7), for the night shifts it is 169.8 (SD 62.4) with a median of 162.3 (IQR 127.7-202.3), while the cumulative mean value of NEMS in daily shifts was 93.2 (SD 40.2) with a median of 93.0 (IQR 59.0-123.0), and for night shifts it was 70.0 (SD 29.3), with a median of 64.5 (IQR 43.0- 95.0). A cumulative mean value of the NAS and the NEMS were significantly higher in daily shifts and on week days (t-test, $p<0.001$).

Correlation between total NEMS and NAS scores were obtained in 197 measurements and calculated also per type of shift. The correlation was demonstrated as very strong by Pearson's correlation coefficient ($r=0.909$, $p<0.001$) and determination coefficient ($R2=0.826$), shown in supplementary Table 4.

The median number of nurses per shift was 2 (IQR 2.0-2.0) in each shift both on weekdays and on weekends and holidays. The data also showed a higher workload during the day shift which was increased up to 188% using NEMS, and up to 234% using the NAS scoring system. Day shifts had a significantly greater workload in comparison with the night shifts as shown in supplementary figure 1. (for NEMS t-test, $t = 4.28$, $p <0.001$; for NAS t-test, $t=6.01$, $p <0.001$).

Overall, 87% of the nurses' time was consumed according to the NEMS, and 103% by using the NAS score system. Supplementary figure 2. shows the calculated total NAS and NEMS per single nurse and also the utilization of working time in 12-hour shift (95% of CI). Apart

from differing in day and night shifts, workload was also different when measured on weekdays, weekends and holidays. Significantly higher workload was measured on weekdays than on weekends and holidays (for NEMS, ANOVA $F = 19.6$, $p < 0.001$; for NAS, ANOVA $F = 17.9$, $p < 0.001$).

Workload measured using NEMS score system was significantly higher for deceased patients than for other patients, while the workload measured by NAS was not significantly different among patient categories. The number of nurses required in 12 hour shifts in this ICU was calculated using both of these scores. Total NAS in shift was divided by 100, and the total NEMS was divided by 46 as is recommended by the authors of the scores. According to NEMS, a required average number of nurses per shift was 1.7 (SD 0.8) with a median of 1.6 (IQR 1.2-2.3) and according to NAS it was 2.1 (SD 1.1) with a median of 1.8 (IQR 1.3-2.8), please see Table 5.

When comparing the required number of nurses as evaluated by NAS and NEMS, NAS showed that a significantly higher number of nurses is required for one 12 hour shift in our ICU (Mann-Whitney U test, $Z = 3.76$, $p < 0.001$). Higher scores were obtained on day shifts vs. night shifts (NEMS, M-W U test, $z=3,25$, $p<0,001$; NAS,M-W U test, $z=4,16$, $p<0.001$). When comparing NAS and NEMS during the week, we calculated higher required number of nurses on weekdays than on weekends and holidays (NEMS, Kruskal Wallis ANOVA, $p<0,001$; NAS Kruskal Wallis ANOVA, $p<0.001$; Table 5). Correlation analysis of NAS and NEMS scoring system with SAPS II has shown that NEMS is positively associated with severity of disease ($r=0.451$, $p<0.001$), while NAS shows no statistically significant correlation ($p=0.074$) (supplementary Table 6).

Discussion

The assessment of nursing workload is essential for calculating nurse/patient ratio, managing hospital budget and planning cost effective treatment of patients in intensive care units. Several scoring systems have been developed for this purpose. However, consensus about which one is the most reliable was not reached, and systematic use of nursing workload measurement tools has not been standard practice in most hospitals. Possible explanations for this are likely errors in the design of the scoring systems. The two instruments that were used in this study define workload quite differently. NEMS scale is derived from the TISS and is based on the therapeutic interventions which patients receive during intensive care unit stay. Its concept is more medically than nursing oriented. In contrast, the NAS counts specific activities of nurses that are part of the total intensive care treatment and is therefore more nursing oriented. Both NAS and NEMS have been frequently used and had been validated as measuring instruments for nursing workload in ICUs.

