Validation of the Nursing Activities Score (NAS) using time-and-motion measurements in Dutch Intensive Care Units

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Abstract

Background

The Nursing Activities Score (NAS) is widely used for workload measurement of Intensive Care Unit (ICU) nurses. However, the performance of the NAS to measure actual nursing time has not been comprehensively and externally validated. The aim of this study is to validate the NAS using time-and-motion measurements in Dutch ICUs.

Methods

We measured nursing time for patients admitted to seven Dutch ICUs, between November 2016 and October 2017. The patient(s) that were under the care of a chosen nurse were followed by the observers during the entire shift and measurements were performed using an in-house developed web application. To validate the reliability of the NAS, we first converted NAS points per activity into minutes. Next, we compared the converted time per NAS item and the converted total nursing time per patient with the actual observed time. We used Wilcoxon signed-rank tests at nursing activity level and Pearon's R and R 2 at patient level for these comparisons.

Results

A Pearson's correlation of R=0.59 (R 2 =0.35) was found between the total converted NAS time and the total observed time per patient. The median converted NAS time per patient (202.6 minutes) was higher compared to the observed time per patient (114.3 minutes). At NAS item level, we found significant differences between the converted NAS time and the observed time for all separate NAS items.

Conclusions

The NAS overestimates the needed nursing time for patients in Dutch ICUs. Therefore, we advise revisions of the time weights assigned to each NAS item to get better insight in the true nursing workload to enable the use of this information for more adequate nursing capacity planning.

Keywords: Nursing Activities Score (NAS), time-and-motion techniques, validation, nursing workload, patient acuity.

Introduction

There are concerns regarding excessively high nursing workload, both in general- and ICU wards [1]. Excessive high nursing workload can lead to burnout and job dissatisfaction among nurses [2] and have a deleterious effect on patients [3]. Workload has risen due to increased turnover of patients, increased complexity of patient cases together with inadequate capacity of nurses due to shortages [4]. All this makes planning of nursing capacity important. In the last 30 years different instruments have been developed to measure the nursing workload to give insight in the needed nursing staff per shift and provide much needed input for capacity planning [5].

To assess nursing workload in the ICU Cullen et al. (1974) [6] created the Therapeutic Intervention Scoring System (TISS). The TISS was originally developed to classify nursing workload in relation to the severity of illness of ICU patients. The TISS exists of 76 therapeutic interventions that receive one to four points based on the severity of illness of the patient. It appeared that nursing workload is only partly related to the severity of illness, since less severely ill patients could also generate high nursing workload. For instance a patient recovering from a serious illness with an agitated delirium would not score high in severity of illness, but could demand very intensive nursing care, up to continuous bedside care throughout the day. This made the TISS less adequate to assess nursing workload. Therefore, the Nursing Activities Score (NAS) was developed in 2003 by Miranda et al. (2003) [7]. The NAS describes activities that largely represent the work actually performed by nurses at bedside in caring for the patients and has been developed to measure the nursing workload for each individual patient. The points assigned to the nursing activities provide an average time consumption in caring for the patients instead of representing the severity of illness. The NAS was created by using the work-sampling approach: at random moments per shift the nurse was asked what he or she was doing at that specific moment. For every activity there was a weight granted by the researchers. The total NAS for an individual patient is the sum NAS points of all activities, varying between 0 to 177 points. A score of 100 NAS points is equivalent to the amount of care which can be provided by one Full Time Equivalent nurse during either one shift or one day. A score above 100 points indicates that

the needed care can only be provided by more than one nurse [7].

The NAS is considered a valuable tool and is widely used for workload measurement in ICUs [8,9]. However, the performance of the NAS has not been comprehensively validated. One study showed that the NAS might either under- or overestimate the actual nursing time required by patients and therefore recommended revision of the original NAS because of inadequate measurement of nursing activities [4].

