Quality of sleep in hospitalised patients: a nationwide, single-day, multicentre study using flash mob design

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KEY POINTS

Question What is the quantity and quality of sleep in hospitalised patients compared to their habitual sleep at home and what are the main factors disturbing sleep during hospitalisation?

Findings In this nationwide, single-day, multicentre, cross-sectional, observational study including 2005 patients, we found that both sleep duration and sleep quality was significantly affected compared to patients habitual sleep at home. We identified many potentially modifiable hospital and patient-related factors associated with sleep disturbances in the hospital.

Meaning Quality and quantity of sleep in hospitalised patients is suboptimal and many hospital related factors are negatively associated. Introducing interventions to target disturbing factors in the hospitals, may improve healing.

ABSTRACT

Importance Although inadequate sleep has been proven to have a negative impact on health care outcomes, no large-scale studies examined sleep in general hospital wards.

Objective The aims of this study were to assess the subjective quantity and quality of sleep, and to identify the (hospital related) factors associated with sleep disturbances in hospitalised patients.

Design A nationwide, single-day, multicentre, cross-sectional, observational study which took place on February 22th 2017.

Setting All hospitals in the Netherlands were encouraged by word-of-mouth, conventional and social media to participate in this study, 39 hospitals participated.

Participants All included patients were at least 18 years of age, able to give informed consent and had spent at least one night on a regular ward.

Exposures Consensus Sleep Diary (CSD) and the Patient-Reported Outcomes Measurement Information System (PROMIS) Sleep Disturbance item bank, were used. Complementary questions assessed disturbing factors.

Main Outcome(s) and Measure(s) Quantity and quality of last night's sleep in the hospital compared to habitual sleep at home the month prior to hospitalisation.

Results In total 2005 patients were included (51% male, median age 68 years [IQR 57-77]). Compared to habitual sleep at home, the total sleep time in the hospital was 83 minutes ([95% CI 75-92], p<·001) shorter. The mean number of nocturnal awakenings was 2·0 [95% CI 1·9-2·1] times at home versus 3·3 [95% CI 3·2-3·5] during hospitalisation (p<·001). Patients woke up 44 minutes ([95% CI 44-45], p<·001) earlier than their habitual wake up time at home. 70% reported to have been awakened by external causes, which in 36% concerned hospital staff. Patients experienced significantly more sleep disturbance in the hospital than at home (p<·001). The most reported sleep disturbing factors were noise of other patients, medical devices, pain, and toilet visits.

Conclusions and Relevance This first large-scale multicentre study assessing sleep in hospitalised patients on regular wards, demonstrated that the duration and the quality of sleep in hospitalised patients were significantly affected and revealed many potentially modifiable hospital-related factors negatively associated with sleep. Raising awareness about the importance of adequate sleep in the vulnerable hospital population, and introducing interventions to target disturbing factors may improve healing.

INTRODUCTION

Inadequate sleep negatively impacts general health and wellbeing.[1-4] Small studies in selected patient populations suggest that sleep in hospitals is suboptimal.[5-9] However, information about the quantity and quality of sleep in patients in general in-hospital wards is lacking. A good night's sleep improves cognitive and emotional functioning[10] which is of importance during an often emotionally challenging stay in the hospital. Sleep is essential for adequate immune-, metabolic-, endocrine functioning [1,11-13] and may have a negative effect on healing and survival.[14] Studies suggest that sleep deprivation is a possible key risk factor for development of delirium.[15,16]

Both patient-related factors such as pain and hospital-related factors such as noises from alarms or sleep interruptions due to medical procedures may contribute to disturbance of sleep. [17-20] However, no large-scale multicentre studies have been performed to investigate how these factors are associated with sleep disturbance in hospitals.

Identifying relevant and potentially modifiable hospital-related factors associated with sleep disturbances can be the key to introducing remedial measures.

The primary aims of this nationwide single day study were to assess the quantity and quality of sleep and to identify the (hospital related) factors associated with sleep disturbances in hospitalised patients.

METHODS

Study Design and Participants

This was a nationwide, single-day, multicentre, cross-sectional observational study using the flash mob research (FMR) method which allows the investigation of clinically relevant questions on a large scale in a short time course.[21] FMR is based on the concept of flash mobs: "a sudden and planned gathering of many people at a particular place that has been arranged earlier". Using multiple hospitals it is possible to obtain sufficient data with FMR in a short time course. After preparing the study, the coordinators invited acute internists from hospitals throughout the Netherlands to participate in the study using word-of-mouth, conventional and social media. Hospitals were also recruited through the professional network of the members of the ORCA Acute Medicine research consortium.[22] All participating hospitals received approval from their local ethics committees to obtain verbal consent with annotation in the patient record. The coordinating centre the VU University Medical Center (VUmc) Amsterdam, provided a standardized protocol, instructions on procedures, case report forms and questionnaires. The study was performed on February 22, 2017 between 8:00-17:00 hours. To stimulate participation by health care workers and patients, conventional and social media received some information prior to the study. However, to minimise observer and participant bias, release of the exact study date was embargoed until 6:00 hours February 22, 2017.

Eligible for enrolment were all patients of at least 18 years of age, with any disease condition, able to give informed consent and who spent at least the night prior to the data collection on a regular ward. Patients from intensive, coronary care, and stroke units were excluded.

Questionnaire

Consensus Sleep Diary (CSD) was used to asses subjective sleep quantity.[23] Additionally, after reaching consensus among the coordinating members, we selected 5 out of 8 items from the Dutch-Flemish Patient-Reported Outcomes Measurement Information System (PROMIS™) v1.0 Sleep Disturbance item bank (Short Form 8a) and a sixth item from the complete PROMIS item bank which in our opinion were best suitable to measure sleep disturbance in hospitalised patients.[24,25] In order to measure the differences in sleep experiences in the hospital versus home, each item was asked twice: once with reference to the previous night at the hospital, and once with reference to habitual sleep at home during the month prior to hospitalisation. These items were complemented by questions about hospital-

related, personal, and environmental factors that could have influenced sleep, including use of sleep medication (see pp 3-8 of supplementary appendix for the questionnaire).

Sleep Quantity: CSD items assessed subjective estimates of: the clock times of lights out (closing the eyes to fall asleep) and final awakening; sleep onset latency (SOL, i.e. time taken to fall asleep); the number of awakenings; and the total duration of wake after sleep onset (WASO i.e. time spent awake after going to sleep). The information provided was used to calculate total sleep time (TST, i.e. actual time spent asleep) and sleep efficiency (SE, i.e. the proportion of sleep relative to the time between lights out and final awakening).