This study is one of the few that have measured nursing workload by both NAS and NEMS per shift, respecting the conditions proposed by the authors of the tools (8,31). Demographics, mortality and clinical findings were uniform to those in the previously published articles in this field (10,15,34). In total, 559 measurements were obtained using NAS and NEMS in 99 day and 98 night shifts during the period of the study. This research has provided evidence that the workload in this ICU varies greatly depending on whether it is a weekend, holiday or working day of the week shift. The results showed that the workload of one nurse reaches up to 188% by NEMS, and up to 234% by NAS during the working days of the week. Therefore, the number of nursing professionals needed per shift, on the day shift during the week is substantially higher than on weekends and holidays. On average, 87% of one nurse time per shift was occupied as determined through the NEMS scale. In comparison, 103% of their time was utilised as assessed by the NAS.

In the period of the study's duration, 6 patients died. We found that the needs for staffing measured by NEMS were significantly higher for deceased patients than for other patients, however NAS scores in that regard were not significantly different. This could be explained by the concept of the score's design that we mentioned earlier. The more medically oriented NEMS scores 9 therapeutic interventions that the patients are undergoing. However, it does not assess nursing procedures for hygiene, positioning in the bed and administrative

procedures which are greatly time consuming. Majority of the NEMS points are associated with interventions closely related to patients being unstable (such as use of vasoactive drugs or mechanical ventilation support). Contrary to that, NAS authors suggest that monitoring, performing procedures of hygiene, administrative and managerial duties are often the most time-consuming activities of an ICU nurse.

Very low correlation between NAS and NEMS was found in most studies that used both scoring systems in several types of ICU (34, 37). Interestingly, in a study by Carmona Monge et al. (36), which was conducted on a larger sample and for a longer period, with high proportion of coronary patients and no postsurgical patients or multiple trauma patients, both measuring tools provided similar assessments of the nursing workload as was the case in our study where we found very strong correlation between both scores even though their concepts are different.

The average length of stay in the ICU in the study by Bernat et al. (34) and Stafseth et al. (37) was about 6 days, while in the study by Carmona - Monge et al. (36) it was 3 days. It seems that the correlation of these two scoring systems depends, to some extent, on the length of stay of patients in the ICU. NEMS is probably a more suitable instrument for measuring workload for patients who are extremely unstable and for patients with short length of stay in an ICU. In other words, NEMS is more suitable for those ICUs where average length of stay is shorter (up to three or four days). In contrast, NAS appears to be a more acceptable measurement tool for patients who have a prolonged ICU length of stay and need more demanding procedures related to hygiene, administration, positioning in bed and mobilization. Therefore, NAS seems more suitable for ICUs which tend to have patients with longer lengths of stay such as a trauma ICU. The time needed to complete NEMS scale is much shorter than the time needed to complete a NAS scale, hence this is a fact to be considered when deciding on which scale to use.

In our study, the number of nurses required to work in an intensive care unit has been assessed by both scores: the total NAS (divided by 100) and the total NEMS (divided by 46). As expected, assessment of the required number of nurses calculated by NAS is significantly higher than the one assessed by NEMS, which is similar to the findings that were reported by Ducci et al. (38). In the period of this study, the total required number of nurses calculated by these two instruments and the total actual number of nurses in our ICU were proportional.

Furthermore, it is worth noting that the time period of this study contained a large number of holidays (December and January), so fewer elective surgeries were performed than usually.

In Croatia, the legislation concerning the number of nurses in the ICU setting is regulated by the Ministry of health and social welfare, which has determined that the minimum number of full time nurses per ICU bed is 6 (39), the same number that has been suggested by the European Society of Intensive Care Medicine. In everyday practice, it is usually not so. For our ICU with 3 beds (without additional beds), the ideal number of nurses would be 18, but in reality, it is 10. According to the scores for measuring nursing workload that were used in this study, the number of nurses was adequate in comparison to the workload. Ideal numbers determined by the Ministry of health and social welfare seem elusive due to shortage of available nurses and current economic constraints facing Croatia and other transitional countries. Consequently, the number of nurses per patient recommended by the authors of NAS and NEMS could perhaps become a standard that Croatia could achieve, and these scores could be used routinely in everyday practice in Croatian Hospitals.