Furthermore, research has demonstrated that the work-sampling approach, as used for the development of the NAS, does not lead to an accurate representation of the true nursing workload. This is due to the fact that the weightings of the nursing activities are based on the probability that a particular nursing activity occurred [10]. The total amount of time in a shift is divided over the occurring nursing activities. When nursing activities frequently occur or take much time, they would also occur more frequent in the work-sampling approach. However, this approach will not lead to precise measurements, but will only approximate the time of the different activities. Thus, in contrast to time-and-motion techniques in which every minute of a nursing shift is measured, the work-sampling approach does not measure the real amount of time spent on the nursing activities which could lead to less accurate results [11]. Therefore, the time-and-motion technique is considered as the best technique for time measurement [12].

The aim of this study is to validate the NAS in the Dutch ICU setting using the time-and-motion technique, and to identify which nursing activities are under- or overestimated in the NAS.

Methods

Setting

All 82 Dutch ICUs participate in the National Intensive Care Evaluation (NICE) quality registry. Fifteen of these ICUs are participating in the newly implemented voluntary nursing capacity module [13]. Seven of these ICUs voluntarily participated in this study. Data on characteristics of the ICUs (such as number of ICU beds) and data on patient characteristics (such as age, BMI, admission type, and mortality) were extracted from the NICE registry.

Time-and-motion

The study involved time-and-motion measurements for patients admitted to the ICU. We measured in different types of hospitals (academic-, teaching-, and non-teaching hospitals) and in different shifts (day, evening, and night). At the start of a shift one nurse was chosen by the observer. The patient(s) that were under the responsibility of this nurse were followed by the observer during the entire shift. A patient admitted for a longer time could theoretically be observed on different dates during different shifts and therefore could possibly be followed during more than one measured shift. The measurements took place during different days of ICU admission of the patients (e.g. first ICU admission day through last ICU admission day) and with different type of nurses (registered and student nurses).

Observers were researchers CM and MH and ten student nurses. The students were trained in performing time-and-motion measurements by oral and written instructions and one day of measuring together with one of the researchers. The observers used an in-house developed web application to record start and stop times of each performed nursing activity [See Additional file 1]. The application contained, among other, all activities occurring in the NAS [See Additional file 2]. If two nurses were simultaneously performing nursing activities for the same patient this was also registered, by pressing the ‘two nurses button’ and multiplying this time by two in the analysis. In case of two different activities carried out by two nurses, these activities could be measurued simultaneaously. Measurements were conducted between November 1st 2016 and October 1st 2017. Participation of the hospitals was on a voluntary basis. Seven hospitals were willing to participate. Data was processed in an anonymous way.

Ethical approval

The Institutional Research Board of the Amsterdam University Medical Centre reviewed the research proposal and waived the need for informed consent (IRB protocol W17_366).

Data analysis

Nursing activities that occurred less than ten times in the total dataset were excluded from the analysis. Most NAS items have a fixed number of NAS points but some items have different categories corresponding to different numbers of NAS points depending on the duration of that activity (e.g.

bedside with hourly vital signs, bedside for two hours or more, or four hours or more). For these duration depended activities, we first used the measured time for that activity during the measurements to assign the correct number of points. For example, a nurse performed hygiene procedures on a patient for 1.2 hours during a shift according to our time measurements. This NAS item has three categories: performing hygiene procedures for less than two hours, for more than two hours, or for more than four hours. In bovementioned example, the activity took 1.2 hours and would therefore be assigned to the category for less than two hours, which corresponds to 4.1 NAS points.

To validate the NAS, we first converted the originally assigned NAS points per activity into time. Based on Miranda et al. (2003) [6] 100 NAS points correspond to 100% of care time provided by one nurse during a shift and hence 1 NAS point corresponds to 1% of care time provided by one nurse. Given the fact that a nurse is productive in 80% of the 8-hour shift, which has been described by the author of the NAS, one NAS point corresponds to 3.84 minutes of nursing care during an 8-hour shift (((8 hours * 60mins)/100)*0.8) [7,14]. With this information we were able to convert the NAS scores into an estimated nursing time per patient and per nursing activity (from now on referred to as *converted NAS time, see Additional file 3*). Next we compared the time per NAS item and the total nursing time per patient, based on NAS scores according to the model, with observed times from the time-and-motion measurements. For the observed time, we took the sum of the times of all performed nursing activities per patient per shift in minutes (from now on referred to as *observed time, see Additional file 3*).