Sleep Disturbance: The included 5-point Likert-type PROMIS items assessed two positive ("satisfying", "refreshing") and three negative ("restless", "difficulty falling asleep", "feeling lousy when waking up") evaluations of sleep. Each item provided a statement and asked how well it suited the patient, from "not at all" to "very much". A sixth item on general sleep quality was answered by "very poor" to "very good". The items assessing positive evaluations were recoded in such a way that a higher score indicated more sleep disturbance. Because the time frame was adjusted for the design of this study, we did not calculate PROMIS T-scores, but only used raw summary scores (0 to 24) describing overall sleep disturbance.

Disturbing factors: The CSD items were complemented by questions on whether sleep was affected by a list of disease related, hospital-related, personal or environmental disturbing factors. An additional text field allowed patients to fill out other factors.

Statistical analysis
Intrinsic to the FMR approach no fixed sample size was set *a priori*, but to obtain reliable and generalizable results, and based on what was shown feasible in previous studies, we aimed to include at least 1000 patients[16].

Categorical variables are summarized by percentages. Continuous variables are summarized by means and 95% confidence intervals (95% CI) or median and inter-quartile range (IQR). Mean sleep quality and quantity were compared between hospital and home using mixed linear models with the patients' difference scores (hospital relative to home) as the dependent variable, an intercept-only model for the fixed part and a random effect for hospital. Means were concluded to differ between hospital and home when the fixed intercept differed significantly from 0. To check whether differences in mean sleep quality and quantity between hospital and home varied across groups of patients, we added a fixed effect for the grouping variable to the mixed model. Transformations of the dependent variable were considered in case residuals were not normally distributed. In order to assess the robustness of the conclusions based on mixed-model analysis to deviations from normality, additional sensitivity analyses were performed in which we compared the individual differences between groups using non-parametric tests (Mann-Whitney test and Kruskal-Wallis ANOVA). The non-parametric tests ignored the clustering of patients within hospitals, but this clustering was found to be ignorable as the variance component for the random effect of hospital in the mixed models was often estimated to be 0. Normality of dependent variables and residuals from the mixed models was checked using normal probability plots. Analyses were performed in Statistical Package for Social Sciences for Windows, version 21 (SPSS Inc., Chicago, IL, USA). P-values <0·05 were considered statistically significant.

RESULTS

An estimated potential population of around 2500 patients could be included. Some could not be included either because they were too sick or could not grant consent due to cognitive disturbances (on clinical grounds). The questionnaire was completed by 2005 patients in 39 Dutch hospitals (out of 93 hospitals). Non-surgical specialties were best represented (81%) (table 1). A total of 335 patients (17%) had been taking sleep medication at home (of which 56% benzodiazepines) and 539 (27%) the previous night (of which 49% benzodiazepines) (supplementary appendix table 1).

The patients (n=1427, 71%) who provided complete (home and at hospital) answers to all CSD questions were included in the sleep quantity analysis (figure 1). Excluded patients (n=578, 29%) did not differ from included patients with respect to baseline characteristics (supplementary appendix table 2).

Raw summary difference scores for PROMIS questions could be calculated in 1885 (94%) patients because of few missing answers in some patients. However, because many patients only forgot to fill out 1 out of 12 questions, we also chose to calculate the difference for each question separately (table 3).

Sleep quantity

Table 2 summarizes the CSD measures of subjective sleep quantity. Average TST was 83 minutes [95% CI 75-92] shorter: 07:27 hours [95% CI 07:21-07:33] at home versus 06:04 hours [95% CI 05:56-06:11] during hospitalisation (p<0·001). The difference resulted primarily from earlier final awakening, on average 44 minutes [95% CI 44-45]. There was a higher number of awakenings in the hospital: 2·0 times [95% CI 1·9-2·1] home versus 3·3 times [95% CI 3·2-3·5] hospital (p<0·001). Sleep efficiency (SE) was lower in the hospital: 88% [95% CI 88-89] home versus 76% [95% CI 75-77] hospital (difference of 12% [95% CI 14-11], p<0·001).

Sleep disturbance

Table 3 summarizes the PROMIS items of subjective sleep disturbance. For all six questions (supplementary appendix table 3 and figure 1) there was a significant worse rating in the hospital versus at home (p<0·001) . Raw summary scores and differences in scores were not significantly influenced by gender (p=0·063), length of stay (p=0·139) or number of patients sleeping in the same room (p=0·540). Patients admitted to a surgical unit experienced more sleep disturbance than patients in non-surgical-units (respectively 10·5 [95% CI 9 ·9-11·2] vs. 9·6 [95% CI 9·3-9·9], p=0·019) while there was no difference in sleep disturbance between these groups at home. Older patients experienced less sleep disturbance during hospitalisation than younger patients . Sleep disturbance at home did not differ across age groups (p=0·839) (supplementary appendix table 4 and figure 2).

Disturbing factors

Sleep was negatively associated with at least one hospital-related factor in 65% of patients. Noise of other patients was found to be the most common disturbing factor, interfering with sleep onset in 24% of the patients. Eighty five percent reported at least one nocturnal awakening of which 66% was attributed to hospital-related factors including noise of other patients (23%), and being woken up by

hospital staff (20%). Toilet visits were responsible for nocturnal awakenings in 22% of the patients. Only 30% of the patients reported to have woken up spontaneously in the morning. Of patients who had not woken up spontaneously, hospital-related reasons were responsible for the awakening in 74% of cases, of which 36% concerned awakenings by a member of the hospital staff (figure 2 and supplementary appendix table 5 and figure 3)).

DISCUSSION

To our knowledge, this nationwide, single-day, multicentre, cross-sectional, observational, flash mob study is the first large scale study examining the prevalence, the severity and the factors negatively associated with sleep quantity and sleep quality in hospitalised patients. We found that hospitalised patients sleep shorter with more interruptions, wake up earlier and experience poorer sleep quality than at home. In two-thirds of cases, disturbances involve hospital-related factors, of which many seem modifiable.

In line with other studies[9,17,20,26,27], we identified noises and awakenings by medical staff as the most important hospital-related sleep-disturbing factors. Although not included in the list of potential disruptors an important disturbing factor frequently mentioned by the patients was waking up for toilet visits. Continuous IV drips at night and extra diuretics may have contributed to this increased frequency in the hospital. Most of the disturbing factors found in our study seem relatively easy to address by incorporating simple changes in nightly hospital routines. A recent pilot study demonstrated an increase in total sleep time and subjective sleep quality after offering sleep hygiene education to nurses, introducing interventions to minimise light and noise disturbances, reducing care related disruptions and overnight fluids.[28]
There was no significant difference in the effects on sleep quantity and quality in patients sleeping in a single room compared to patients sleeping in a room with other patients. A probable explanation is that in most Dutch hospitals the sickest patients are prioritized for sleeping in a single room because of scarcity and need for more care related disruptions. Majority of our population (57%) was above 65 years and experienced less sleep disturbances in the hospital possibly because they are used to more disrupted sleep at home. In addition, sleep disturbance at home did not differ across age groups probably because the younger patients were also likely to have relatively high burden of co-morbidity affecting their sleep at home as well as in the hospital.