In general, two patients are discharged and two patients are admitted to our ICU on the working day of the week. In such a day shift, 321 NAS points are scored, so the required number of nurses per shift would be 3.21, while with the NEMS, 109 points are scored, which would require 2.3 nurses per shift. Given the difference in the design of these two workload measurement tools, it is most likely that the real required number of nurses is somewhere between these two estimates. Therefore, combined use of both NAS and NEMS is in our opinion, the best method to measure the nurse workload in an ICU.

From the data collected, it is evident that NEMS correlates well with the severity of illness measured with SAPS II hence by calculating the NEMS, severity of the disease can be predicted. Moreover, we found no correlation between SAPS II and NAS, confirming the results of Lucchini at al. (40). The explanation is probably again the fact that NEMS is more medically than nursing-oriented, as opposed to NAS which is more nursing-orientated by assigning points to specific activities of nurses that are part of the total intensive care stay. Therefore, lack of correlation of NAS with SAPS II suggests that severity of disease and the nursing workload are not necessarily proportional. Similar conclusions were suggested in a study by Debergh et al. (10).

The development of new diagnostic, therapeutic and prognostic techniques, combined with growing diversity of staff that work in an ICU result in a need to update nursing workload assessment instruments and to adapt them to constantly changing working conditions of a modern ICU setting.

Limitations

This study was conducted in a single cardiac-surgery ICU which could impact the general applicability of our results. The data were collected by nurses who had been trained in using the NAS and NEMS scoring tools. SAPS II was reported 24 hours after admission by an attending physician, however an aspect of subjectivity should still be considered. Another possible limitation may be the specific time period of research which included more holidays than usually, thus a smaller number of elective cardiac surgeries was performed.

Conclusion

In this study, the nursing workload was similar to the workload recommended by the authors of NAS and NEMS scoring systems. However, the staffing requirements remain higher when estimated by the NAS scale than those estimated by the NEMS. As expected, the workload was significantly higher in the day shifts, especially on working days of the week, than during night shifts, weekends and holidays.

The correlation between severity of illness measured with SAPS II and NEMS is high. Contrary to that, there is no correlation of NAS and SAPS II. Therefore the higher workload measured by NEMS scale can be predicted with higher SAPS II scores. However, with low SAPS-II scores it cannot be assumed that the nursing workload will also be low, due to nursing workload that is necessary for intensive care which is unrelated to the severity of illness.

For countries in transition, the numbers of nurses proposed by state legislation are often hard to achieve due to economic and organizational constraints, however, NAS and NEMS seem to provide realistic standards for nursing workload assessment.

Finally, both NAS and NEMS can be used to estimate the required number of nurses in 12-hour shifts, although NAS seems more suitable for ICU's with prolonged length of stay, while NEMS appears more appropriate for ICU's with shorter average length of stay (up to three or four days). Nevertheless, further research is needed to confirm these results and to determine the best tool to assess nursing workload in the ICU setting.

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Supplementary data

Item	Points
1.Basic monitoring: hourly vital signs, regular record and calculation of fluid balance	9
2.Intravenous medication: bolus or continuously, not including vasoactive drugs	6
3.Mechanical ventilatory support: any form of mechanical/assisted ventilation with or without PEEP (e.g., continuous positive airway pressure), with or without muscle relaxants	12
4.Supplementary ventilatory care: breathing spontaneously trough endotracheal tube; supplementary oxygen any method, except if (3) applies	3
5.Single vasoactive medication: any vasoactive drug	7
6.Multiple vasoactive medication more than one vasoactive drug, regardless of type and dose	12
7.Dialysis techniques: all	6
8.Specific interventions in the ICU: such as endotracheal intubation, introduction of pace-maker, cardioversion, endoscopy, emergency operation in the past 24h, gastric lavage; routine interventions such as X-rays, echocardiography, electrocardiography, dressings, introduction of venous or arterial lines, are not included	5
9.Specific interventions outside the ICU: such as surgical intervention or diagnostic procedure; the intervention/procedure is related to the severity of illness of the patient and makes an extra demand upon manpower effort in the ICU	6