The median and interquartile ranges (IQR) of the converted NAS times and the observed times were calculated. First, the difference between the total converted NAS times and the total observed times per patient were visualized by scatterplots. Second, the correlation between the total converted NAS times and the total observed times per patient were assessed with the Pearson's correlation test. In addition, we also assesed the R^2, a measure for the proportion of the variance. For each nursing activity separately, medians and interquartile ranges (IQR) of the converted NAS times and observed times were calculated and differences were tested with the Wilcoxon signed-rank test. All statistical

analyses were performed using R statistical software, version 3.3.2 [15].

Results

Baseline results

Table 1 shows the ICU characteristics of the seven included ICUs compared to all Dutch ICUs. No significant differences were found in ICU characteristics between the included ICUs and all Dutch ICUs (Table 1). During our study, a total of 287 unique patients have been observed during 371 different shifts with time-and-motion measurements. In these patients, 46.319 nursing activities have been measured. In 60% of the measurements, nurses took care for two or three patients per shift. For the remaining 40%, nurses cared for one patient per shift. The patients in our study had a significant higher in-hospital mortality rate (22.3% versus 13.0%) and length of ICU stay (3.2 days versus 1.0 day) compared to all Dutch patients in the same period (Table 2). Furthermore, acute renal failure, chronic respiratory insufficiency, and cirrhosis differed between the groups, with a higher percentage in the patients in our study. For the other patient characteristics, the included patients and all Dutch ICU patients in this period were comparable.

Table 1

ICU characteristics

Variable	Included ICUs (N = 7)	All Dutch ICUs (N = 84)
Number of university hospitals (%)	1 (14%)	9 (11%)
Number of teaching hospitals (%)	4 (57%)	23 (27%)
Number of non-teaching hospitals (%)	2 (29%)	52 (62%)
Median number of ICU beds per ICU (IQR)	13.0 [9.0, 17.0]	12.0 [8.0, 16.0]

Table 2

Patient Characteristics

Variable	Included patients in measurements	All Dutch ICU patients
Number of unique patients, N	287	100.145
Age, median [IQR]	66.0 [56.0–76.0]	66.0 [55.0–75.0]
BMI, median [IQR]	26.0 [23.6–28.7]	25.9 [23.1–28.4]
Admission type		
-Medical, N (%)	121 (42.2)	51290 (52.7)
-Surgical: urgent and elective, N (%)	151 (52.6)	45905 (47.2)
In-hospital mortality, N (%)*	85 (22.3)	13017 (13.0)
ICU LOS (in days), median [IQR]*	3.2 [0.9, 14.8]	1 [0.7–4.0]
Comorbidities		
Acute renal failure, N (%)*	37 (12.9)	9211 (9.2)
Cardiovascular insufficiency, N (%)	16 (4.2)	4257 (4.3)
Chronic renal failure[1], N (%)	25 (6.7)	7976 (7.9)
Chronic respiratory insufficiency, N (%)*	7 (2.4)	4620 (4.6)
Cirrhosis, N (%)*	1 (3.5)	1751 (1.7)
COPD, N (%)	36 (12.5)	13304 (13.3)
Diabetes, N (%)	68 (17.8)	16273 (16.2)
Gastrointestinal bleeding, N (%)	2 (0.7)	2263 (2.3)
Hematologic malignancy, N (%)	6 (2.1)	2143 (2.1)
Immunological insufficiency, N (%)	16 (5.6)	8290 (8.3)
Neoplasm, N (%)	9 (3.1)	4506 (4.5)

* Indicates a significant P-value of < 0.05

COPD: Chronic Obstructive Pulmonary Disease; IQR: Interquartile Range

1 Chronic renal failure consists of chronic renal insufficiency and chronic dialysis

NAS validation

Excluded nursing activities

The following three NAS nursing activities occurred less than 10 times in all measurements and were therefore excluded from the analysis at activity level: activities at the pulmonary- or left atrium catheter, cardiopulmonary resuscitation (CPR), and specific interventions in the ICU (endotracheal intubation, insertion of pacemaker, cardioversion, endoscopies, emergency surgery in the previous 24 hours, gastric lavege). Furthermore, we did not measure specifically intravenous replacement of large fluid losses and treatment of metabolic acidosis/alkalosis, since these two nursing activities are usually administered under bedside activities.

