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Development and daily use of a numeric rating score to assess sleep quality in ICU patients

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Abstract

Purpose Insufficient sleep burdens critically ill patients, optimizing sleep may enhance patient's outcomes. Current assessment methods may unnecessary burden patients. Therefore, a single numeric rating score was validated for sleep assessment.

Materials and methods: First, two cross-sectional measurements on two separate days, from cooperative patients from 19 centers assessed their sleep sufficiency, the numeric rating score (NRS) and the Richards Campbell Sleep Questionnaire (RCSQ). Assessments were compared using a Bland Altman plot. A NRS cut-off was determined using regression analysis. Second, daily sleep assessment was implemented and monitored single center for a year.

Results: Multicenter, 194 patients assessed sleep quality, of which 53% was rated as sufficient. Mean (±SD) difference between RCSQ and NRS-Sleep using Bland-Altman analysis was 0.25 (±1.21, 95% limits of agreement -2.12 to 2.62). The optimal cut-off was >5. Single center, 1603 patients ranked 4532 ICU nights of sleep, of which 71% was sufficient; median NRS was 6 [IQR 5-7].

Conclusions: A single numeric rating score for sleep is interchangeable for the RCSQ score for assessment of sleep quality. Optimal cut-off is >5. Use of a numeric rating score for sleep is a practical way to evaluate and monitor sleep as perceived by patients in daily ICU practice.

Introduction

Insufficient sleep is a major burden to critically ill patients and may exert negative effects on both physical and psychological functioning, including altered immune function, hormonal imbalances, and cognitive disturbances [1-3]. Intensive care unit (ICU) patients have an increased risk of disturbed sleep [4, 5]. In order to mitigate the consequences of insufficient sleep, a first step is to have access to a feasible method to quantitatively determine the quality of sleep in critically ill patients.

Currently, the quality of sleep is measured in various ways, of which polysomnography (PSG) is considered the gold standard. However, this method is labor-intensive and a burden to patients and as a consequence rarely used in daily clinical practice [6]. In order to gather information on patients' sleep quality, a number of techniques and sleep questionnaires have been developed to assess different aspects of sleep, including the bispectral index [7, 8] and patient- [9-11] and nurse-derived assessments [12]. The Richards Campbell Sleep Questionnaire (RCSQ) [11] (Appendix 3) is currently the most widely used instrument for assessing sleep in ICU patients [2, 3, 6]. It consists of five themes assessing sleep depth, falling asleep, number of awakenings, awake time, and overall sleep quality [11]. However, to complete the RCSQ, patients must be awake and have the concentration span and cognitive ability to process five questions using 100 millimeter visual analogue scales. As a large proportion of ICU patients is unable to execute the RCSQ, its clinical feasibility in the ICU is limited [13]. It would therefore be of value for daily clinical use to be able using a more simple, accessible, but still accurate, quantitative measure to qualify sleep [14]. Furthermore, in patients that judge their sleep as adequate by the patient, the RCSQ questions may be considered as redundant. A numeric rating scale (NRS) is a simple and efficient way for assessments currently used for pain, but may also be convenient manner to rate ICU patients' sleeping experience that can also be used to visualize inter- and intra-patient trends over time. If a patient reports inadequate sleep, the RCSQ could then, subsequently be used to further identify and assess specific problems.

Therefore, we aimed to validate the use of a single numeric rating score for sleep assessment, and to determine a cut-off point for sufficient sleep, and assess sleep problems in daily ICU practice.

Material and methods

Study design

The study was conducted in two prospective phases.

In the first phase, a cross sectional multi center study was performed in 19 Dutch ICUs (three university, seven teaching and nine non-teaching hospitals, 4-42 beds) to assess the patients' perceived quality of sufficient sleep using the current standard, the Richards Campbell Sleep Questionnaire (RCSQ), a numeric rating scale and qualitative inquiry. All consecutive cooperative patients that were treated in the ICU during two separate visits in April 2014 and December 2014 were included.

