



## Sleep in hospitalized pediatric and adult patients – A systematic review and meta-analysis



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### ABSTRACT

**Background:** Sleep is essential for recovery from illness. As a result, researchers have shown a growing interest in the sleep of hospitalized patients. Although many studies have been conducted over the past years, an up to date systematic review of the results is missing.

**Objective:** The objective of this systematic review was to assess sleep quality and quantity of hospitalized patients and sleep disturbing factors.

**Methods:** A systematic literature search was conducted within four scientific databases. The search focused on synonyms of 'sleep' and 'hospitalization'. Papers written in English or Dutch from inception to April 25th, 2022 were included for hospitalized patients >1 year of age. Papers exclusively reporting about patients receiving palliative, obstetric or psychiatric care were excluded, as well as patients in rehabilitation and intensive care settings, and long-term hospitalized geriatric patients. This review was performed in accordance with the PRISMA guidelines.

**Results:** Out of 542 full text studies assessed for eligibility, 203 were included, describing sleep quality and/or quantity of 17,964 patients. The median sample size of the studies was 51 patients (IQR 67, range 6–1472). An exploratory meta-analysis of the Total Sleep Time showed an average of 7.2 h (95%-CI 4.3, 10.2) in hospitalized children, 5.7 h (95%-CI 4.8, 6.7) in adults and 5.8 h (95%-CI 5.3, 6.4) in older patients (>60y). In addition, a meta-analysis of the Wake After Sleep Onset (WASO) showed a combined high average of 1.8 h (95%-CI 0.7, 2.9). Overall sleep quality was poor, also due to nocturnal awakenings. The most frequently cited external factors for poor sleep were noise and number of patients in the room. Among the variety of internal/disease-related factors, pain and anxiety were most frequently mentioned to be associated with poor sleep.

**Conclusion:** Of all studies, 76% reported poor sleep quality and insufficient sleep duration in hospitalized patients. Children sleep on average 0.7–3.8 h less in the hospital than recommended. Hospitalized adults sleep 1.3–3.2 h less than recommended for healthy people. This underscores the need for interventions to improve sleep during hospitalization to support recovery.

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## 1. Introduction

Sleep is an essential daily requirement for the development and maintenance of physical and psychological health [1]. Among the important functions of sleep are memory processing and consolidation, cellular repair, brain development and hormonal regulation

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[2–6]. Good sleep quality consists of a sufficient amount of sleep, uninterrupted sleep, age-appropriate naps and a sleep schedule that fits with one's natural biological rhythms [7]. Sleep satisfaction – one's subjective perception of the quality of sleep – is also important, since people with a high sleep satisfaction have a better quality of life [8]. The most common short-term consequences of insufficient sleep are daytime sleepiness, reduced alertness, poor emotion regulation, increased pain perception, memory loss and difficulties with decision-making [9–13]. It is also associated with an increased risk of fall incidents and delirium [14]. Long-term health consequences of sleep disturbances include anxiety, hypertension, cardiovascular disease, weight-related issues, dyslipidemia, and type 2 diabetes mellitus [1,15,16].

Hospitalized patients are at risk for sleep disturbances caused by disease-related factors (e.g. pain, discomfort, co-morbidities, medications), environmental factors (e.g. care-related routines, noise and light), psychological factors (e.g. anxiety or fatigue) and social factors (e.g. changed parenting strategies for hospitalized children, loss of autonomy and familiar bedtime routines) [17–20]. There is evidence that hospitalization is a risk indication for insomnia that may remain for months or years after discharge [21,22]. In addition, sleep deprivation may contribute to impaired recovery, prolonged length of stay, reduced subjective well-being, and poor patient perception of hospitalized care [23]. The growing evidence for the importance of sleep in physical and mental health and recovery, has stimulated research into this topic. However, an overview of all findings is still missing today. Therefore, the aim of this study was to systematically review all studies that describe the quality and quantity of sleep in hospitalized pediatric and adult patients, and to perform meta-analyses where possible.

## 2. Method

This systematic review was performed according to the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines [24]. This review has been registered on PROSPERO (international prospective register of systematic reviews), with registration number CRD42022300723. Where possible, a meta-analysis was performed.

### 2.1. Search strategy

A systematic search was performed on November 2nd, 2021 (by PB and GLB) using the databases MEDLINE (OVID), Embase.com, Clarivate Analytics/Web of Science Core Collection and PsycINFO. An updated search followed on April 25th, 2022. The search included keywords and free text terms for (synonyms of) 'sleep' combined with (synonyms of) 'hospitalization'. A full overview of the search strategy can be found in the supplementary information of this paper. No limitations on date or language were applied in the search.

### 2.2. Inclusion/exclusion criteria

The inclusion criteria were: 1) patients of one year and older 2) assessment of sleep and report on at least one sleep outcome variable (see paragraph "main outcomes") 3) hospitalization for at least one night, and 4) written in Dutch or English. Excluded were studies: 1) related to specific diagnosed sleep conditions, 2) related to specific sleep-inducing medications, 3) conducted in Intensive Care Units, 4) exclusively reporting about patients receiving palliative care, obstetric care, or psychiatric care 5) including solely patients in sleep-laboratories, 6) in rehabilitation settings, 7) containing long-term hospitalized geriatric patients (e.g. patients in

nursing homes) 8) were systematic reviews or conference abstracts, 8) or non peer-reviewed studies from Embase or Web of Science.

### 2.3. Main outcomes

The phenomena of interest before data analysis took place were: total sleep time (TST), sleep duration, time in bed, wake-up time, sleep efficiency (SE), sleep onset latency (SOL), wake after sleep onset (WASO), nighttime awakenings, total daily sleep time, daytime sleep time, Pittsburgh Sleep Quality Index (PSQI) scores, Richards-Campbell Sleep Questionnaire (RCSQ) scores. Sleep outcomes were added when additional relevant outcomes arose from the data during data analysis, and if they were used more often. Table 1 shows an overview of all definitions/explanations, as well as all extra sleep outcomes added in this review. For interventional studies, only data from the control group were used, as the aim of this review is to describe sleep unaffected by interventions.