Total patient time and times per NAS item

The median converted NAS time per patient (202.6 minutes; IQR 155.0 – 241.2 minutes) was significantly higher ($p<0.001$) compared to the observed time per patient (144.3 minutes; IQR 81.3 – 168.4 minutes), see Figure 1. A Pearson's correlation of $R=0.59$ ($R^2=0.35$) was found between the total converted NAS time and the total observed time per patient (Table 3).

For the time differences at NAS item level, we found significant differences between the converted NAS times and observed times for all items. These differences ranged from -54.6 minutes (support or care for patient or relatives for about 1 hour) to 79.2 minutes (mobilization and positioning with three nurses). For most (86%) nursing activities the median converted NAS time overestimated the observed time. For four activities (support or care for patient for about 1 hour, administrative tasks for less than 2 hours, administrative tasks for about 2 hours and specific interventions outside the ICU) the converted NAS time underestimated the observed time (Table 3).

Table 3. NAS activities with their points according to Miranda et al. (2003)[6], and the median converted NAS times and observed times per NAS item.

N = 371 patients and 46.319 measured nursing activities.

NAS item	NAS points per activity	Median converted NAS time (minutes)	Median observed time (minutes) [IQR]	Difference in minutes, median [IQR]
1a Present at bedside and continuous observation or active for <2 hours [1]	4.5	21.6	14.22 [7.26-26.17]	7.38 [-4.57-14.35]*
1b Present at bedside and continuous observation or active for ≥2 hours	12.1	NA	NA	NA
1c Present at bedside and continuous observation or active for ≥4 hours	19.6	NA	NA	NA
2 Laboratory, biochemical and microbiological investigations	4.3	20.64	5.45 [3.13-8.81]	15.19 [11.83-17.51]*
3 Medication, vasoactive drugs excluded	5.6	26.88	2.24 [0.90-4.91]	24.64 [21.97-25.98]*
4a Performing hygiene procedures ≤2 hours	4.1	19.68	11.58 [3.95-27.8]	8.1 [-8.12-15.73]*
4b Performing hygiene procedures >2 hours	16.5	NA	NA	NA
4c Performing hygiene procedures >4 hours	20.0	NA	NA	NA
5 Care of drains	1.8	8.64	2.41 [0.92-4.64]	6.23 [4.0-7.72]*
6a Mobilization and positioning, performing procedure(s) up to 3 times per 24 hours	5.5	26.4	2.46 [0.91-4.88]	23.94 [21.52-25.49]*
6b Mobilization and positioning, performing procedure(s) >3 times per 24 hours, or with two nurses	12.4	59.52	4.82 [2.17-9.33]	54.69 [50.19-59.49]*
6c Mobilization and positioning, performing procedure(s) with 3 nurses	17.0	81.6	2.4 [0.89-6.16]	79.2 [75.44-80.71]*
7a Support or care for patient or relatives for about 1 hour	4.0	19.2	2.4 [0.89-6.16]	-54.58 [-65.18--49.26]*
7b Support or care for patient or relatives for about 3 hours	32.0	NA	NA	NA
8a Administrative or managerial tasks for <2 hours	4.2	20.16	40.91 [28.53-60.33]	-20.74 [-40.17--8.37]*
8b Administrative or managerial tasks for about 2 hours	23.2	111.4	130.0 [126.3-157.4]	-18.67 [-46.02--14.92]*
8c Administrative or managerial tasks for about 4 hours	30.0	NA	NA	NA
9 Respiratory support	1.4	6.72	2.99 [1.42-5.9]	3.73 [0.82-5.30]*
10 Care of artifical airways	1.8	8.64	1.43 [0.5-4.77]	7.21 [3.87-8.14]*
11 Treatment for improving lung function	4.4	21.12	1.32 [0.64-2.79]	19.80 [18.33-20.48]*
12 Vasoactive medication	1.2	5.76	1.99 [0.95-4.99]	3.78 [-0.77-4.81]*
13 Intravenous replacement of large fluid losses	2.5	NA	NA	NA
14 Left atrium monitoring	1.7	NA	NA	NA
15 Cardiopulmonary resusctitation after arrest	7.1	NA	NA	NA
16 Hemofiltration techniques	7.7	36.96	18.76 [7.83-36.66]	18.20 [-1.67-28.78]*
17 Qualitative urine output measurement	7.0	33.6	1.35 [0.66-2.45]	32.25 [31.15-32.96]*
18 Measurement of intracranial pressure	1.6	7.68	0.91 [0.28-2.62]	6.77 [5.07-7.4]*
19 Treatment of complicated metabolic acidosis	1.3	NA	NA	NA
20 Intravenous hyperalimentation	2.8	13.44	2.64 [0.79-4.1]	10.80 [9.41-12.65]*
21 Enteral feeding trhourgh gastric tube	1.3	6.24	1.87 [0.81-4.64]	4.37 [1.6-5.43]*
22 Specific interventions in the ICU	2.8	NA	NA	NA
23 Specific interventions outside the ICU	1.9	9.12	18.18 [5.69-27.46]	-9.06 [-18.34-3.43]*
Total per patient	-	202.56 [155.04-241.2]	98.52 [71.86-127.72]	84.7 [50.31-127.72]*