Main strength of the present study is that by using the FMS design we included a large heterogeneous sample of patients within one day. The hospitals were located in different regions of the Netherlands and included academic, non-academic teaching and non-teaching hospitals in urban and rural areas. Therefore, it was very likely that we had a representative sample of the Dutch hospitals.

There were some limitations. For the subjective sleep quantity outcomes almost one-third of the patients had to be excluded because of missing or incompatible data.
 There were no differences in the demographic characteristics of included and excluded patients hence we assumed that the included population was representative for the total study population. In addition, 41 patients reporting total sleep deprivation the last night in the hospital were excluded because of missing exact time data. This will have led to un overestimation of sleep duration during hospitalization.

In addition, some admitted patients were not eligible for inclusion due to delirium or cognitive problems. Other patients were asleep when the questionnaires were handed out, possibly because they

did not sleep enough at night. Some were too ill or exhausted.   This may have led to a conservative estimate of sleep problems during hospitalisation.

A downside of using the habitual sleep at home during the month prior to admission is the lack of information about the condition patients were in during that period. Possibly, it deviated from their usual sleep at home because of upcoming illnesses prior to admission. In addition, recall bias may have played a role leading to more positive estimates of in-home sleep and inflated the differences between in-home and in-hospital sleep ratings. This could have led to underestimation of sleep quantity and quality difference at home versus hospital. .

In conclusion, this first large scale multicentre study demonstrated compromised sleep quantity and quality in hospitalised patients and identified many potentially preventable hospital-related factors. Increasing the awareness among the health care workers of the importance of adequate sleep and introducing interventions targeting sleep disturbing factors in the hospitals may lead to better sleep and better health outcomes.

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Table 1: Patient characteristics

	n (%) or median (IQR)
Gender (n=1935)	
Male, n (%)	994 (51)
Female, n (%)	941 (49)
Age (years) (n=1975), median (IQR)	68 (57 – 77)
≤ 35, n (%)	117 (6)
36-50, n (%)	216 (11)
51-65, n (%)	525 (27)
66-80, n (%)	765 (39)
≥ 81, n (%)	352 (18)
Length of stay (n=1773), median (IQR)	4 (2 - 8)
1 night, n (%)	359 (20)
> 1 nights, n (%)	1414 (80)
Number of patients in room (n=1773), median (IQR)	2 (1 - 4)
1, n (%)	504 (25)
2, n (%)	514 (26)
3, n (%)	163 (8)
4, n (%)	774 (39)
≥ 5, n (%)	35 (2)
Ward type (n=1945)	
Acute admission unit, n (%)	269 (14)
Regular ward, n (%)	1676 (86)
Specialty (n=1897)	
Surgical specialties, n (%)[a]	361 (19)
Non-surgical specialties, n (%)[b]	1536 (81)
Surgery (n=1981)	
Yes, n (%)	451 (23)
No, n (%)	1530 (77)

Data are median (IQR) or n (%).
[a]Surgical specialties: (Cardiothoracic-, Vascular-, Plastic-, Neuro-, Ophthalmic-, General-) Surgery, Orthopaedics, Urology, Gynaecology, Traumatology, Anaesthesiology, Ear, nose, throat.
[b]Non-surgical specialties: Cardiology, Geriatrics, Dermatology, Gastroenterology, Haematology, Internal medicine, Nephrology, Neurology, Oncology, Psychiatry, Pulmonology, Rheumatology.
All 2005 patients answered the questions concerning demographics and disturbing factors. In 30 cases the necessary demographic information could not be extracted mainly because we could not read their hand writing (n=1975).

Table 2: Subjective Sleep Disturbance scores (PROMIS)

	Median (IQR)	Mean difference (CI)	p-value
My sleep quality was…			
Home (n=1958)	3 (2-3)	0·58 (0·52 - 0·64)	p<·001
Hospital (n=1966)	2 (1-3)		
I was satisfied with my sleep			
Home (n=1960)	3 (2-3)	0·60 (0·53 - 0·67)	p<·001
Hospital (n=1961)	2 (1-3)		
My sleep was refreshing			
Home (n=1961)	3 (2-3)	0·63 (0·56 - 0·70)	p<·001
Hospital (n=1969)	2 (1-3)		
My sleep was restless			
Home (n=1951)	1 (0-2)	-0·45 (-0·52 --0·38)	p<·001
Hospital (n=1952)	1 (0-3)		
I had difficulty falling asleep			
Home (n=1957)	0 (0-1)	-0·51 (-0·59 --0·44)	p<·001
Hospital (n=1958)	1 (0-3)		
I felt lousy when I woke up			
Home (n=1952)	0 (0-1)	-0·24 (-0·30 --0·18)	p<·001
Hospital (n=1956)	0 (0-1)		
Summary Score			
Home (n=1914)	5 (3-9)	-3·0 (-3·4 - -2·7)	p<·001
Hospital (n=1921)	9 (5-14)		

Every question was answered using a 5-point scale, scored as follow: very poor/not at all (0), poor/ a little bit (1), fair/somewhat (2), good/quite a bit (3), very good/very much (4). A summary PROMIS Sleep Disturbance score was calculated after reverse coding the second and third item. A higher summary score indicates more subjective sleep disturbance (range 0-24). Differences indicate hospital minus home scores.

Table 3: Subjective sleep quantity and timing measures (CSD)

	Home	Hospital	Difference	p-value
Lights out time	23:05 (23:01 – 23:08)	22:57 (22:52 – 23:01)	-8 (-9 – -8)	·002
Sleep onset	23:29 (23:25 – 23:33)	23:41 (23:35 – 23:46)	12 (12 – 12)	<·001
Sleep onset latency	23 (21 – 25)	44 (40 – 47)	21 (21 – 21)	<·001
Wake after sleep onset	32 (29 – 34)	61 (57 – 65)	29 (29 – 29)	<·001
Final wake time	07:28 (07:24 – 07:32)	06:44 (06:40 – 06:48)	-44 (-45 – -44)	<·001
Sleep window	08:23 (08:18 – 08:28)	07:47 (07:42 – 07:52)	-36 (-36 – -36)	<·001
Total sleep time	07:27 (07:21 – 07:33)	06:04 (05:56 – 06:11)	- 83 (-92 – -75)	<·001
Sleep efficiency	88% (88% – 89%)	76% (75% –77%)	-12% (-14% – -11%)	<·001

Mean clock time (hh:mm), duration (minutes) or percentage, and 95% confidence intervals (CI) of subjective sleep measures at home during the month prior to admission and in the hospital the night before the questionnaire was filled out. All time differences are shown as minutes (CI). Differences indicate hospital minus home scores. The summary measures are based on the N=1427 patients who provided compatible answers to all Consensus Sleep Diary questions.