### 2.4. Meta-analysis

Performing a meta-analysis on all data was not feasible, due to the heterogeneity of the data and the different ways of annotating results. A series of random effects exploratory meta-analyses was conducted on the PSQI Total score (45 out of 65 possible papers were included), RCSQ Total Score (18 out of 24), TST (42 out of 60), sleep duration (18 out of 29), SE (37 out of 54) and WASO (17 out of 22) [25]. Only studies reporting means with standard deviations were included in the meta-analysis; as a result, median (IQR) were excluded (since normal distribution of the data could not be guaranteed). The tables containing data of all studies (medians (IQR), means (SD) etc.) are published separately [26]. Out of 203 included studies, 110 studies were included in one or more of the meta-analyses. A wide variety of outcome measures have been used in the different articles. To improve readability, only the most frequently reported outcomes are shown in the figures of this manuscript. The results of all papers including those that used less common outcome measures can be found in the separately published dataset.

The  $I^2$  index was used to measure the potential heterogeneity present between the point estimates.  $I^2$  is a ratio of variation among point estimates, and its values lie on a scale from 0 to 100. Large  $I^2$  values suggest that the point estimates are not drawn from the same population.

### 2.5. Study selection and data extraction

Following the initial database search a total of 12,861 papers were identified after deduplication. All titles and abstracts were screened independently for eligibility by two researchers (PB and EE). In case of disagreement, consensus was obtained by involving a third team member. After identifying all eligible papers, one reviewer (PB or EE) collected all the data using a structured form, while a second reviewer (PB, EE or WL) assured quality by validating the extracted data. Disagreements were resolved through discussion.

### 2.6. Quality assessment

A quality assessment was independently performed by two researchers (PB, EE, WL) on all included papers using the Study Quality Assessment Tool created by NHLBI for Controlled Trials and observational studies [27]. Each paper was assessed using the standardized criteria. Each criterion was rated yes, no, not reported or not applicable. A total score was determined by evaluating the number of positive ratings out of applicable criteria. A paper with a

**Table 1**  
Definitions or explanations of all sleep parameters used to describe sleep quality. Items in italic style represent sleep outcomes added during data analysis.

Sleep parameter	Definition/Explanation
<b>Total sleep time (TST)</b>	Total minutes of night-time sleep (“Time in bed” minus “wake after sleep onset” minus “sleep onset latency” OR “sleep duration” – “wake after sleep onset”)
<b>Sleep duration</b>	Total amount of time between sleep onset and offset (“time in bed” minus “sleep onset latency”)
<b>Time in bed</b>	Total number of minutes in bed during the night; The time between Bedtime and wake-up time.
<b>Bedtime</b>	Time of going to bed
<b>Wake-up time</b>	Time of waking
<b>Wake after sleep onset (WASO)</b>	Total number of minutes spent awake after sleep onset during the sleep period at night
<b>Sleep efficiency (SE)</b>	Number of minutes of actual sleep (TST) during the night divided by the number of minutes in bed, multiplied by 100
<b>Sleep onset latency (SOL)</b>	Duration between bedtime and sleep onset
<b>Nighttime Awakenings</b>	Total number of wake episodes between bedtime and wake time.
<b>Total daily sleep time</b>	Total minutes of sleep in a 24h period
<b>Daytime Sleep time</b>	Number of minutes sleep during daytime
<b>Pittsburgh Sleep Quality Index (PSQI) [229]</b>	19 self-rated questions (and 5 questions rated by the bed partner or roommate) which assesses sleep behavior from the previous month. PSQI has 7 subcategories, which sums up to a score between 0 and 21: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, daytime dysfunctions, sleep disturbances, sleep medication). A total score $\geq 5$ is considered poor quality.
<b>Richards-Campbell Sleep Questionnaire (RCSQ) [244]</b>	5 self-rated questions which assess sleep quality of the previous night, rated on a 100 mm Visual Analogue Scale (VAS). Questions are about awakenings, sleep quality, sleep latency, sleep depth, and returning to sleep. The average of all questions is considered the RCSQ total score. A total score $\leq 50$ is considered poor sleep quality.
<b>Verran Snyder-Halpern Sleep scale (VSH) [247]</b>	Originally an 8-item VAS tool to capture sleep latency, fragmentation, length and depth, but often the extended 15-item version is used which sums scores to calculate sleep quality in three domains: sleep effectiveness (5 questions, sums up to scores between 0 and 500), sleep disturbance (7 questions, sums up to scores between 0 and 700) and supplemental sleep (4 questions, sums up to scores between 0 and 400). For disturbance and supplementation, higher scores indicate worse sleep quality, whereas for effectiveness, higher scores indicate better sleep quality.
<b>Insomnia Severity Index (ISI) [248]</b>	7 self-rated questions, using a 5-point Likert scale, to assess the severity of sleep-onset, sleep-maintenance, and early awakenings, as well as the satisfaction with current sleep patterns, interference with daytime functioning, noticeability of impairment to others and level of distress. Assesses the last 2 weeks. Total scores range from 0 to 28, with scores of 0–7, 8–14, 15–21 and 22–28 deemed indicative of no clinically significant insomnia, subthreshold insomnia, moderate insomnia and severe insomnia, respectively.
<b>Epworth Sleepiness Scale (ESS) [249]</b>	8 self-report items to evaluate the general sleepiness state within a day, using a 4-point Likert type scale. Total scores range from 0 to 24, where 0–5 indicates enough sleep, 6–10 indicates slight drowsiness, 11–15 indicates average drowsiness and >15 indicates severe drowsiness.
<b>St. Mary Hospital Sleep Questionnaire [250]</b>	11 self-reported items to assess sleep pattern disorders, using a 3-point Likert type scale. Total scores range from 11 to 44, where scores of 11–21 indicate slight sleep disorders, 22–32 indicate average disorders and 33–44 indicate severe sleep disorders.
<b>PROMIS Sleep disturbance [251]</b>	8- or 4-items questionnaire to assess sleep quality of the previous night, rated on a five-point scale. A standardized T-score can be calculated from the total score, to allow for comparison to a reference population. A patient with a T-score of 60 has a sleep quality that is worse than approximately 84% of persons in the reference population.
<b>Karolinska Sleepiness scale [252]</b>	Nine-point Likert scale assessing the patient’s subjective sleepiness over the past 10 min, ranging from 1 = very alert to 9 = very sleepy.

score above 65% was considered of ‘good quality’, studies with a score between 35% and 65% were considered of ‘fair’ quality and studies with a score below 35% were considered ‘poor’ quality. The quality assessment has been used primarily to determine if studies included are consistent with the standard quality appraisal. Yet, no papers were excluded based upon this assessment.