* Indicates a significant P-value of <0.05 (Wilcoxon signed-rank test)

[1] Titles are abbreviated. For full activity names see Supplementary Table 1.

NA: not measured during measurement

Discussion

Our analysis showed that the NAS overestimates the needed nursing time for patients in the Dutch ICU setting. Times of most NAS items were overestimated by the NAS, except for four activities (support or care for patient for about 1 hours, administrative tasks for less than 2 hours, administrative tasks for about 2 hours, and specific interventions outside the ICU), where the NAS gives an underestimation of the observed time. This study showed that 35% of nursing time is explained by the NAS model ($R^2 = 0.35$). The converted NAS time per patient (202.6 minutes per shift) in our study was comparable with the converted NAS times per patient in other studies. Bernet et al. (2005)[16] found 150 to 156 minutes per shift and Deberg et al. (2007)[17] found 180 to 228 minutes per shift. The different articles on the NAS give variable NAS times per shift. A full shift of work equals 480 minutes of nursing time.

The low correlation of Pearon's R and R^2 (0.59 and 0.35) implicates that the NAS is not accurate enough to estimate the nursing time at patient level. However, it is currently still the best nusing workload model for quantifying nursing workload in ICUs [5]. There is no clear cut-off point from which the model can be identified as 'good enough' based on the R^2. However, since the NAS is used for capacity planning, a R^2 closer to 1 would be more desirable.

Since in almost each shift ICU nurses also spend time on non-nursing duties, e.g. coaching a student or participating in an emergency team within the hospital, we performed a sensitivity analysis to determine whether these non-nursing duties were affecting the correlation. According to several studies nurses spend approximately 3 to 6% of their shift on non-nursing duties [18,19,20,21,22]. We therefore took the average of 4.5% and substracted this from the 80% of productive nursing time, which we used in this study to calculate the converted time per NAS point. Using this approximation, the converted time would have changed from 3.84 to 3.62 minutes per NAS point. This change does not affect the results and we therefore conclude that non-nursing duties are not significantly influencing the performance of the NAS.

A strength of our study is that we validated the NAS with time-and-motion measurements which are

considered to be the best technique for measuring nursing workload [12]. To our knowledge this has not been performed before in the context of NAS validation. Measurements for nursing activities by using time-and-motion measurements, are more accurate compared to the work-sampling approach as used for the development of the NAS [23]. Furthermore, since measurements took place in all types of ICUs, we believe that results of this study are generalizable to all Dutch ICUs.