The second phase was conducted in one university hospital between January and December 2015 in a 31 bed mixed ICU, in which sleep quality was prospectively assessed as standard of care in ICU patients, to evaluate the use of the score in daily practice and assess feasibility before considering broader multicenter implementation. We implemented a standardized evaluation of sleep quality using the NRS-Sleep for all patients that were able to communicate (Appendix 1). When patients ranked their sleep as insufficient (as illustrated by a NRS<6, based on the results of phase one), subsequently the full RCSQ was completed. This enabled nurses to systematically evaluate specific sleeping problems and assess them as appropriate, without burdening patients that judged their sleep sufficient. The attending nurse registered the score in the patient data management system, and provided a tailored sleep optimization protocol of non-pharmacological interventions, such as optimizing circadian rhythm and reducing stimuli at night, combined with protocolized pharmacological interventions based on patient inventoried needs and preferences

The study obtained ethical approval by the MREC region Arnhem-Nijmegen (2015-1706). The need for informed consent was waived. The results are reported according to the STARD 2015 reporting criteria [15].

Participants

All admitted and cooperative ICU patients of 18 year or older were included when conscious and alert or only lightly sedated (Richmond Agitation and Sedation Scale (RASS) -2 through +1) and admitted for at least one full night in the ICU. Patients were not approached when they were unable to

communicate in Dutch, were moribund, severely mentally disabled or suffered from serious receptive aphasia, or when patients would be disproportionally burdened by the questionnaires as judged by the attending nurse (i.e. because of critical illness, anxiety, delirium, or other relevant reasons).

Assessment methods

To avoid nightly disturbances and biased measurements because the night shift nurse may also have influenced sleep quality, all assessments were performed in the morning, between 08.00AM and noon, as soon as patients were ready for assessment. Patients were asked: 'Could you rank your sleep of the last night on a scale between 0 (a worst night sleep) and 10 (a best night sleep), verbally, or using your fingers? And was this sufficient or insufficient?'. Subsequently, the Dutch version of the RCSQ was used, for which patients were also asked to numerically rank verbally or using their fingers. When the patient perceived their sleep as insufficient, also further qualitative inquiry was performed towards potential causes: We asked: 'what was, or were the most important reasons you could not sleep?' In the first phase, dedicated and expert-trained nursing student researchers visited the 19 participating ICUs on two separate days.

During the second phase, the NRS was performed daily in ICU patients, as part of standard ICU care. Similar as in the first phase, all assessments were performed between 08.00AM and noon, as soon as patients were ready for assessment. Based on the results in the first phase, we protocolized that only in patients with a NRS<6, possible underlying sleep causes as measured by the RCSQ themes should be assessed.

Analyses

Patients characteristics, sleep data and other outcomes were collected and reported using descriptive statistics. Continuous variables were reported as either mean (SD) or median (interquartile range [IQR]), based on their distribution. The agreement between both scores was assessed using a Bland-Altman plot, for which the RCSQ scores were rounded into integer. The correlation between the RCSQ total score and the NRS-Sleep was determined using Pearsons' correlation coefficient. For

performance assessment of the RCSQ and NRS-Sleep, their AUROC-curves were plotted against sleep sufficiency, and the difference between both AUROCs was tested using the Hanley&McNeil test[16].

Logistic regression analysis was used in order to determine the cut-off value for sufficient sleep using the data of phase one, in which the sleep sufficiency (sufficient/insufficient) as judged by the patient, was entered as binary dependent variable. This was plotted against the numeric rating scores structured into cumulative categories (>1, >2, … >9). An optimal cut-off point was estimated through selection of the greatest area under the receiver operating characteristic (AUROC) (Figure 2, Appendix 2). The RCSQ themes collected in phase two were dichotomized to 'problematic' or 'not problematic', and the proportions of problematic scores were plotted to the NRS scores, in order to assess trends in the RCSQ themes related to the level of insufficiency (Figure 3).

Data were analyzed using SPSS Statistics 22-25 (IBM, New York, USA) and MedCalc for Windows, version 18.6 (MedCalc Software, Ostend, Belgium). A p-value of <0.05 was considered statistically significant.