### 3. Results

#### 3.1. Selection and quality assessment

In Fig. 1, a PRISMA flow chart describes the selection of studies. Out of 542 potentially eligible studies, 202 were included. A total of 17,964 patients were described in these studies. The median sample size was 51 patients (IQR 67, range 6–1472). Eighty-four studies were of good quality [28–50, 51–70, 71–110], 100 studies were considered to be of fair quality [111–130, 131–150, 151–180, 181–211], and 18 of poor quality [13,212–228]. A variety of tools have been used to assess sleep, which are displayed in Table 2. Among the included studies 30 studies were conducted on children, and the remaining on adults/elderly. Ninety papers included patients admitted to a medical ward, 56 to a surgical ward, 2 to an oncology, 28 to a cardiology, 11 to a neurology, 2 to a geriatric ward and 4 to an emergency department. Also, 143 studies were observational, whereas 65 were interventional studies.

#### 3.2. Sleep quantity

A combination of different quantitative sleep variables enables a comprehensive description of sleep. Most studies (76%, 80/106) reported that sleep duration was shorter during hospitalization [13,29,30,32–34,37–40,42–45,49–57,60,63,65–67,70,72,76–80, 82,83,97,98,101,102,105, 110,111,113–115,117,122–127, 131,133,134, 136,138,141,143–145,147,149,151–153,156,157,161–164,166, 168–172,174,175,177, 183,188,191,208,212,221,223,224], as compared to National Sleep Foundation (NSF) recommendations. A subgroup meta-analysis of the TST showed an average sleep of 7.8 h (95%-CI 6.8, 8.8) in hospitalized children, 7.8h (95%-CI 6.0, 10.1) in adolescents, 5.6h (95%-CI 4.6, 6.5) in adults and 5.9 h (95%-CI 5.2, 6.4) in elderly patients (>60y), see Fig. 2. The total sample included 2539 observations; the main analysis of TST indicated a significant amount of heterogeneity ( $\tau^2 = 47,001$ ), most of which was true heterogeneity, not sampling error ( $I^2 = 99\%$ ). Twenty out of 22 studies (90%) comparing TST or sleep duration during hospitalization with sleep at home, age-specific norms or healthy volunteers reported TST/sleep duration to be significantly lower during hospitalization [29,30,38,44,54,67,72,80,105,111,113,114,117,120, 127,133,134,156,174,213,216]. Similarly, a meta-analysis in patients >18y showed an average sleep duration of 6.6h (95%-CI 6.4, 6.9), see supplement.

SE was also reported to be lower in-hospital compared to home [38,72,111,114]. The meta-analysis showed an average of 71.9% (95%-CI 66.9, 73.9), with no differences between hospitalized

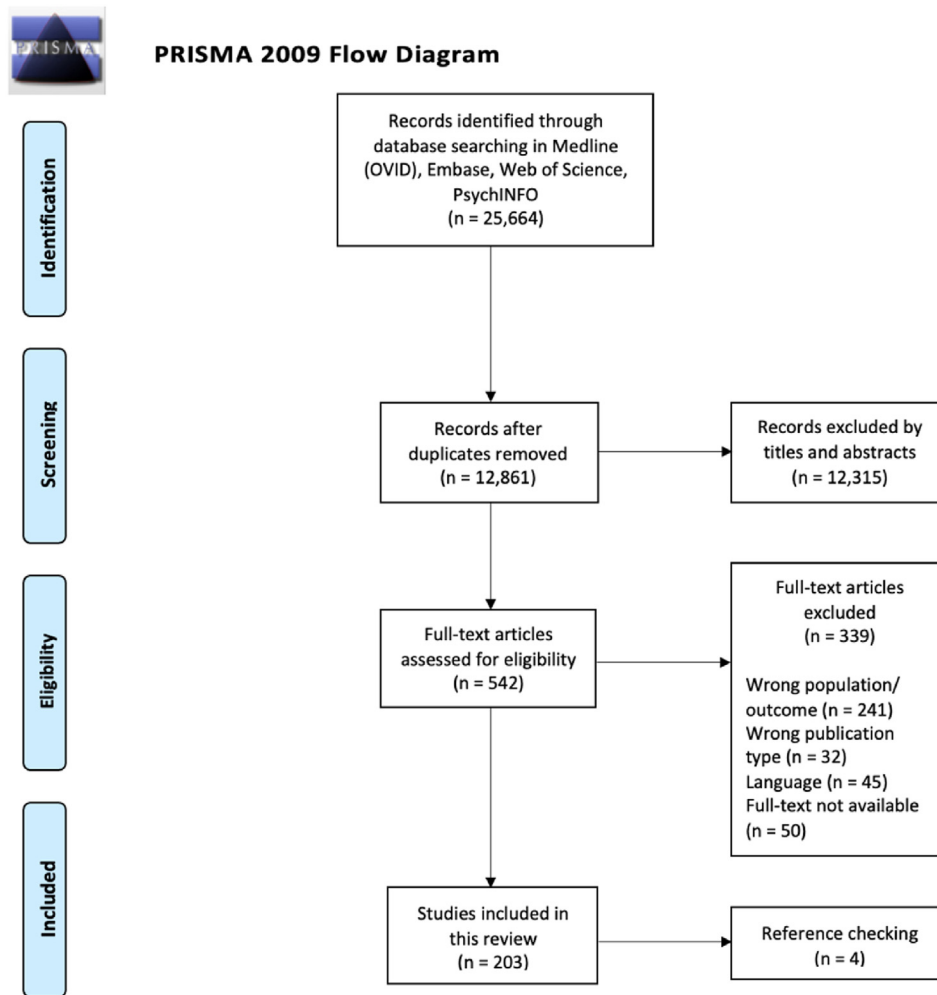


Fig. 1. PRISMA flow diagram of study selection.