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│  ┌──────────────┐                          ┌──────────────────────────┐    │
│  │   n=2005     │                          │  Data hospital n=413     │    │
│  └──────┬───────┘                          │  (Did not sleep at all   │    │
│         │                                  │   n=41)                  │    │
│         │                                  │  (missing n=363)         │    │
│         │                                  │  (incompatible n=9)      │    │
│         │        ┌──────────────────┐      └──────────────────────────┘    │
│         ├───────▶│ Excluded n=578ᵃ  ├───┐                                   │
│         │        └──────────────────┘   │                                  │
│         │                               │  ┌──────────────────────────┐    │
│         │                               │  │  Data home n=165         │    │
│         │                               └─▶│  (missing: n=161)        │    │
│         │                                  │  (incompatible: n=4)     │    │
│         │                                  └──────────────────────────┘    │
│         ▼                                                                  │
│  ┌──────────────┐                                                          │
│  │   n=1427     │                                                          │
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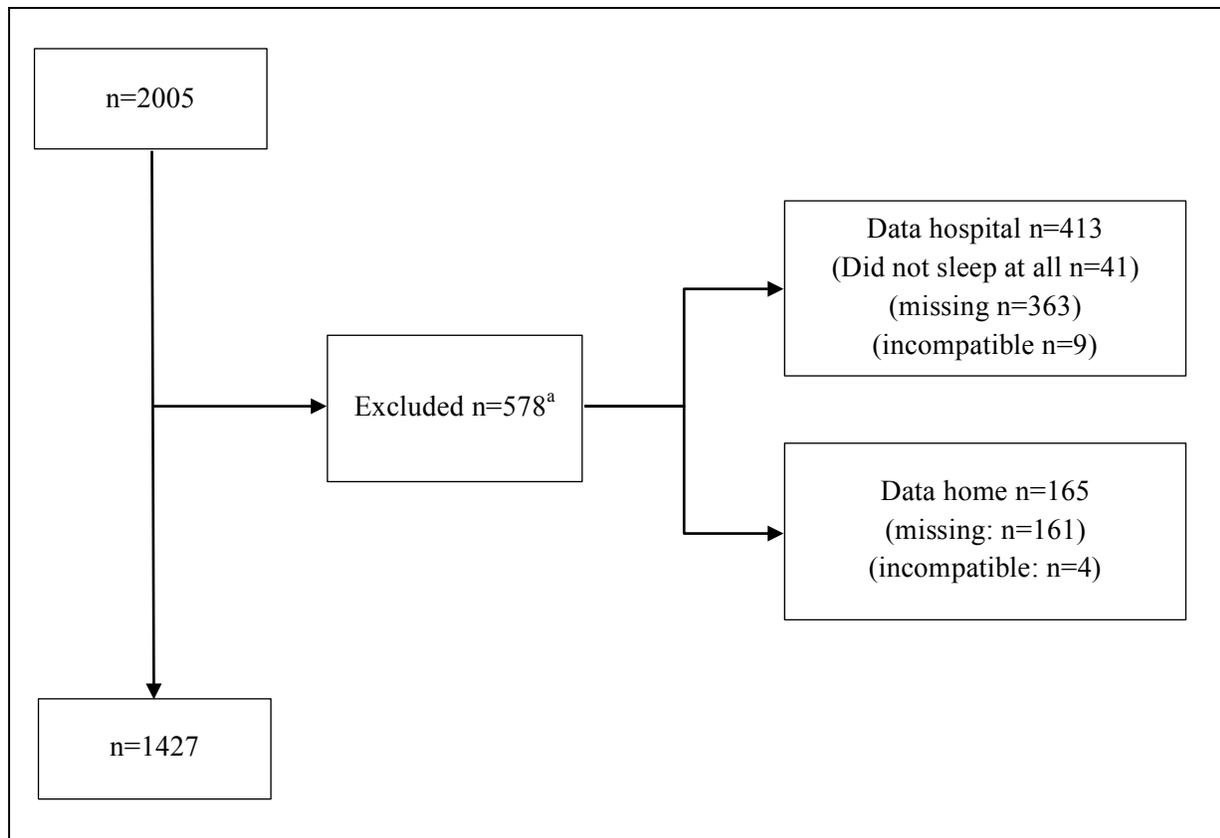
[a]A total of 578 patients did not answer questions or gave answers that were not compatible with the questions asked about sleep in hospital and/or home situation. Furthermore, 41 patients reported no sleep at all during the past night so time calculations could not be made. They were excluded from analyses.

Figure 1: Inclusion

SLEEP VARIABLE	CATEGORY DISTURBING FACTOR[a]	TOP 3 DISTURBING[b]
SLEEP ONSET LATENCY ≥ 1 reasons n=1276 (65%) N=1976	HOSPITAL RELATED 65% / PATIENT RELATED 35%	NOISE OF OTHER PATIENTS (24%) PAIN (20%) NOISE OF HOSPITAL EQUIPMENT (19%)
NOCTURNAL AWAKENINGS ≥ 1 reasons n=1696 (85%) N=2004	HOSPITAL RELATED 66% / PATIENT RELATED 34%	OTHER REASON (36%)[c] NOISE OF OTHER PATIENTS (23%) AWAKENED BY HOSPITAL STAFF (20%)
FINAL AWAKENING ≥ 1 reasons n=1344 (70%) N=1910	HOSPITAL RELATED 74% / PATIENT RELATED 26%	AWAKENED BY HOSPITAL STAFF (36%) OTHER REASON (12%)[c] NOISE OF OTHER PATIENTS (11%)

[a]Proportion of all reasons given.
Hospital related: awakened by hospital staff, noise of other patients, noise of hospital staff, noise of medical instruments, uncomfortable bed or pillow, lights, transfer to new room and other hospital related answers to the open-ended question.
Patient related: pain, anxiety, worrying about illness, dyspnea, alarm clock, other patient-related answers to the open-ended question.
[b]Proportion of all patients (N=2005) who suffering from this disturbing factor.
[c]In the category "other factors" 60% of nocturnal awakenings and 51% of final awakenings were caused by toilet visits, this was not an option included in the survey.

Figure 2: Disturbing factors

SUPPLEMENTARY MATERIALS

TRANSLATED QUESTIONNAIRE INSOMNIA STUDY

Case Report Form

Name hospital: .………………………………………………………………………..