One of the limitations in our study are the excluded NAS activities due to their non- or limited occurrence of less than ten times. Two of these activities are mostly scored in other categories of activities: the activity ‘intravenous replacement of large fluid losses’ is mostly scored under NAS item 1 ‘bedside’. The activity ‘treatment of complicated metabolic acidosis/alkalosis’ is mostly scored in NAS item 3 ‘medication’. Since these activities could be scored in other categories, these activities can be excluded from the NAS. Three NAS activities (respectively left atrium monitoring, cardiopulmonary resuscitation after arrest, and specific interventions in the ICU) and six subcategories 1b, 1c, 4b, 4c, 7b, and 8c (the nurse activities that required dedication from the nurse for more than 2, 3 or 4 hours) did not happen often enough (>=10 times) during the measurements which makes the validation of the NAS incomplete. Given the fact that the median time of nursing care per patient is 2.4 hours (144.3 minutes), dedication of a nurse for more than 2, 3 or 4 hours to one activity is extremely high. As these nursing activities rarely occur in daily ICU practice it is not likely that our results have been affected by this situation.

Furthermore, the observed patients seem to have been more severely ill and consequently had a longer length of stay compared to all Dutch patients in the same time period, which is likely caused by our selection mechanism. In order to measure as many nursing activities as possible we probably choose more often nurses who took care of patients that were expected to stay the whole shift and these patients were probably more severely ill. This may have biased our results since our aim was to validate the NAS and check for under- or overestimations compared to time-and-motion measurements and it is possible that observed times in sicker patients differ from those in less sick patients. However, according to Armstrong et al. (2015) NAS scores in intermediate care patients did

not differ from those in ICU patients [24].

Based on our results we believe there is room for improvement in the measurement of nursing workload. The NAS could be improved by adjusting the NAS points given to the different items. The developers of the NAS did not report the Pearsons R or R^2, but stated that the NAS is reflecting 81% of total nursing time. About 11% of the nurses' time is spent on personal activities. The remaining 8% comes from nursing activities derived from medical interventions, related exclusively to the severity of illness of the patient not measured by the NAS [7]. The TISS is taking these medical interventions into account, such as induced hypothermia, cardiac assist device, pacemaker, or ECG monitoring. For this reason, we suggest additional research towards the merging of the TISS-28 and the NAS. The models could be partly combined which could possibly improve the estimation of nursing workload. Our results on observed time per patient and per nursing activity could be taken into consideration when assigning weights to the activities in this new model. Moreover, we think that expressing nursing activities in minutes or hours would be more informative compared to points, since it is more straight forward for ICU managers to work with.

Conclusion

The NAS has been developed more than 15 years ago and significantly overestimates the needed nursing time for ICU patients in the current daily ICU practice. Therefore we recommend a revision of the time weights assigned to each nursing activity to get better insight in the true nursing workload and to enable a more adequate nursing capacity planning.

References

1. Hughes, R.: Patient safety and quality: An evidence-based handbook for nurses (Vol. 3). *Rockville, MD: Agency for Healthcare Research and Quality*
2. Aiken, L. H., Clarke, S. P., Sloane, D. M., et al: Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *Jama* 2002; 288(16), 1987-1993.
3. Margadant, C., Wortel, S., Hoogendoorn, et al.: The Nursing Activities Score per Nurse Ratio Is Associated With In-Hospital Mortality, Whereas the Patients Per Nurse

Ratio Is Not. *Critical Care Medicine* 2019; 48(1), 3-9.