**Table 2**  
Ways of assessing sleep in hospitalized patients including the number of papers using the assessment.

Type of measurements	Type of assessment
Objective measurements	Wrist actigraphy (50 studies) [30,32,35,37–40,43,49–53,55,57,60,65,66,70,72,74–76,82,83,97,101,105,106,110,114–116,127,144,145,149,151–153,157,161,162,166,172,174,175,183,188,191,253,254], video recordings (1 study) [126], polysomnography (10 studies) [45,56,67,115,125,131,132,143,169,176], silent observations with a 5 or 10-min interval (3 studies) [138,223,255], sleep diaries (34 studies) [13,36,38,43,47,49,50,54,55,57,65,66,70,72,74,79,80,84,98,101,105,121,127,133,136,151,162–164,166,175,183,191,253], activity sensors (2 studies) [128,133], Fitbit (2 studies) [31,141], hourly patient sleep log [123], vitalog [147]
Subjective measurements	Interviews (6 studies) [20,113,163,213,256,257], numeric rating scales (3 studies) [58,59,258], Sleep in a Children's Hospital Survey (4 studies) [29,66,77,127], Children's Sleep Habit Questionnaire (CSHQ) (4 studies) [20,66,74,77], Patient Sleep Questionnaire + Brief Infant Sleep Questionnaire (1 study) [42], Spence Children's Anxiety Scale and Post-Hospital Behavior Questionnaire (1 study) [66], Potential Hospital Sleep Disruption and Noises Questionnaire [259], Pediatric Sleep Questionnaire [133], Pediatric Quality of Life Inventory [254], Selfmade/unpublished/unvalidated (22 studies) [28,54,66,69,113,117,122,125,137,156,171,177,178,180,204,212,214,216,223,224,260,261], Verran and Snyder-Halpern (VSH) (13 studies) [44,46,75,92,120,142,144,162,170,176,204,211,215], Insomnia Severity Index (ISI) (5 studies) [34,71,109,118,139], Epworth Sleepiness scale (ESS) (9 studies) [85,104,134,136,139,145,166,183,219], PROMIS Sleep disturbance (6 studies) [78,80,89,104,134,160], Sint Mary Hospital Sleep Questionnaire (SMHSQ) (9 studies) [64,91,102,124,190,197,199,219,262], Karolinska sleepiness scale (7 studies) [30,36,60,101,110,183,188], Karolinska Sleep Quality Log (3 studies) [30,110,166], Visual Analogue scale (13 studies) [13,36,58,59,122,132,161,180,183,207,210,216,222], Pittsburgh Sleep Quality Index (PSQI) scores (65 studies) [33–35,41,60,61,67,68,73,76,82,84–86,88,90,95,98–100,103,112,119,121,129,130,139,140,145,146,148,154,158,163,165,168,173,181–189,193–195,202,203,205,206,208,217,223,225–228,263–265], Richards-Campbell Sleep Questionnaire (RCSQ) scores (26 studies) [31,62–64,79,82,87,93,94,96,107,108,128,135,149,150,153,155,159,192,198,200,201,207,209,220,221], Quality of Life Questionnaire – Core 30 [53], Edmonton Symptom Assessment Scale [222], Leeds Sleep Evaluation questionnaire [158]

children, adolescents, adults, and older adults (>60y) (Fig. 3). The main analysis of SE indicated a significant amount of heterogeneity

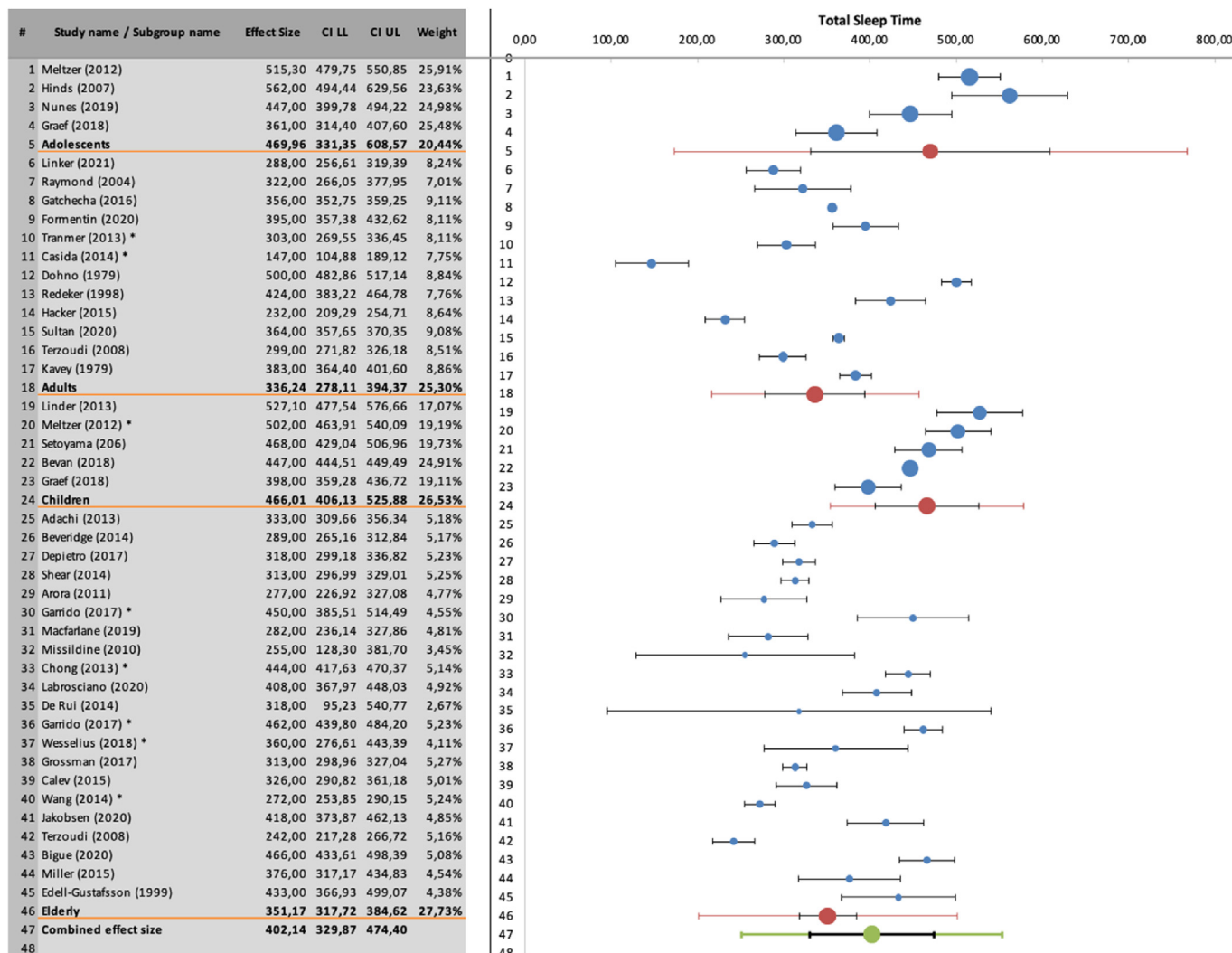


Fig. 2. Subgroup meta-analysis for Total sleep time (children, adolescents, adults, elderly), shown in minutes. Recommended sleep duration in children (6–12y) is between 540 and 660 min, in adolescents (13–18y) 480 and 600 min, in adults (18–60y) 420 and 540 min..