Name researcher:.………………………………………………………………….

Function researcher:.…………………………………………………………………….

Data filling in questionnaire:

Answers questions recorded by: *(mark right answer)*	Patient / Researcher
Time filling in questionnaire *(hours:minutes)*	……. : …….

Admission data:

Admission date *(dd-mm-yyyy)*	…….-…….-201…
Ward type *(mark right answer)*	Acute medical ward / Regular ward
Admission specialty	
Room type (..-*person*) *(mark right answer)*	1 / 2 / 3 /4 / 5 / 6 / >6
Underwent operation during admission *(mark right answer)*	Yes / No

Sleep questionnaire

Thank you for participating in this study. Below you will find questions about your **sleep of the previous night in the hospital** and questions about your **sleep at home the month prior to hospital admission**. When asked for a time, please use 24-hour notation i.e. from 00:00 until 23:59. Try to answer every question and please make an estimate if you don't know an exact answer.

General questions
1a. I am ...... years of age (*record your age*).
1b. I am a woman / man (*mark the right answer*).
1c. I was informed about: (*mark every applicable answer*)
   ☐ Participation to this study is voluntary,
   ☐ Participation is free-standing from my treatment in the hospital, and
   ☐ I can withdraw from participation in the study at every moment without any consequence

Questions about your sleep
2a. What time did you try to go to sleep last night?   .………………(hours:minutes)
2b. What time did you usually try to go to sleep at home the month prior to admission?

                                                                                 .……..…………(hours:minutes)

3a. How long did it take you to fall asleep last night?   .……............(hours:minutes)
3b. How long did it usually take you to fall asleep at home the month prior to admission?

                                                                                 ………………..(hours:minutes)

3c. If falling asleep lasted longer than at home, what factor(s) was contributing to that? *Please mark in the table below what is applicable multiple answers can be given:*

a.	Kept awake by hospital staff	
b.	Noises of medical equipment	
c.	Noises of other patients	
d.	Noises of hospital staff	
e.	Light	
f.	Movement to other room or ward	
g.	Uncomfortable bed or pillow	
h.	Pain	
i.	Shortness of breath	
j.	Anxiety	
k.	Worrying about your disease	
l.	Other, namely: ……………………………………………………………..…............................	

4a. How many times did you wake up last night, not counting your final awakening?   ……….. times

4b. In total, how long did these awakenings last?   …….. hours and …….. minutes

4c. What woke you last night, not counting your final awakening? *Please mark in the table below what is applicable multiple answers can be given:*

1. Woken up by hospital staff	
2. Noises of medical equipment	
3. Noises of other patients	
4. Noises of hospital staff	
5. Light	
6. Movement to other room or ward	
7. Uncomfortable bed or pillow	
8. Pain	
9. Shortness of breath	
10. Anxiety	
11. Worrying about your disease	
12. Other, namely: ……………………………………………………................................	

4d. How many times did you usually wake up during the night at home the month prior to admission, not counting your final awakening?

………..times

4e. In total, how long did these awakenings approximately last?   …….. hours and …….. minutes

5a. What time was your final awakening this morning? ………………………….. (hours:minutes)

5b. What woke you up this morning? *Mark one of the two possibilities:*
□ Spontaneously
□ Other reason, namely: *Please mark in the table below what is applicable multiple answers can be given:*

1. Self-set alarm clock	
2. Woken up by hospital staff	
3. Noises of medical equipment	
4. Noises of other patients	
5. Noises of hospital staff	
6. Light	
7. Movement to other room or ward	
8. Uncomfortable bed or pillow	
9. Pain	
10. Shortness of breath	
11. Anxiety	
12. Worrying about your disease	
13. Other, namely: ………………………………………………………..................................	

5c. What time was your final awakening usually at home the month prior to admission?
………………..(hours:minutes)

6a. For how long did you try to get back to sleep after your final awakening this morning?

.... hours and .... minutes

6b. For how long did you usually try to get back to sleep after your final awakening at home the month prior to admission?

.... hours and .... minutes

7a. Did you nap during daytime yesterday? *Mark one of two answers:*   Yes □   No □

7b. Did you usually nap during daytime at home the month prior to admission? *Mark one of two answers:*

Yes □   No □

8a. Did you use sleep medication last night? *Mark one of two answers:*   Yes □   No □

   When yes, please note name and dose of the sleep medication below

   Name sleep medication: …………………………….. Dose: ………………………………

8b. Did you usually take sleep medication at home the month prior to admission?   Yes □   No □

   When yes, please note name and dose of the sleep medication below

   Name sleep medication: …………………………….. Dose: ………………………………

9a. How would you rate the quality of your sleep of the previous night in the hospital?
    'Quality of sleep is if you feel you slept well or poor'.

Very poor	Poor	Fair	Good	Very good
□	□	□	□	□

9b. How would you rate the usual quality of your sleep at home the month prior to admission?
    'Quality of sleep is if you feel you slept well or poor'.

Very poor	Poor	Fair	Good	Very good
□	□	□	□	□

Please react to the statements below by marking one of the boxes.

10a. I am satisfied with my sleep of previous night.

Not at all	A little	Somewhat	Quite a bit	Very much
□	□	□	□	□

10b. I am satisfied with how I slept at home the month prior to admission.

Not at all	A little	Somewhat	Quite a bit	Very much
□	□	□	□	□

11a. Tonight's sleep was refreshing.

Not at all	A little	Somewhat	Quite a bit	Very much
□	□	□	□	□

11b. My sleep at home the month prior to admission was refreshing.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

12a. Tonight's sleep was restless.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

12b. At home the month prior to admission, my sleep was restless.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

13a. Last night I had difficulty falling asleep.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

13b. At home the month prior to admission I had difficulty falling asleep.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

14a. This morning I felt lousy when I woke up.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

14b. At home the month prior to admission I felt lousy when waking up.

Not at all	A little	Somewhat	Quite a bit	Very much
☐	☐	☐	☐	☐

Thank you for filling in the questionnaire. Would you please check if you answered all the questions?

SUPPLEMENTARY TABLES

Supplementary table 1. Overview of use sleep medication

Supplementary table 1: Overview of use sleep medication	Home (n=335)	Hospital (n=539)
Benzodiazepine	189 (56%)	264 (49%)
Melatonin	12 (4%)	6 (1%)
Antidepressant	10 (3%)	10 (2%)
Antipsychotic	3 (1%)	6 (1%)
Antiepileptic	1 (0%)	1 (0%)
Antihistamine	0 (0%)	8 (2%)
Opioid	8 (2%)	42 (8%)
Paracetamol	39 (12%)	61 (11%)
Other	18 (5%)	14 (3%)
Unknown by patient	55 (16%)	127 (24%)

Of 2005 patients, 335 (17%) reported the use of sleep medication at home and 539 (26%) in the hospital. This table shows frequencies and proportions (n, %) of the different types of sleep medication that was reported by patients within these groups.
Besides conventional sleep medication, patients indicated medicine like Paracetamol and opioids as medication to promote sleep.