Results

First phase

In the first phase a total of 468 ICU patients were enrolled, of which 194 patients (119 male (61%), age 65±16 years) were able to assess their previous night's sleep quality. Median 8 [IQR 6-13] patients per unit assessed their sleep. Main reason for exclusion were not being able to cooperate (N=109), and disproportional burdening to participate (as defined in the method section) (N=161). Patients were visited after a median ICU length of stay of 4 [IQR 2-9] days (Table 1).

The median numeric rating scale (NRS) score given was 6 [IQR 4-8]. When asked to rank their sleep in terms of adequacy, 103 (53%) experienced their sleep as sufficient. Comparably, median RCSQ rank was 6 [IQR 4-7] (Table 1). When sleep was reported as insufficient, reported causes as determined by the RCSQ were often multi-factorial. Pain was the most frequently reported reason for insufficient sleep (23%), followed by noise (19%) and light (11%) (Table 1).

The mean (±SD) difference found between the RCSQ and the NRS-Sleep in the Bland-Altman analysis was 0.25 (±1.21, 95% limits of agreement -2.12 to 2.62). No heteroscedasticity was observed (Figure 1). The NRS-Sleep significantly correlated with the RCSQ score R of0.88 (p<0.01).

The optimal cut-off value for good sleep was determined at a NRS >5 resulting in an AUROC of 0.81 (95%CI: 0.74-0.87, Figure 2) with a sensitivity of 83% and a specificity of 79% (Appendix 2).The AUROC of mean RCSQ was 0.84 (95%CI: 0.78-0.90) and AUROC of mean NRS-Sleep was 0.86 (95%CI: 0.81-0.92) which were not significantly different (Z-statistic 0.93, p=0.36) (Figure 2).

Second phase

In the second phase, 1603 patients rated their sleep in 4532 out of 7646 (59%) full nights of sleep in the ICU. Of them, 998 (62%) were male, the mean age was 63±14 years. The median [IQR] length of stay in the ICU was 1 [0-2] day (Table 1). Patients reported sufficient sleep in 3199 (71% of total) nights. Median NRS-Sleep was reported as 6 [IQR 5-7]. The sleeping problems were mostly multi-factorial and related to sleep depth (summed percentage 94%), sleep quality (88%), number of awakenings (76%), returning to sleep (74%) and falling asleep (61%) of the insufficient nights asleep and no trends were observed when these were related to the extent of insufficiency (Table 1, Figure 3).

Discussion

In this two-phased study we determined that the accuracy of a single numeric rating score for sleep (NRS-Sleep) is comparable to the Richards Campbell Sleep Questionnaire (RCSQ) mean score to assess sleep quality, with an optimal cut-off above five. Furthermore, we found that after implementation of the NRS-Sleep as part of standard care, the NRS-Sleep is a feasible method to evaluate and monitor sleep as perceived by the patient in daily ICU practice. As a consequence, the NRS appears valid to be used in daily clinical practice and to evaluate interventions aimed to enhance sleep quality in ICU patients in view of currently available and validated assessment instruments that are disproportionally burdening for patients due to time investment, complexity and number of questions [6, 12] and the observation that nurses overestimate the patients' sleeping quality [14, 17]. Although we want to emphasize the importance of adequate and sufficiently detailed assessment of sleeping problems, we should also aim to minimize the burden for patients and the registration burden for healthcare professionals in patients that rate their sleep as sufficient. We therefore recommend the use of a two step sleep assessment approach: First perform a NRS-Sleep assessment in all ICU patients, and second only perform a more detailed problem assessment by adding qualitative inquiry towards problems such as pain, light and noise or the use of a validated sleep assessment tool like the RCSQ in those patients that report that they had insufficient sleep. We feel the policy decision to only perform the full RCSQ when the patient rates his/her sleep as 'insufficient', reduces the burden for both care-providers and still facilitates personally tailored care for the patient.