( $\tau^2 = 105$ ), most of which was true heterogeneity, not sampling error ( $I^2 = 98\%$ ). Compared to home, more awakenings [29,67,80,113,116,117,127,216], longer sleep onset latency (SOL) [47,72,81,113,173] and longer WASO have been reported [67]. A meta-analysis of the WASO showed an average of 105 min (95%-CI 39, 171), again with a significant amount of heterogeneity (Fig. 4). Studies using wrist actigraphy or polysomnography, reported up to averages of 41 awakenings per night [35,45,51,55, 60,66,70,72,75,77,83,105,115,124,125,127,141,143,145,152,153,161, 162,172,183]. Findings about bedtime and wake up time in hospital are inconclusive; while some studies report earlier bedtimes and wakeup times compared to home [47,72,113], others report delayed ones [29,105,117]. Only 12 studies assessed daytime sleep duration [32,47,51,65,66,72,78,97,113,131,161,214]. Half of which assessed children <18 years old. Mean total daytime sleep duration in children ranged from 39 to 221 min. Studies in adults reported mean daytime sleep duration between 55 and 90 min.

Some studies have reported that sleep gradually improves over the course of hospitalization hospital length of stay [47,53,61,62,68,132,135,140,143,151,166,173], while others did not find any significant improvement over time [40,41,45,64,65,80,89,128,129,147,175,215].

### 3.3. Sleep quality

An overview and explanation of all sleep questionnaires used is presented in Tables 1 and 2. All but one (60/61) studies reporting on total PSQI showed a total score greater than 5, which distinguishes good sleepers from bad sleepers, with higher scores indicating worse sleep [229]. Scores ranged from 3.27 to 18.79 [33,34, 41,61,73,84–86,88,90,95,98–100,103,112,119,129,130, 139,140,145,146,148, 154,158,163,165,168,173,181,183–189,193–195, 202,203,205,206,208,217,225–228]. A meta-analysis of the PSQI total score showed a mean of 9.70 (95%-CI 9.66, 9.74), with no difference between younger adults (18–60y) and older adults (Fig. 5). Subgroup analysis showed that oncology patients had the worst PSQI total scores (12.80 (95%-CI 10.08, 15.52)), compared to mean scores of 10.00 (95%-CI 8.36, 11.64), 8.44 (95%-CI 6.74, 10.14) and 8.42 (95%-CI 8.42, 10.10) in cardiology, medical and surgical patients, respectively. The main analysis of PSQI Total score indicated a significant amount of heterogeneity ( $\tau^2 = 19$ ), most of which was true heterogeneity, not sampling error ( $I^2 = 99\%$ ). From the seven available subscores, sleep duration and sleep latency were the biggest contributors to the total score.

RCSQ scores revealed a similar trend, where all but one (25/26

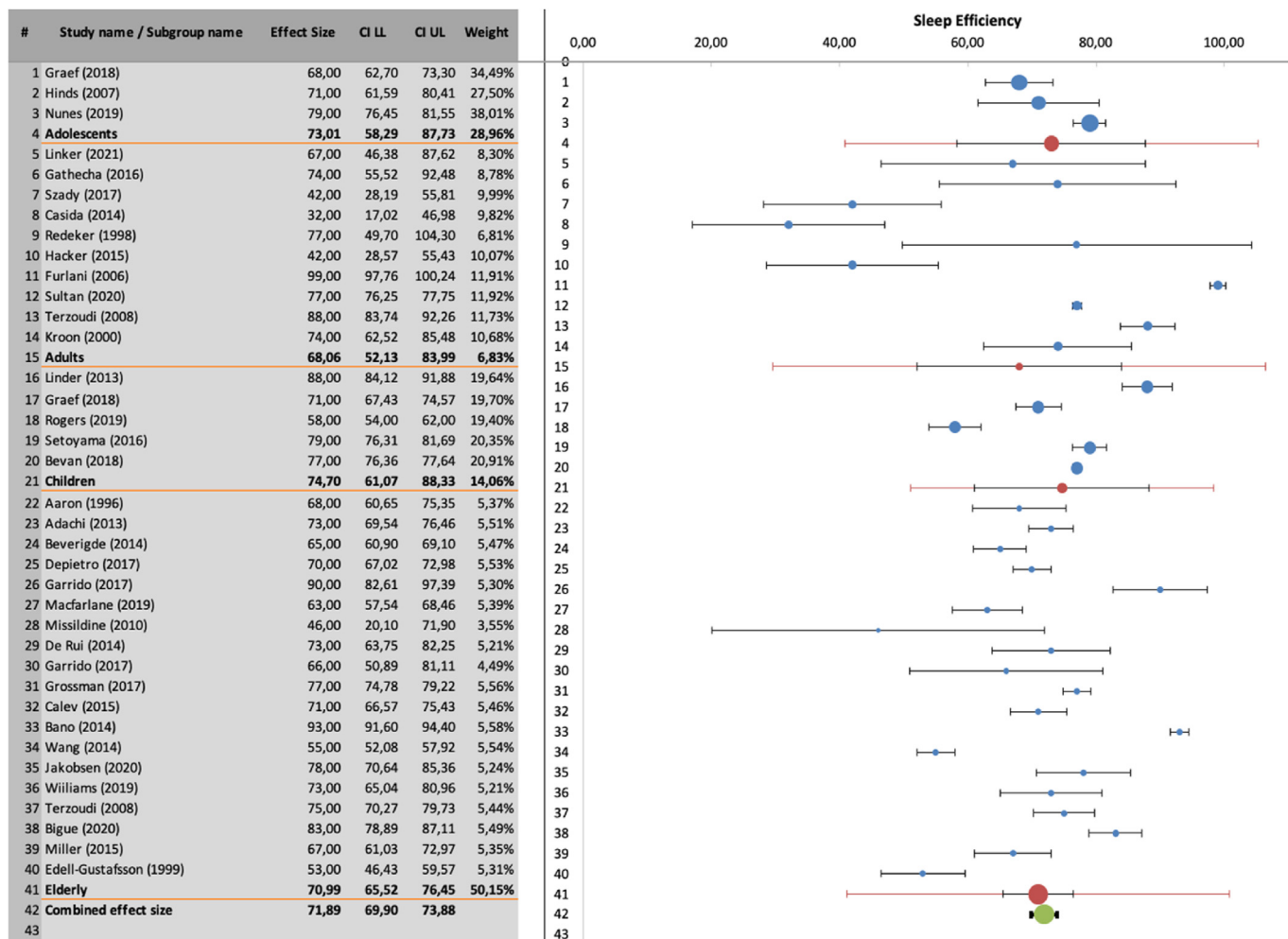


Fig. 3. Subgroup meta-analysis for Sleep efficiency (children, adolescents, adults, elderly), shown in percentages.