Supplementary table 2. Characteristics of patients included and excluded in analysis on subjective sleep quantity

Supplementary table 2: Characteristics of patients included and excluded in analysis on subjective sleep quantity		
	Included patients	**Excluded patients**
Gender		
Male	657 (47%)	260 (48%)
Female	734 (53%)	284 (52%)
Age		
<35	94 (7%)	23 (4%)
36-50	166 (12%)	50 (9%)
51-65	382 (27%)	143 (25%)
66-80	533 (38%)	232 (41%)
81+	234 (17%)	118 (21%)
Length of stay		
1 day	246 (20%)	113 (22%)
2 days	213 (17%)	91 (18%)
3 days	106 (8%)	34 (7%)
4+ days	693 (55%)	277 (54%)
Number of patients in room		
1	372 (26%)	132 (23%)
2	369 (26%)	145 (25%)
3	116 (8%)	47 (8%)
4	540 (38%)	234 (41%)
5	4 (0%)	5 (1%)
≥ 6	14 (1%)	1 (0%)
Specialty		
Non-surgical unit	1110 (82%)	426 (74%)
Surgical unit	246 (18%)	115 (20%)
Surgery		
Yes	319 (23%)	132 (23%)
No	1093 (77%)	437 (77%)
Sleep medication		
Yes	383 (27%)	156 (27%)
No	1044 (73%)	422 (73%)
Assistance filling out questionnaire		
Yes	403 (30%)	108 (19%)
No	953 (70%)	440 (76%)

n (%) of included or excluded patients within this specific variable

Supplementary table 3. Distribution of answers to PROMIS sleep quality items

Supplementary table 3: Distribution of answers to PROMIS sleep quality items

	Very poor (0)	Poor (1)	Fair (2)	Good (3)	Very good (4)	Median (IQR)	Difference (CI)
My sleep quality was…							
Home (n=1958)	2 %	9 %	25 %	50 %	14 %	3 (2-3)	0·58 (0·52 - 0·64)
Hospital (n=1966)	8 %	19 %	35 %	31 %	6 %	2 (1-3)	p<·001

	Not at all (0)	A little (1)	Somewhat (2)	Quite a bit (3)	Very much (4)	Median (IQR)	Difference (CI)
I was satisfied with my sleep.							
Home (n=1960)	7 %	10 %	17 %	48 %	18 %	3 (2-3)	0·60 (0·53 - 0·67)
Hospital (n=1961)	19 %	14 %	23 %	35 %	9 %	2 (1-3)	p<·001
My sleep was refreshing.							
Home (n=1961)	9 %	11 %	22 %	46 %	12 %	3 (2-3)	0·63 (0·56 - 0·70)
Hospital (n=1969)	22 %	19 %	24 %	30 %	5 %	2 (1-3)	p<·001
My sleep was restless.							
Home (n=1951)	49 %	21 %	16 %	12 %	3 %	1 (0-2)	-0·45 (-0·52 --0·38)
Hospital (n=1952)	35 %	22 %	17 %	18 %	9 %	1 (0-3)	p<·001
I had difficulty falling asleep.							
Home (n=1957)	56 %	20 %	13 %	89 %	3 %	0 (0-1)	-0·51 (-0·59 --0·44)
Hospital (n=1958)	40 %	21 %	13 %	15 %	11 %	1 (0-3)	p<·001
I felt lousy when I woke up.							
Home (n=1952)	69 %	14 %	9 %	6 %	2 %	0 (0-1)	-0·24 (-0·30 --0·18)
Hospital (n=1956)	57 %	20 %	10 %	9 %	4 %	0 (0-1)	p<·001

Every question is answered using a 5-point scale so a median and inter-quartile range (IQR) could be calculated. The 'difference' is the result of the mean at home minus hospital score.

Supplementary table 4. Differences in raw summary Sleep Disturbance scores between groups

Supplementary table 4: Differences in raw summary Sleep Disturbance scores between groups

	Hospital	Home
Gender		
Male	9·5 (9·1-9·9)	6·0 (5·7-6·4)
Female	10·0 (9·6-10·4)	7·4 (7·1-7·8)
Age		
<35	11·6 (10·6-12·7)	6·9 (6·0-7·8)
36-50	11·0 (10·2-11·8)	7·0 (6·2-7·7)
51-65	10·0 (9·5-10·6)	6·7 (6·3-7·2)
66-80	9·2 (8·8-9·6)	6·6 (6·2-7·0)
81+	9·1 (8·5-9·8)	6·6 (6·0-7·1)
Specialty		
Non-surgical unit	9·6 (9·3-9·9)	6·8 (6·5-7·1)
Surgical unit	10·5 (9·9-11·2)	6·3 (5·7-6·9)
Operation		
Yes	10·4 (9·8-10·9)	6·5 (6·0-7·0)
No	9·6 (9·3-9·9)	6·8 (6·4-7·1)
Sleep medication		
Yes	10·5 (10·0-11·0)	9·2 (8·7-9·8)
No	9·5 (9·2-9·8)	6·2 (5·9-6·5)
Assistance filling out questionnaire		
Yes	9·0 (9·7-10·3)	6·5 (6·0-7·0)
No	10·0 (8·5-9·5)	6·8 (6·5-7·1)