Table 1. Nine Equivalents of Nursing Manpower Use Score

Basic Activities	
Item	**Points**
1. Monitoring and titration (only one sub item (a, b, or c) can be scored)	
1a. Hourly vital signs, regular registration and calculation of fluid balance	4.5
1.b.Present at bedside and continuous observation or active for 2 hrs or more per shift, for reasons of safety, severity, or therapy such as noninvasive mechanical ventilation, weaning procedures, restlessness, mental disorientation, prone position, donation procedures, preparation and administration of fluids or medication, assisting specific procedures	12.1
1.c. Present at bedside and active for 4 hrs or more per shift for reasons of safety, severity, or therapy such as those examples above (1b)	19.6
2. Laboratory, biochemical and microbiological investigations	4.3
3. Medication, vasoactive drugs excluded	5.6
4. Hygiene procedures (only one subitem (a, b, or c) can be scored)	
4a. Performing hygiene procedures such as dressing of wounds and intravascular catheters, changing linen, washing patient, incontinence, vomiting, burns, leaking wounds, complex surgical dressing with irrigation, and special procedures (e.g. barrier nursing, cross-infection related, room cleaning following infections, staff hygiene)	4.1
4b. The performance of hygiene procedures took > 2 hrs per shift	16.5
4c. The performance of hygiene procedures took > 2 hrs per shift	20.0
5. Care of drains, all (except gastric tube)	1.8
6. Mobilization and positioning, including procedures such as: turning the patient; mobilization of the patient; moving from bed to chair; team lifting (e.g. immobile patient, traction, prone position) (only one subitem (a, b, or c) can be scored)	
6a. Performing procedure(s) once per shift	5.5
6b. Performing procedure(s) more frequently than once per shift, or with two nurses, any frequency	12.4
6c. Performing procedure with three or more nurses, any frequency	17.0
7. Support and care of relatives and patient, including procedures such as telephone calls, interviews, counseling; often, the support and care of either relatives or patient communication with patients during hygiene procedures, communication with relatives while present at bedside, and allow staff to continue with other nursing activities (e.g., observing patient) (only one subitem (a or b) can be scored)	
7a. Support and care of either relatives or patient requiring full dedication for about 1 hr per shift such as to explain clinical condition, dealing with pain and distress, difficult family circumstances	4.0
7b. Support and care of either relatives or patient requiring full dedication for 3 hrs or more per shift such as death, demanding circumstances (e.g., large number of relatives, language problems, hostile relatives)	32.0
8. Administrative and managerial tasks (only one subitem (a or b) can be scored)	
8a. Performing routine tasks such as processing of clinical data, ordering examinations, professional exchange of information (e.g., ward rounds)	4.2
8b. Performing administrative and managerial tasks requiring full dedication for about 2 hrs in any shift such as research activities, protocols in use, admission and discharge procedures	23.2
8c. Performing administrative and managerial tasks requiring full dedication for about 4 hrs or more of the time per shift such as death and organ donation	30.0

procedures, coordination with other disciplines	
Ventilatory support	
9. Respiratory support: any form of mechanical ventilation/assisted ventilation with or without positive end-expiratory pressure, with or without muscle relaxants, spontaneous breathing with or without positive end-expiratory pressure with or without endotracheal tube supplementary oxygen by any method	1.4
10. Care of artificial airways: endotracheal tube or tracheostomy cannula	1.8
11. Treatment for improving lung function: thorax physiotherapy, incentive spirometry, inhalation therapy, intratracheal suctioning	4.4
Cardiovascular support	
12. Vasoactive medication, disregard type and dose	1.2
13. Intravenous replacement of large fluid losses. Fluid administration >1 L/m²/shift, irrespective of type of fluid administered	2.5
14. Left atrium monitoring: pulmonary artery catheter with or without cardiac output measurement	1.7
15. Cardiopulmonary resuscitation after arrest, in the past period of 24 hrs (single precordial thump not included)	7.1
Renal support	
16. Hemofiltration techniques, dialysis techniques	7.7
17. Quantitative urine output measurement (e.g., by indwelling urinary catheter)	7.0
Neurologic support	
18. Measurement of intracranial pressure	1.6
Metabolic support	
19. Treatment of complicated metabolic acidosis/alkalosis	1.3
20 Intravenous hyperalimentation	2.8
21. Enteral feeding through gastric tube or other gastrointestinal route (e.g., jejunostomy)	1.3
Specific interventions	
22. Specific intervention(s) in the intensive care unit: endotracheal intubation, insertion of pacemaker, cardioversion, endoscopies, emergency surgery in the previous 24 hrs, gastric lavage; routine interventions without direct consequences to the clinical condition of the patient, such as: radiographs, echography, electrocardiogram, dressings, or insertion of venous or arterial catheters, are not included	2.8
23. Specific interventions outside the intensive care unit: surgery or diagnostic procedures	1.9