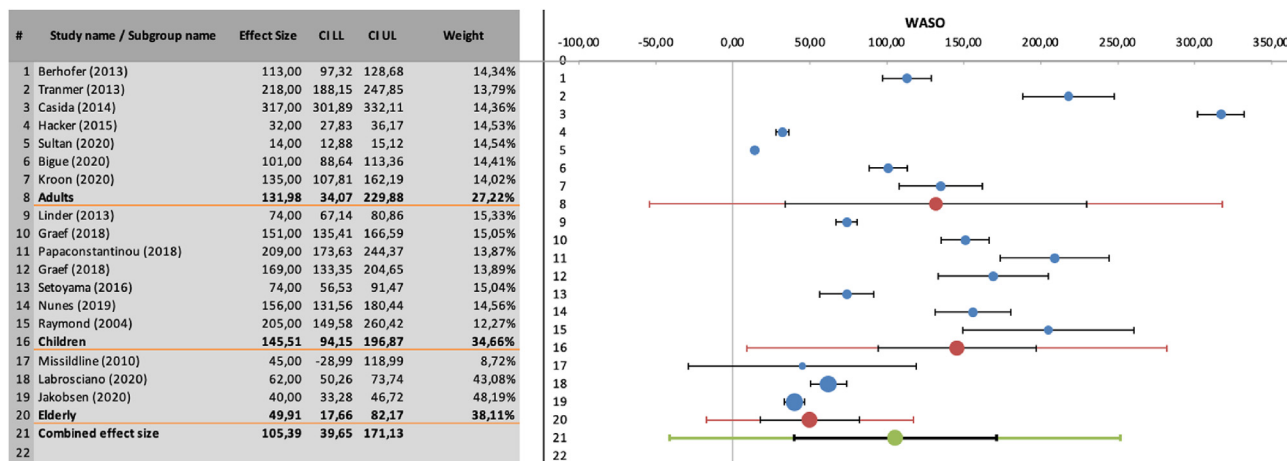


Fig. 4. Meta-analysis of Wake after sleep onset, shown in minutes.

studies) showed average total scores below 70, indicating poor sleep [31,62–64,79,87,93,94,96,107,108,128,135,149,150,153,155, 159,192,198,200,201,209,220]. A meta-analysis of the RSCQ total score revealed a mean of 50.4 (95%-CI 45.4, 55.5), with no difference between younger and older adults (Fig. 6). Studies using the

Verran and Snyder-Halpern Sleep Scale (VSH) also showed low levels of sleep quality [44,46,142,162,176,204,211,215]. Compared to US non-hospitalized adults [46], inpatients seem to have worse scores in all scales.

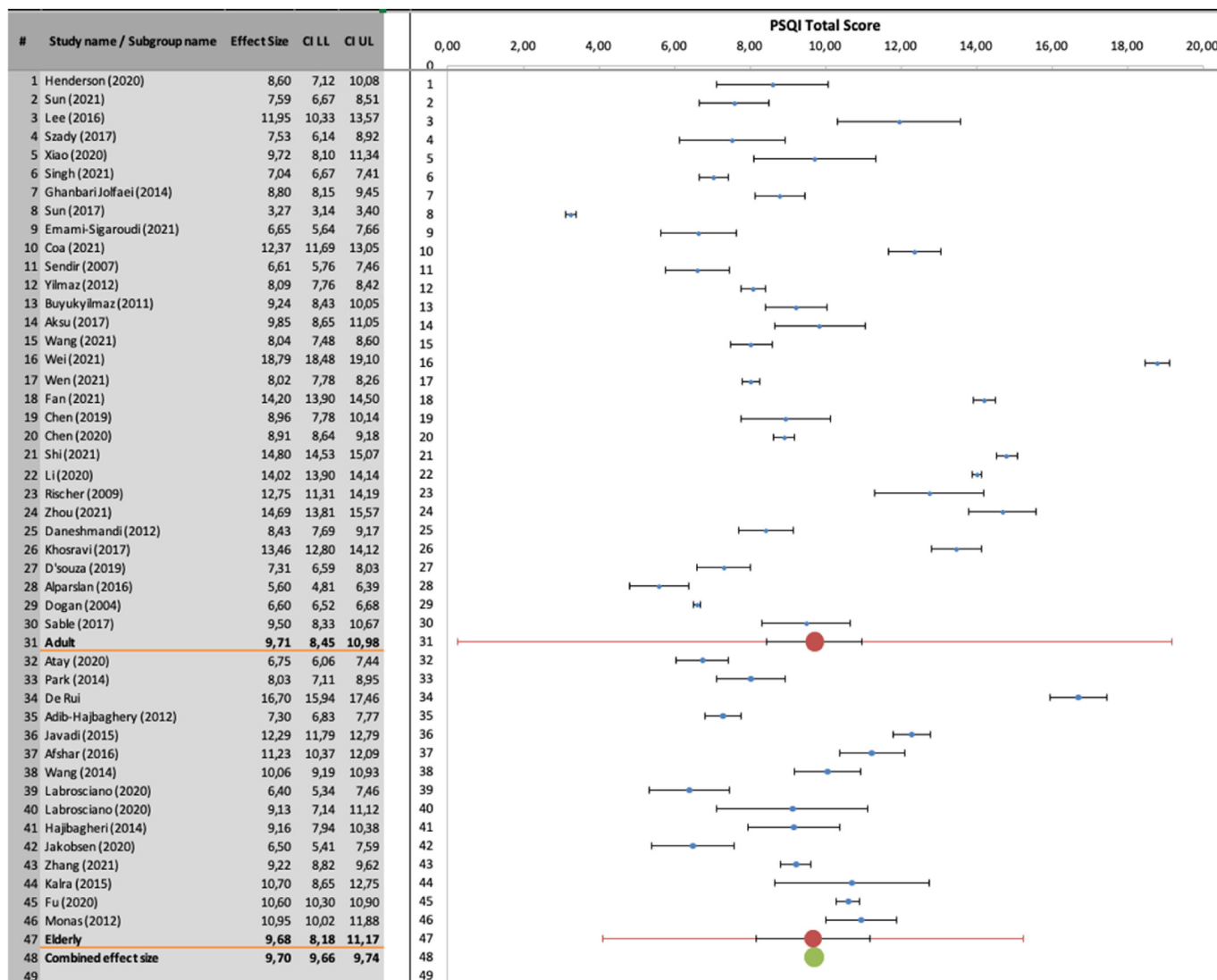


Fig. 5. Subgroup meta-analysis of Pittsburgh Sleep Questionnaire Index (adults, elderly). Total score between 0 and 21, with a score  $\geq 5$  considered to be poor quality.