Mean and (95% CI) of raw summary PROMIS Sleep Disturbance scores (0-24) in different groups. A higher score indicates more sleep disturbance.
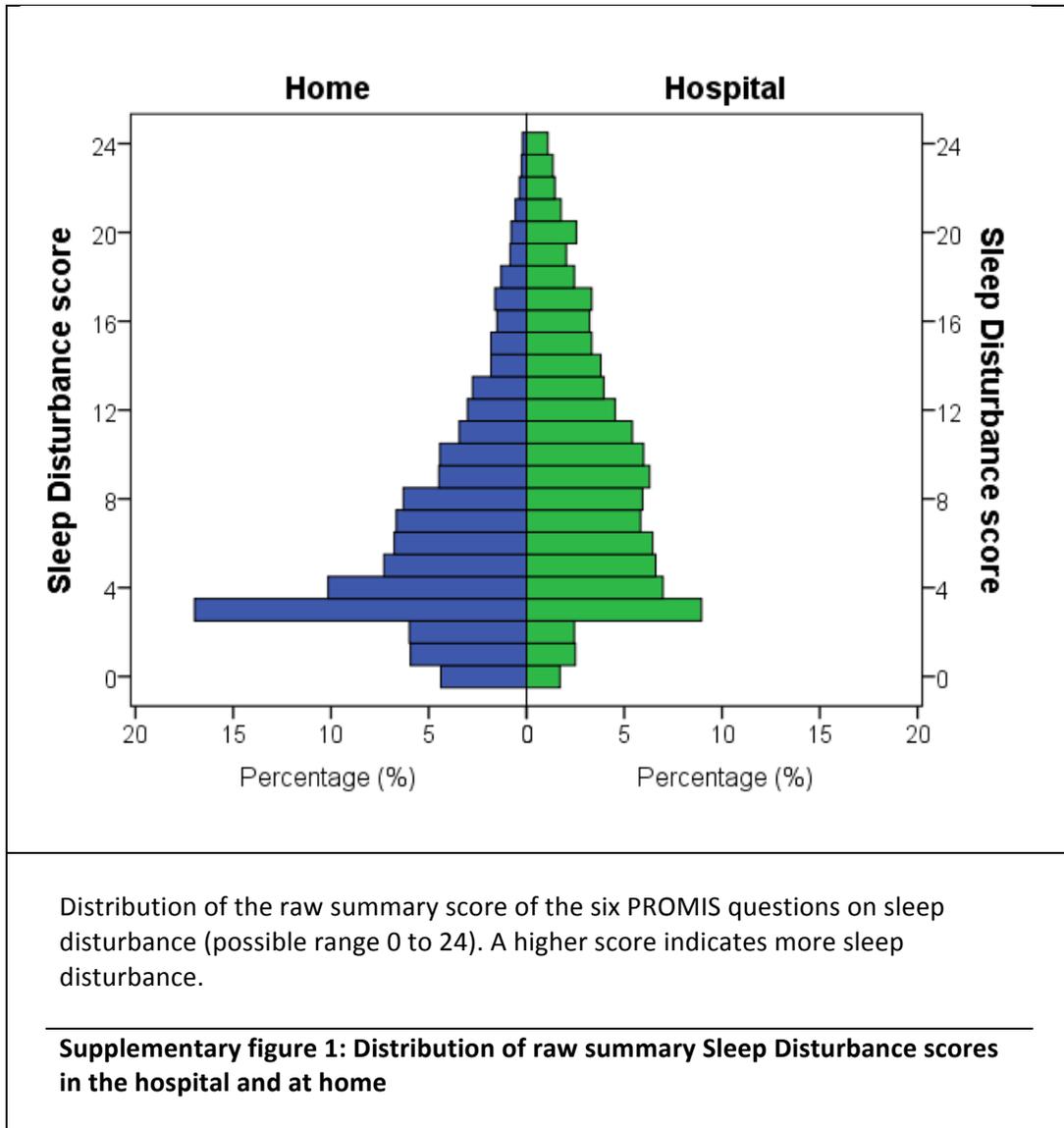
Supplementary table 5. Listing of all disturbing factors

Supplementary table 5: Listing of all disturbing factors

| SLEEP ONSET LATENCY (n=1976)	NOCTURNAL AWAKENINGS (n=2004)	FINAL AWAKENING (n=1910)
Noise of other patients (24%)	Other answer (36%)	Woken by hospital staff (36%)
Pain (20%)	Noise of other patients (23%)	Other answer (12%)
Noise of hospital equipment (19%)	Woken by hospital staff (20%)	Noise of other patients (11%)
Worrying about illness (17%)	Pain (20%)	Pain (11 %)
Other answer (17%)	Noise of hospital equipment (18%)	Lights (10%)
Uncomfortable bed/pillow (16%)	Uncomfortable bed/pillow (14%)	Noise of hospital staff (9%)
Woken by hospital staff (16%)	Lights (11%)	Noise of hospital equipment (7%)
Lights (15%)	Worrying about illness (10%)	Uncomfortable bed/pillow (6%)
Noise of hospital staff (11%)	Dyspnoea (10%)	Dyspnoea (5%)
Dyspnoea (11%)	Noise of hospital staff (10%)	Worrying about illness (5%)
Anxiety (6%)	Anxiety (5%)	Private alarm (4%)
Transfer (2%)	Transfer (2%)	Anxiety (3%)
		Transfer (1%)

(%) Percentage of patients that suffered from this disturbing factor.

SUPPLEMENTARY FIGURES

Supplementary figure 1. Distribution of raw summary Sleep Disturbance scores in the hospital and at home

Distribution of the raw summary score of the six PROMIS questions on sleep disturbance (possible range 0 to 24). A higher score indicates more sleep disturbance.

Supplementary figure 1: Distribution of raw summary Sleep Disturbance scores in the hospital and at home

Supplementary figure 2. Raw summary Sleep Disturbance scores in the hospital and at home in different age groups

Box-whisker plots of raw summary PROMIS Sleep Disturbance scores in different age groups. Higher scores indicate more sleep disturbance (possible range 0-24).