Table 2. Nursing Activities Score per shift

In the items 1, 4, 6, 7, and 8, only one subitem (a, b, or c) can be scored; the weights represent the percentage of time spent by one nurse on the activity mentioned in the item, if performed.

Number of patients	99
Gender (M/F)	72% /28%
Type of admission (Elective surgery/Emergency surgery)	95% / 5 %
Origin	
Operating room	92%
Emergency room	2%
Other ICU	2%
Cath lab	1%
Coronary unit	1%
missing data	2%
Destination	
Cardiac - surgery ward	91%
Thoracic and vascular surgery ward	2%
Other ICU	1%
Deceased	6%
Age (in yrs.), *median (IQR)*	68 (62-74)
Length of stay in ICU (in days), *median (IQR)*	1 (1-2)
Length of stay in hospital after ICU (in days), *median (IQR)*	6 (5-8)
SAPS II, *median (IQR)*	28 (23-37)
Mortality	6%

Table 3. Demographic and health characteristics of patients in the study sample.

Scores	N	r	R^2	p
Total NAS & total NEMS	197	0.909	0.826	<0.001
Day shift	99	0.938	0.880	<0.001
Night shift	98	0.831	0.691	<0.001

Table 4. Correlation of total NEMS with total NAS scores; r- Pearson's correlation coefficient; R2 – coefficient of determination (proportion of variance explained); p-level of statistical significance.

Nurses needed according to:	mean	SD	median	IQR	range	*p*
NEMS	1.7	0.8	1.6	1.2-2.3	0.4-3.8	
Day shift	2.0	0.8	2.0	1.3-2.7	0.4-3.8	<0.001
Night shift	1.5	0.6	1.4	0.9-2.0	0.4-3.0	
Week	1.9	0.8	2.0	1.3-2.5	0.4-3.8	<0.001
Weekend	1.4	0.6	1.3	0.8-1.6	0.4-3.0	
Holliday	1.2	0.6	0.8	0.8-1.4	0.8-2.7	
NAS	2.1	1.1	1.8	1.3-2.8	0.4-4.9	
Day shift	2.7	1.1	2.7	1.8-3.5	0.6-4.9	<0.001
Night shift	1.5	0.6	1.4	1.1-1.7	0.4-3.8	
Week	2.3	1.1	2.0	1.3-3.3	0.4-4.9	0.002
Weekend	1.6	0.7	1.6	1.2-1.8	0.4-3.5	
Holliday	1.4	0.9	1.1	0.8-2.0	0.7-3.3	

Table 5. The number of nurses required considering daily workload measured by total NEMS and total NAS scores.

	r	R2	p
NEMS/patient & SAPS II	0.451	0.203	<0.001
NAS/patient & SAPS II	0.182	0.033	0.074

Table 6. Correlation of SAPS II with NAS and NEMS; r- Pearson's correlation coefficient; R2 – coefficient of determination (proportion of variance explained); p-level of statistical significance.