In accordance with previous studies, we confirmed that a significant proportion of ICU patients suffers from insufficient sleep [18, 19]. Importantly, the reported incidences of insufficient sleep may still be an underestimation due to the substantial proportion of patients who are unable to assess their quality of sleep, for example due to delirium or the effect of sedatives [20]. Our finding that 59% in the first phase and 41% of patients in the second phase were unable to rank their previous nights slept illustrates this issue. On the other hand, the median ICU length of stay of 4 days in the ICU in phase one and from day 1 onwards in phase 2 indicates that the patients are able to rank their sleep while still critically ill or recovering from critical illness.

While the effects of insufficient sleep and their associations with ICU outcome measures have not been established unequivocally [18, 21], we found that application of a structured measurement and optimization of sleep is feasible in conscious and alert, or only lightly sedated, cooperative patients. As the current Society of Critical Care Medicine guideline [22] recommends that sedation should be titrated to maintain a light rather than a deep level of sedation in adult ICU patients [22], their effects on perceived sleep quality, but also delirium and agitation, should be monitored. We feel that patients will benefit from structural evaluation of and pro-active approach to improve sleep quality in the ICU setting.

There are several limitations of our study that need to be addressed. In the first phase we performed only two days of measurements. A point prevalence measurement has drawbacks, nevertheless, our results were similar compared to recent studies on sleep quality in the ICU [23, 24] and the fact that 19 ICUs participated increases the generalizability of the reported results. Second, because we only tested structured measurement of sleep in conscious and alert, or only lightly sedated, as well as cooperative patients, our findings may only apply to other ICU patients that not fulfill these criteria. Further studies should evaluate the NRS in these patients. Third, for pragmatic reasons, we decided to inquire the RCSQ as numerically rank verbally or using patients fingers, instead of the exact millimeters as described in the original publication [11]. This may have reduced the accuracy of the measurement of the RCSQ, but it appears unlikely that this would influence the outcome of our study. Finally, we did not assess the compliance and effect of the interventions that were taken to improve sleep quality and the association of the quality of sleep with sedation and delirium. Assessments of these associations might provide further insights in the contribution of sleep towards the impact on short- and long-term ICU outcomes, but was beyond the scope of the current study.

Conclusions

The accuracy of a single numeric rating score for sleep (NRS-Sleep) is similar, and therefore interchangeable with the Richards Campbell Sleep Questionnaire mean score for assessment of sleep quality. Using the optimal cut-off value of NRS-Sleep above five to indicate sufficient sleep, the RCSQ needs only to be assessed in patients with an NRS-score<5. Use of the NRS-Sleep in daily

practice is a feasible method to evaluate and monitor perceived sleep and may be used to evaluate interventions to enhance sleep quality.

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Table 1 – Patient characteristics and outcome measures

Patient characteristics	*Phase 1 - N=194*	*Phase 2 - N=1603*
Male	119 (61.3)	998 (62.3)
Age, mean (SD)	65 (±16)	63 (±14)
APACHE II score, median [IQR]	*not collected*	15 [12-19]
Admission type		
- Surgical	75 (38.6)	1062 (66.3)
- Medical	99 (51.0)	331 (20.6)
- Neurological	14 (7.2)	201 (12.5)
Admission day, median [IQR]	4 [2-9]	1 [1-2]
Mechanically ventilated	93 (48.0)	476 (29.7)
Sedatives administered	57 (19.6)	965 (60.2)
Use of sleeping medication	56 (29.6)	512 (31.9)
RASS score, median [IQR]	0 [-1-0]	0 [-2-0]
Outcome measures	*N=194 nights*	*N=4532 nights*
NRS Sleep, median [IQR]	6 [4-6]	6 [5-7]
Sufficient	103 (53.1)	3199 (70.6)
RCSQ-score		
Sleep depth, median [IQR]	6 [4-7]	-
Falling asleep, median [IQR]	6 [4-8]	-
Awakenings, median [IQR]	5 [3-7]	-
Returning to sleep, median [IQR]	6 [3-7]	-
Sleep quality, median [IQR]	6 [4-8]	-
Total, median [IQR]	6 [4-7]	-
Insufficient sleep - Important reasons stratified	*N=91 nights*	*N=1379 nights*
Pain	44 (22.7)	-
Noise	36 (18.6)	-
Light	21 (10.8)	-
RCSQ-themes		
Sleep depth	-	1296 (94)
Falling asleep	-	847 (61.4)
Awakenings	-	1042 (75.6)
Returning to sleep	-	1026 (74.4)
Sleep quality	-	1217 (88.3)

Data are presented as N (%), unless mentioned otherwise.