Supplementary figure 2: Raw summary Sleep Disturbance scores in the hospital and at home in different age groups
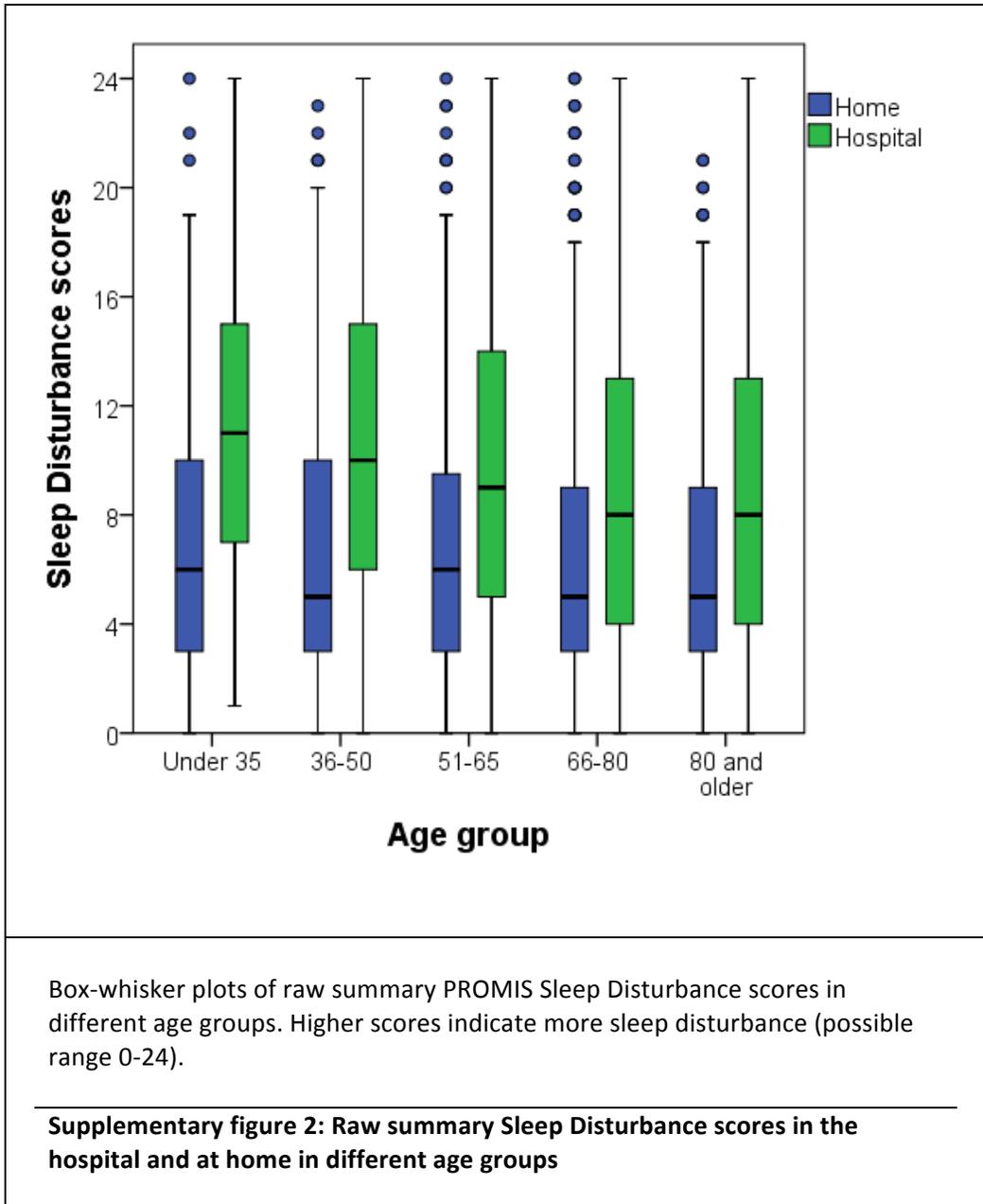
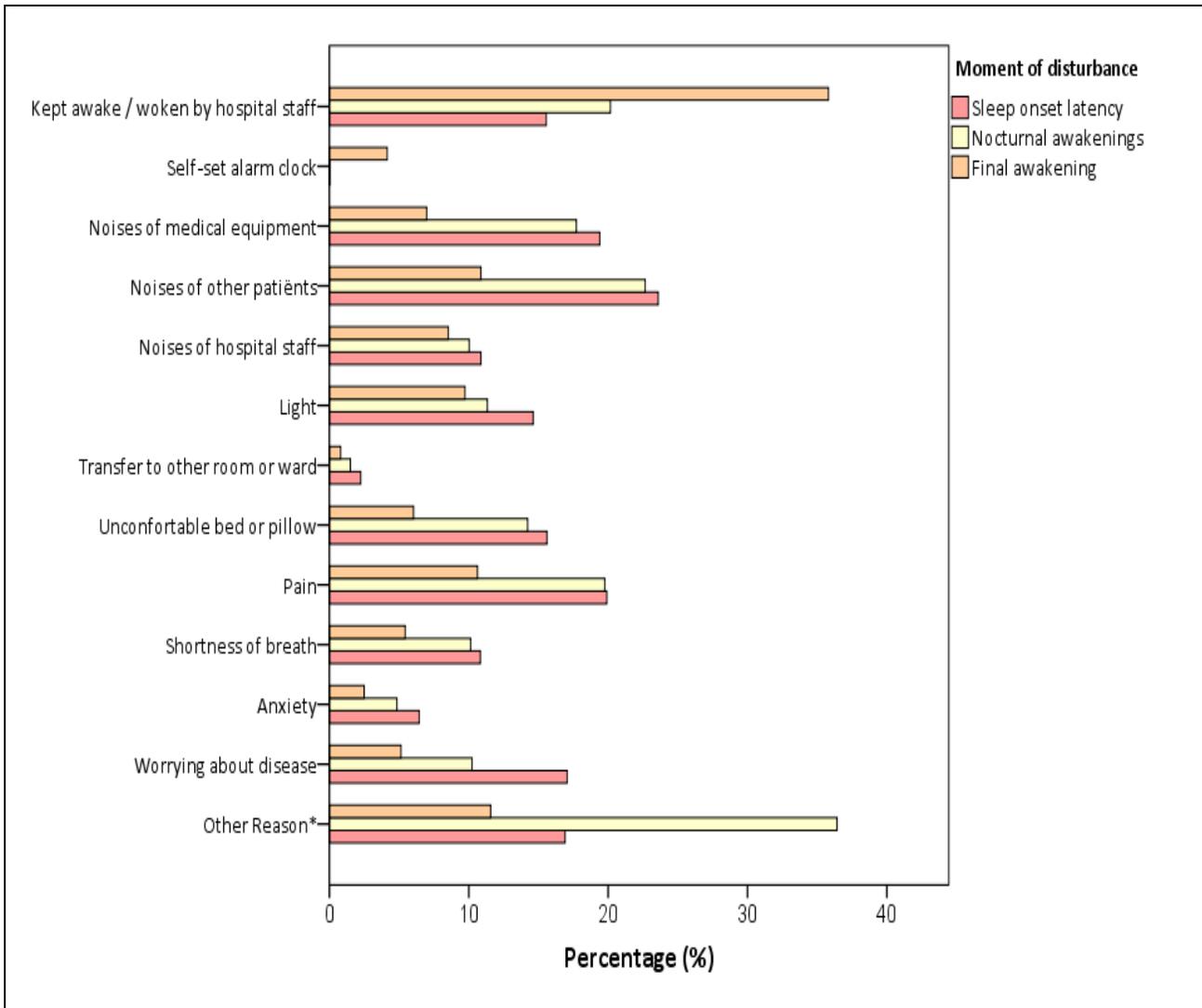**Supplementary figure 3. Overview of disturbing factors (before, during, after sleep onset)**

Figure shows the proportion of all patients (N=2005) who have chosen this specific reason.
 * Other reasons: toilet visits, room temperature, no fresh air, uncomfortable sleeping posture, negative emotions, nausea, unknown environment, drains/IV lines/ urinary catheters, coughing, pruritus, noise in general, to many hours of rest during daytime.

Supplementary figure 3: Overview of disturbing factors (before, during, after sleep onset)

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