### 3.4. Associations/correlations with sleep

Many associations and/or correlations with (poor) sleep have been described (Fig. 7). Two of the most frequently cited external factors are noise [29,52,61,71,73,74,77,106,111,112,122,139,146,155,158,164,174,180,214,215,218] and the number of patients in the room [38,43–45,55,62,71,73,74,140,180]. A variety of internal/disease-related factors have been reported to be associated with poor sleep as well, with pain [13,28,29,52,53,58,68,73,106,112,119,122,134,139,140,151,161,165,168,170,180,201,215], and anxiety/fear [62,64,71,72,77,86,113,135,146,180,215,230] being most frequently reported to be associated with poor sleep quality. Please see the supplemental information for an overview of all associations found, which also includes studies that did not find correlations.

## 4. Discussion

To the best of our knowledge, this systematic review with meta-analysis is the most extensive and complete overview of sleep measurements in normal care inpatients to date. It provides an overview of the magnitude and causes of the sleep problems in the

hospital population for various medical specialties and age groups. In addition, it provides a clear picture of the current state of literature, the knowledge gaps and challenges for future sleep research in the hospital setting.

Overall, this review provides solid evidence that patient's sleep is impacted negatively during hospitalization. Of all included studies that report on sleep duration/TST, 76% (80/106) found a sleep quantity less than the recommended average for healthy people by the National Sleep Foundation (NSF) [231]. Of these, 37 studies (46%) reported adults sleeping even less than 6 h, which is considered unhealthy sleep as per NSF recommendations. To specify, meta-analysis showed a large sleep deficit of 0.7–3.8 h in hospitalized children and 1.3–3.2 h in adult inpatients. In addition, patients experience many (up to 42 per night) nocturnal awakenings and a high average WASO of 122 min, often caused by external and potentially avoidable sleep disturbances. The high WASO could account for a low SE. Yet the average SE in hospitalized children (71%–91%) was comparable to SE in healthy populations (76%–82%) [232].

Impaired sleep during admission probably results from factors related to hospitalization, e.g. environmental, disease or treatment-related factors. However, studies also suggest that suboptimal sleep

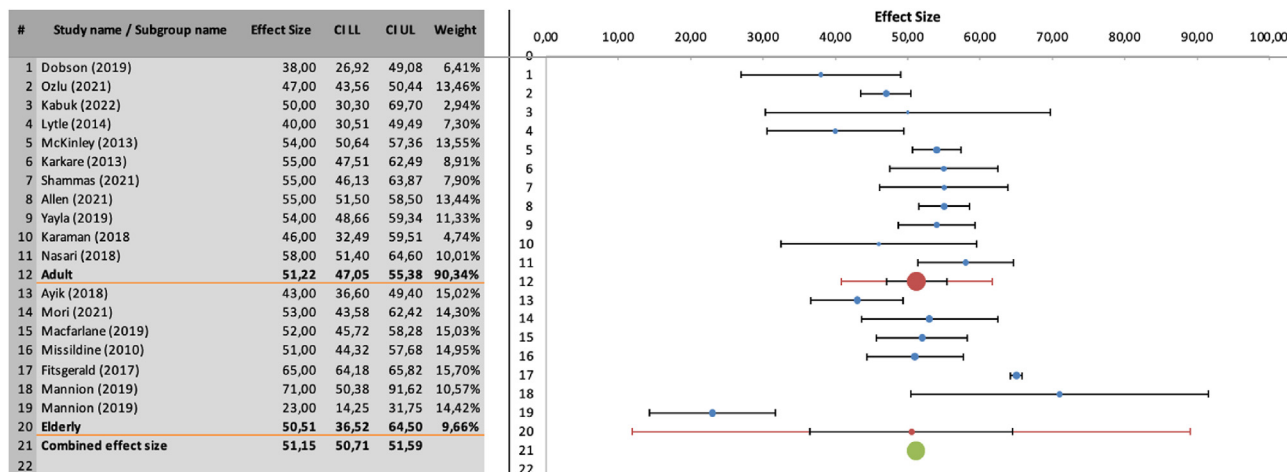


Fig. 6. Subgroup analysis of Richard-Campbell Sleep Questionnaire (adults, elderly). Total score ranging from 0 to 100 with a score  $\leq 50$  considered to be poor sleep quality.



Fig. 7. Overview of items associated with inpatient sleep, where dotted lines are positive correlations. The bigger the balloon, the more frequently the association has been reported.

during hospitalization is associated with poor sleeping prior to admission [44,47,54,223]. This indicates that poorer sleep during hospitalization might partly result from overall bad sleep hygiene or from imminent disease or underlying (chronic) condition. It underlines the importance of the use of control data in future research (e.g. include questions about sleep prior to hospitalization/onset of disease). Many sleep disrupters in the hospital seem to be related to external factors, with noise being the most frequently reported cause. Also, sleep in hospitalized patients may be substantially affected by (nocturnal) care related, but potentially

redundant, interventions (e.g. vital signs check-ups). Hospitals are therefore advised to take a critical look at the design of both the care processes and in-patient ward structure. Optimizing individualized patient care could play a key role in optimizing patients' sleep; is bad sleep due to a room close to the nurse desk or does a patient share a room with a restless fellow patient? Are the nightly checkups necessary for this specific patient? Can vital check-ups, iv fluid changes and medication rounds be postponed to the day shift instead of the night shift? Or can vital signs be monitored remotely (and automatically with silent alarms) limiting the need of



interventions in the room? Etc. Sleep disturbances are also related to emotions like depression and anxiety. While it will be difficult to completely rule out such feelings, it could help when healthcare professionals pay attention to both the medical as well as the psychological state of their patients during hospital stay.

More research is warranted to understand the exact influence of hospital setting, healthcare professionals' behavior and disease on patient's sleep. In addition to the need for extra research, healthcare professionals can already play a key role in sleep promotion with relatively simple and cheap interventions. Previous research highlighted the lack of awareness among healthcare professionals of the importance of sleep for general health and physical recovery, however [233]. Therefore, education for health care professionals about the importance of sleep and factors affecting patient's sleep quality for (better recovery to) optimal health seems important.