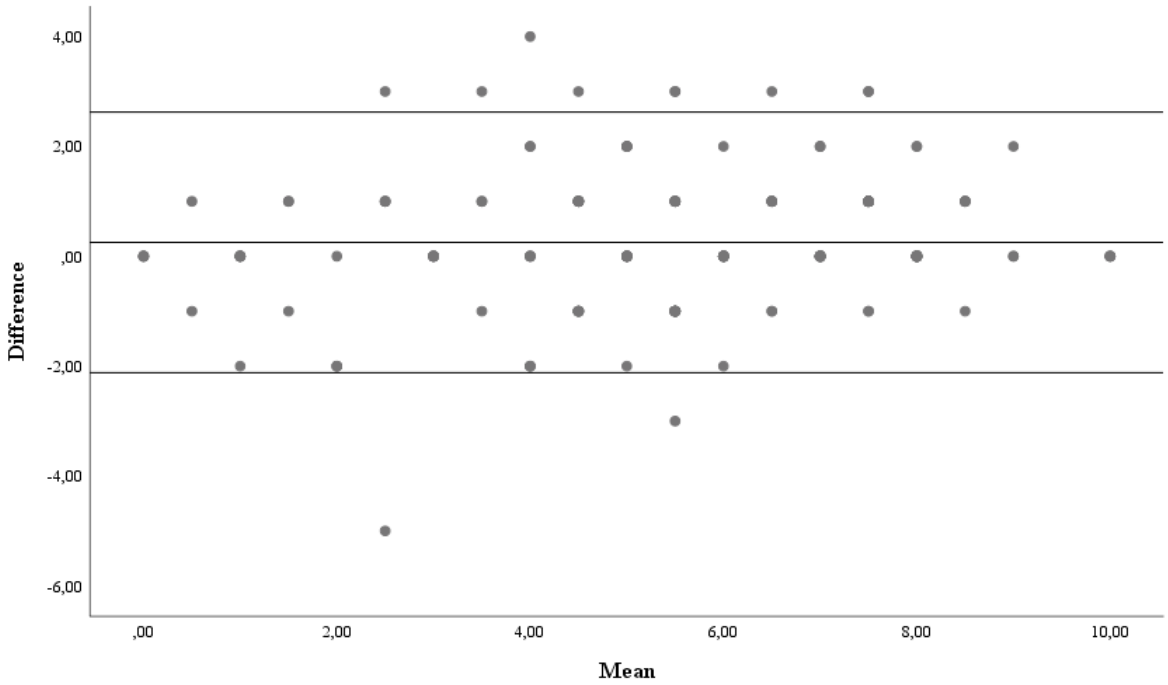


Figure 1. Bland Altman plot of rounded RCSQ mean score versus NRS-Sleep score

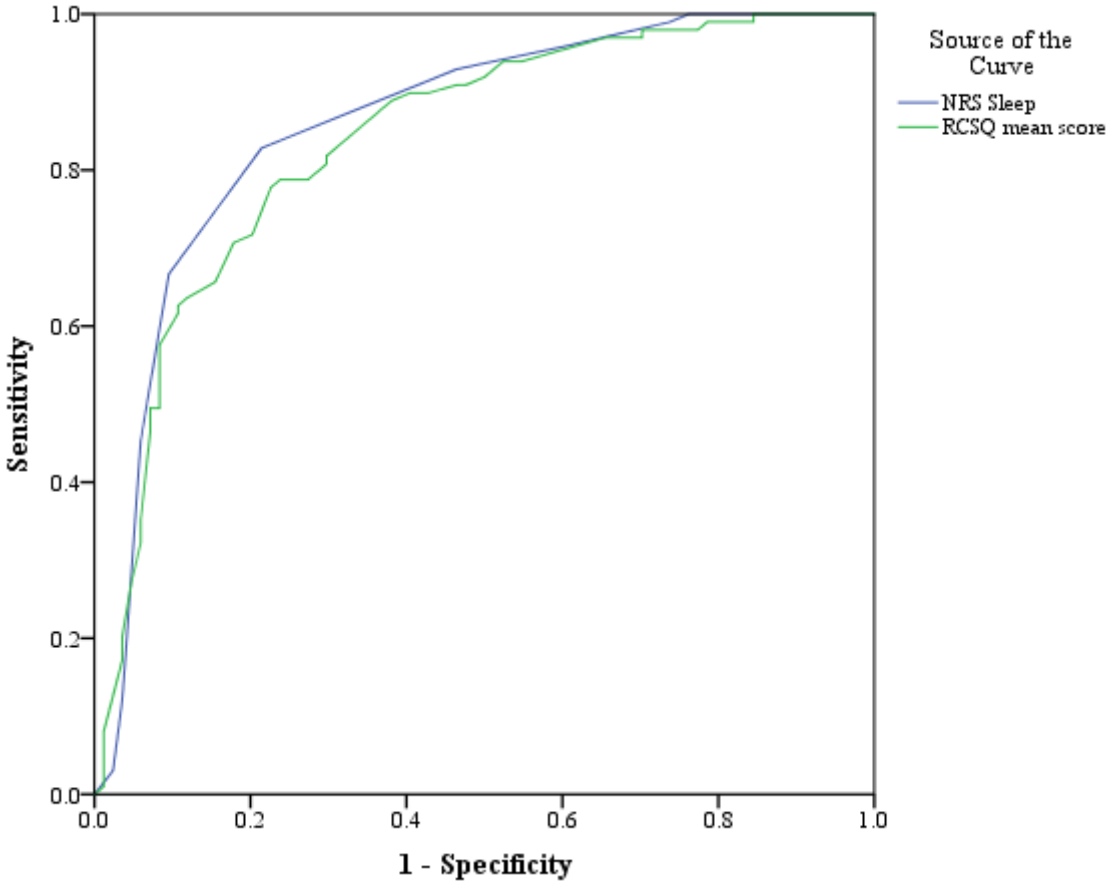


Figure 2. Performance assessment of NRS-Sleep versus RCSQ total score, compared to patients assessment of sleep sufficiency (AUROC RCSQ: 0.84 (95%CI: 0.78-0.90), AUROC NRS-Sleep: 0.86 (95%CI: 0.81-0.92) (p=0.36).