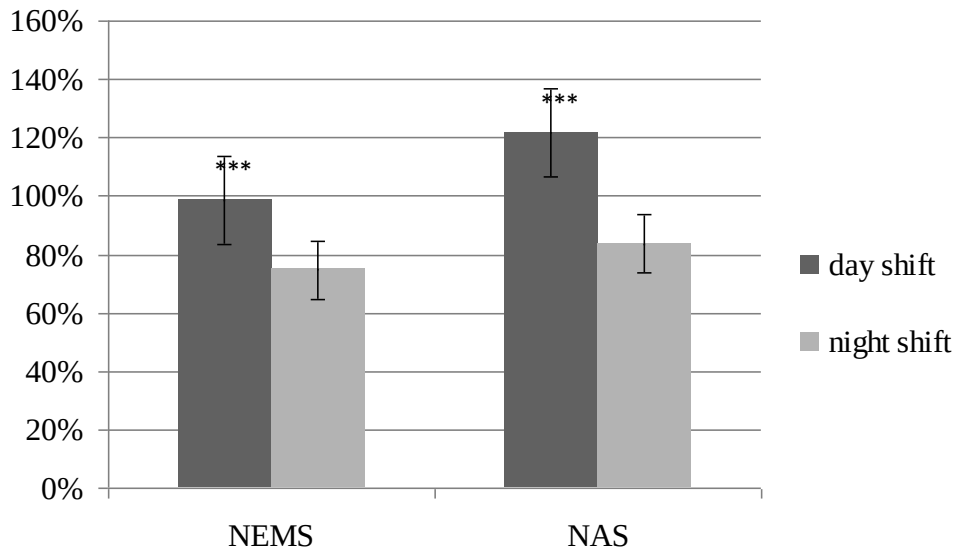

Figure 1. Mean values of % of workload using NAS and NEMS scores for day and night shifts (with 95% CI). Significant differences are labeled as *** $p<0.001$, ** $p<0.01$ and * $p<0.05$.

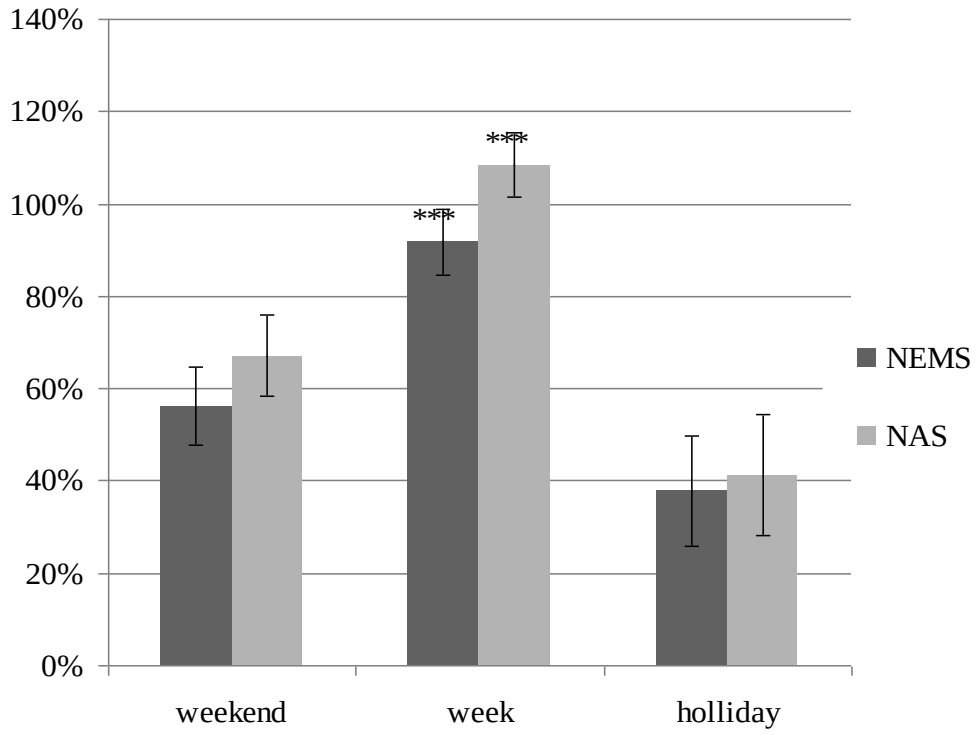

Figure 2. Mean values of % of consumption of nurses time measured by NAS and NEMS scores depending on the weekday, weekend, or holiday (with 95% CI). Significant differences are labelled as *** $p<0.001$.