4. Palese, A., Comisso, I., Burra, M., et al.: Nursing Activity Score for estimating nursing care need in intensive care units: findings from a face and content validity study. *Journal of nursing management*, 2006; *24*(4), 549-559.
5. Hoogendoorn, M. E., Margadant, C. C., Brinkman, S.: Workload scoring systems in the Intensive Care and their ability to quantify the need for nursing time: a systematic literature review. *International Journal of Nursing Studies* 2019; 103408.
6. Cullen, D. J., Civetta, J. M., Briggs, B. A., & Ferrara, L. C. (1974). Therapeutic intervention scoring system: a method for quantitative comparison of patient care.*Critical care medicine* 1974; 2(2), 57-60.
7. Miranda, D. R., Nap, R., de Rijk, A., et al.: Nursing activities score.*Critical care medicine* 2003; 31(2), 374-382.
8. Padilha, K. G., de Sousa, R. M. C., Garcia, P. C., et al.: Nursing workload and staff allocation in an intensive care unit: a pilot study according to Nursing Activities Score (NAS). *Intensive and Critical Care Nursing* 2010; 26(2), 108-113.
9. Gonçalves, L. A., Padilha, K. G., & Sousa, R. M. C. Nursing activities score (NAS): a proposal for practical application in intensive care units. *Intensive and Critical Care Nursing* 2007; 23(6), 355-361.
10. Urden, L. D., & Roode, J. L.: Work sampling: a decision-making tool for determining resources and work redesign.*Journal of Nursing Administration* 1997; *27*(9), 34-41.
11. Finkler, S. A., Knickman, J. R., Hendrickson, G. et al.: A comparison of work-sampling and time-and-motion techniques for studies in health services research.*Health services research* 1993;*28*(5), 577.
12. Burke, T. A., McKee, J. R., Wilson, et al.: A comparison of time-and-motion and self-reporting methods of work measurement. *JONA: The Journal of Nursing Administration*

2000; 30(3), 118-125.

13. Dutch National Intensive Care Evaluation (NICE) foundation. Available at: https://www.stichting-nice.nl/dd/#561 Accessed June 1, 2019.
14. Interview Reis Miranda, jaarboek NICE. Available at: https://www.stichting-nice.nl/focusIC.jsp Accessed September 1, 2019.
15. R Core Team. R: A language and Environment for Statistical Computing [computer program]. Vienna, Austria: R foundation. Available at: http://www.R-project.org Accessed May 1, 2019.
16. Bernat Adell A, Abizanda Campos R.: Nursing Activity Score (NAS). Our experience with a nursing load calculation system based on times. *Enferm Intensiva* 2005 Oct-Dec;16(4):164-73.
17. Debergh, D. P., Myny, D., Van Herzeele, I., et al.: Measuring the nursing workload per shift in the ICU. *Intensive care medicine* 2012; 38(9), 1438-1444.
18. Abbey Mphil, M., Chaboyer, W., & Mitchell, M.: Understanding the work of intensive care nurses: a time and motion study. *Australian Critical Care* 2012; 25(1), 13-22.
19. Bosman, R., Rood, E., Oudemans-van Straaten, H., Van der Spoel, J., et al.: Intensive care information system reduces documentation time of the nurses after cardiothoracic surgery. *Intensive care medicine* 2003; *29*(1), 83-90.
20. Harrison, L., Nixon, G.: Nursing activity in general intensive care. *Journal of Clinical Nursing* 2002; 11(2), 158-167.
21. Kaya, H., Kaya, N., Turan, Y. et al.: Nursing activities in intensive care units in Turkey. *International journal of nursing practice* 2011; *17*(3), 304-314.
22. Norrie, P.: Nurses' time management in intensive care. *Nursing in critical care* 1997; *2*(3), 121-125.
23. Steyerberg, E.W.: Evaluation of Performance. Clinical Prediction models: a practical

approach to development, validation, and updating. *Springer* 2009; p. 83-99.

24. Armstrong, E., de Waard, M. C., de Grooth, H. J. S., et al.: Using nursing activities score to assess nursing workload on a medium care unit. *Anesthesia & Analgesia* 2015; 121(5), 1274-1280.

Additional Files

Additional file 1

File format: .docx

Additional Figure 1. Interface of the web application used by observers during measurements.

Additional file 2

File format: .docx

Additional Table 1. Nursing activities according to the Nursing Activities Score.

Additional file 3

File format: .docx

Additional Box 1. Description of main variables.

Declarations

Ethics approval and consent to participate

All human and animal studies have been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Approval medical ethics committee: METC 28-09-2017.

Consent for publication

Not applicable.

Availability of data and material

The data that support the findings of this study are available from the National Intensive Care Evaluation (NICE) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the NICE registry.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CM and MH performed measurements for this study. CM analyzed and interpreted the data and wrote the article. All authors read and approved the final manuscript.