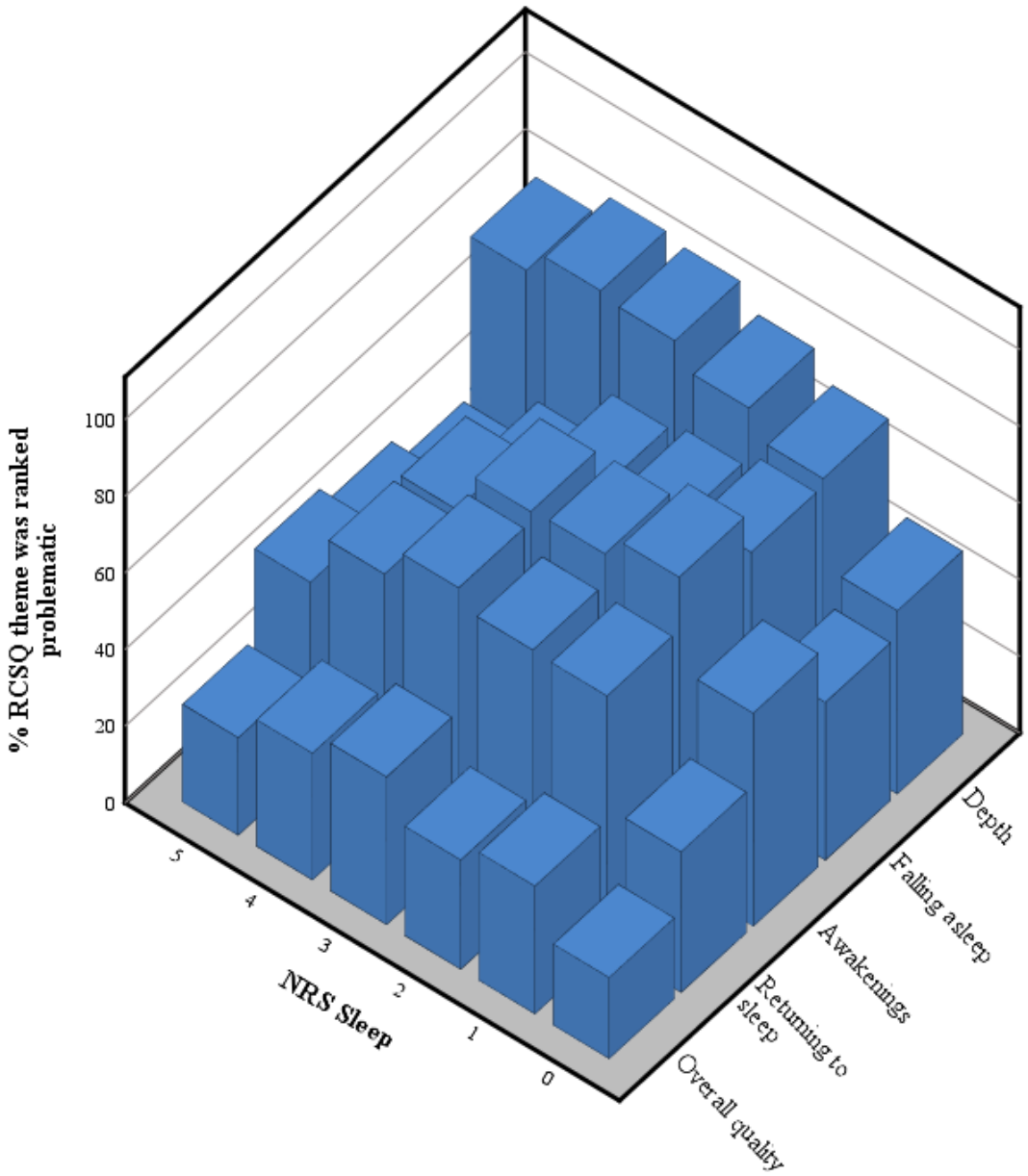
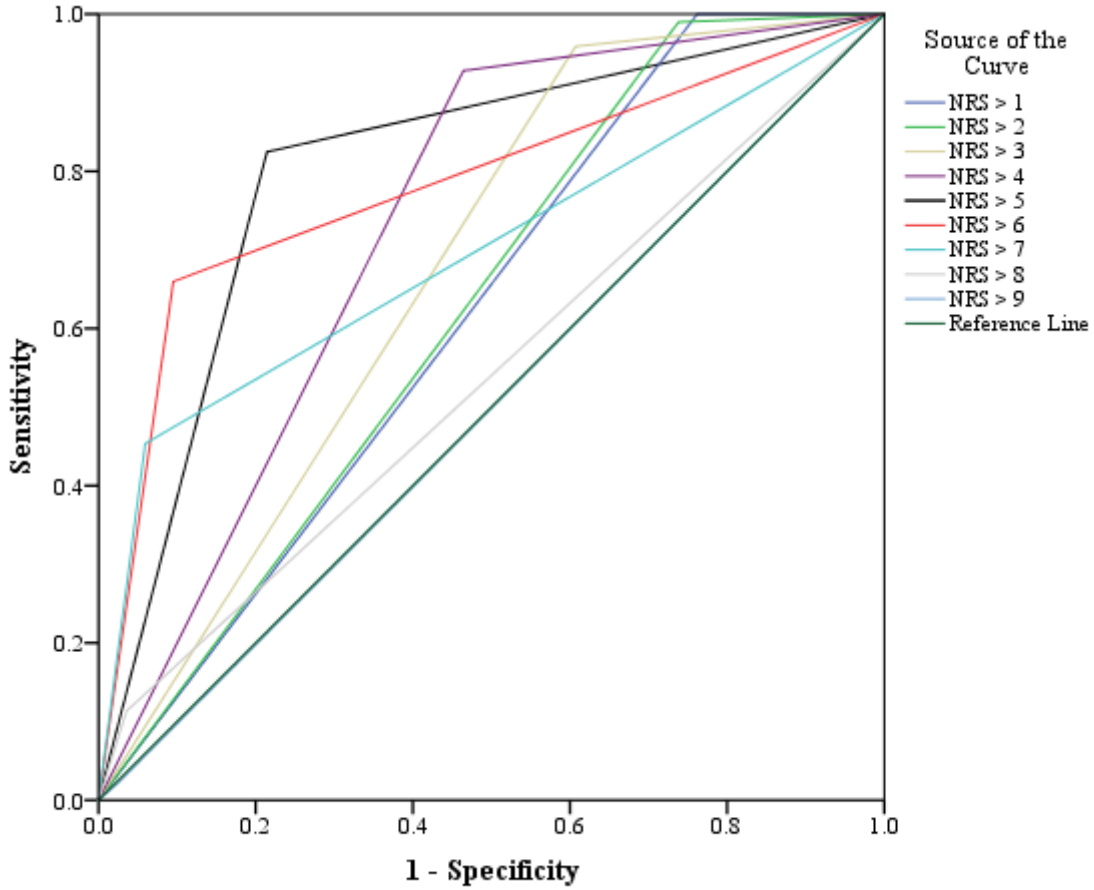