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Not applicable.

Authors’ information

Four coauthors (M. Hoogendoorn, R.J. Bosman, J.J. Spijkstra, and N.F. de Keizer) are members of the board of NICE.

Figures

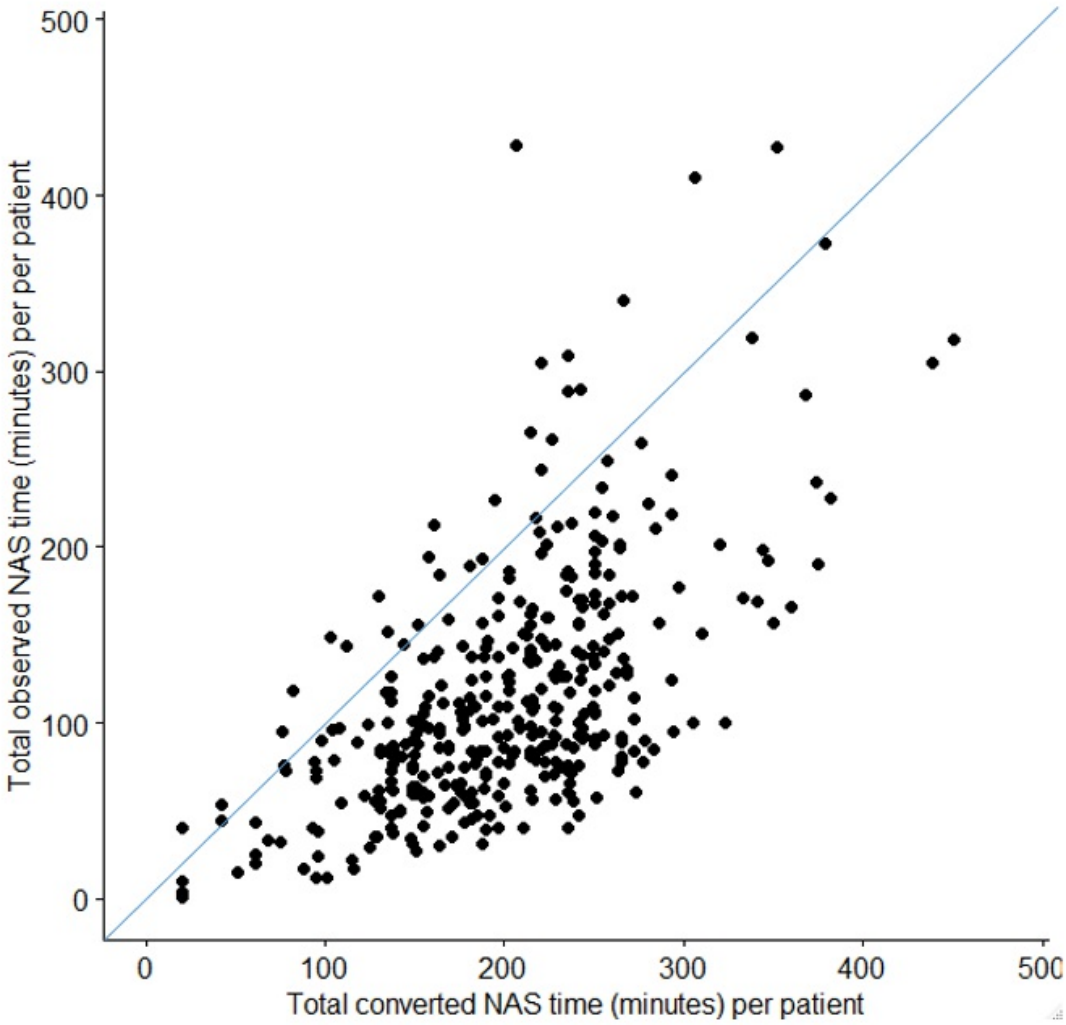

Figure 1

The correlation between the total converted NAS time in hours and the total observed time in minutes per patient. A full nursing shift is 480 minutes. Blue diagonal shows equal converted and observed time per patient.

Supplementary Files

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Additional file 2.docx
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