Figure 3. Proportion in which RCSQ theme was problematic and contributed to insufficient sleep in (NRS Scores 0-5, N=1379 nights)

Appendix 1. Numeric Rating Scale for Sleep (NRS-Sleep)

Appendix 2. Area under the curve for determination of a cut off for the NRS-Sleep



NRS	Area	SE	Sensitivity	Specificity	PPV	NPV
>1	0.62	0.04	1.0	0.24	0.65	1.0
>2	0.63	0.04	0.99	0.26	0.65	0.94
>3	0.68	0.04	0.96	0.39	0.68	0.91
>4	0.73	0.04	0.93	0.54	0.72	0.85
>5	***0.81***	***0.03***	***0.83***	***0.79***	***0.84***	***0.76***
>6	0.78	0.04	0.67	0.92	0.95	0.68
>7	0.70	0.04	0.46	0.94	0.95	0.56
>8	0.54	0.04	0.12	0.96	0.9	0.44
>9	0.50	0.04	0.03	0.98	1.0	0.42

Appendix 3. Richards-Campbell Sleep Questionnaire

1. My sleep last night was	Deep Sleep	Light Sleep
2. Last night, the first time I got to sleep, I:	Fell asleep almost immediately	Just never could
3. Last night, I was:	Awake very little	Awake all night long
4. Last night, when I woke up or was awakened, I:	Got back to sleep immediately	Couldn't get back to sleep
5. I would describe my sleep last night as:	A good night's sleep	A bad night's sleep

In the original version of the RCSQ items are constructed by five visual analog scales (VAS) of 100 millimeters. Scores for each visual analog and the composite score range from 0 (indicating poorest quality sleep) to 100 (indicating optimum sleep). Responses are scored by measuring the millimeters from the low end of the scale to the subject's mark. The total score for the RCSQ is calculated by dividing the sum of the total length in millimeters of the VAS lines by five[11].

In this study, patients were asked: 'Could you rank your sleep of the last night on a scale between 0 (a worst night sleep) and 10 (a best night sleep), verbally, or using your fingers?

Highlights

- Insufficient sleep burdens critically ill patients, optimizing sleep may enhance patient's outcomes.
- Current assessment methods may unnecessary burden patients.
- A single numeric rating score for sleep (NRS-Sleep) is interchangeable for the RCSQ score for assessment of sleep quality.
- An optimal NRS-Sleep cut-off for sufficient sleep is >5.
- Use of the NRS-Sleep is a practical way to evaluate and monitor sleep as perceived by patients in daily ICU practice.