Studies investigating sleep of hospitalized children are sparse; only 30 out of the 205 included studies investigated the sleep of hospitalized children. Some of these studies did not find a difference in total sleep time among various ages, which could suggest that sleep of younger children is more affected in the hospital compared to older children. On the other hand, many studies did not stratify for age which hampers to infer robust conclusions. Not only sleep duration is decreasing over the years [234,235], a recent study among healthy subjects also showed a shorter SOL, a decreased WASO, and (hence) an increased SE in older children compared to young ones [232]. It is therefore recommended that future research should stratify for age (e.g. toddlers, school aged children and adolescents).

Sleep measurements varied among the studies, hampering firm conclusions on sleep during hospitalization. Using wrist actigraphy only, has its limitations since it is accurate in estimating wake and sleep patterns, but is limited in its ability to measure sleep latency, and therefore may overestimate sleep efficiency [236]. In addition, actigraphy only measures sleep quantity, and therefore does not tell anything about (subjective) sleep quality. Furthermore, standardized sleep actigraphy requires a minimum of five days to gather reliable data [237], while patients in acute care settings are often admitted for shorter time periods. Other studies used (only) sleep diaries which are found to be an accurate way of measuring total time in bed and SOL. However, patients (and parents rooming in) are less accurate in assessing TST and number of nocturnal awakenings [238]. Therefore, it is recommended to combine wrist actigraphy with sleep diaries. Only 12 studies assessed daytime sleep time using actigraphy and diaries. Subjective daytime sleep time was also assessed as a sub score in the St Mary's Hospital Sleep questionnaire (8 studies), and 12 studies appraised daytime sleepiness (using the Epworth Sleepiness Scale [ESS] or Karolinska Sleepiness Scale [KSS]). It is plausible that bedridden sick patients spent many hours sleeping during the day. Physical inactivity and daytime naps potentially negatively influence sleep pressure and sleep quality at night [64]. In addition, taking a nap is (often) part of young children's normal sleep-rhythm. It is therefore worth considering measuring 24-h sleep in inpatients, rather than focusing solely on nighttime sleep. Therefore, future research could focus on a reliable way to measure daytime sleep in bedridden hospitalized patients. Is actigraphy specific enough, are sleep diaries reliable for afternoon naps and is the ESS reliable in sick patients?

Moreover, even when sleep quantity is considered adequate, sleep quality can still be impaired. Some studies even conclude that sleep quality is superior to quantity regarding prevention of sleep-related negative health outcomes [239]. Therefore, it is essential to combine subjective (sleep questionnaires) and objective sleep measures (like wrist actigraphy and sleep diaries) for a comprehensive overview of all aspects of sleep. While many papers

investigating inpatient sleep in adult populations include both objective as well as subjective measures for sleep behavior, most sleep research in hospitalized children does not [240–242].

Although subjective sleep quality is often assessed in the adult population, due to the many different questionnaires that have been used, it is difficult to compare results. Apparently, there is no consensus on which questionnaire is best to assess sleep quality of hospitalized patients. The most frequently used questionnaire is the PSQI [229]. The PSQI assesses sleep behavior from the previous month, and it has been validated in many populations, both healthy as well as with/during diseases [243]. The median length of stay in inpatients in an hospital is two to three days, resulting in the need to adapt the PSQI to match the timelines in hospital. In addition, the 5 questions rated by the bedpartner/roommate have often been omitted when assessing inpatient sleep. Making changes into validated questionnaires not only affects the validity of the tool, but it also makes it difficult to compare results. Another questionnaire commonly used to assess sleep quality is the RCSQ [244]. It takes approximately 2 min to complete, and it has been largely used in critical care settings. It is one of the few questionnaires that assess last-night sleep and can be used in the hospital setting without textual adjustments. The Verran Snyder-Halpern Sleep scale is another frequently used tool, but originally validated to measure sleep in healthy adults. As shown in Table 2, other questionnaires have been used as well to evaluate sleep quality. It goes beyond the scope of this paper to discuss all in detail. Above illustrates however, the need for the development/validation of questionnaires that fit the hospital setting, i.e. that are easy to use (especially for children, older or seriously ill patients), evaluate the intended sleep period (e.g. one night instead of a week or month) and that is validated for the population that is to be investigated. Reaching consensus on which questionnaire is best to use, would better allow inter-study comparison of results.

This review showed that the studies assessing the sleep of hospitalized patients often consist of small sample sizes, use modified or non-validated questionnaires, or suffer from overall poor quality. However, this is mostly an expression of the complexity of doing research in this field. As stated earlier, there is a need for validated questionnaires that fit the hospital setting. In addition, quality assessment tools often require studies to assess patients for consecutive nights, which may not be desirable because short stay patients will be missed. Nevertheless, in some respects, the reporting of much sleep research is indeed deficient, such as the reporting of a sample size justification and the duration of daytime sleep. The development of symptoms over time substantially affects sleep. Often sleep increases with an increasing length of stay, as symptoms disappear with adequate treatment and patients get used to the hospital environment [62,68,165]. Yet, studies rarely report how many nights patients had spent in the hospital at the time of assessment. Also, information about the many potential confounders (e.g. use of sleep medication) and about pre-existing sleep disorders is often missing. These are crucial for interpreting the results.

The strength of this review is its comprehensiveness. It includes 203 articles, whereas previously published reviews often include no more than 50 due to restriction in study type or specific patient group [245]. A recently published scoping review on the sleep of hospitalized children focused only on sleep duration [246]. Therefore, we feel that this is the first review that provides a complete overview of all existing sleep parameters – both qualitative (subjective) as well as quantitative. However, this review also comes with some limitations. First, it was limited by the overall quality and heterogeneity of the included studies. Yet as nearly all studies conclude that patients suffer from poor sleep quality and quantity during hospitalization, this appears a message to be taken seriously.

Secondly, the language was restricted to English and Dutch. Thirdly, we included an overview of sleep promoting and disturbing factors, showing the frequency with which certain associations have been reported in the literature. However, the frequency of reporting does not necessarily say something about the impact of the association. Fourth, our study does not include the full range of hospitalized patients. For instance, patients admitted to the ICU have been excluded, since several recent reviews on this subpopulation have been published and sleep in the often heavily sedated ICU population cannot be compared with that of non-ICU patients. In addition, infants have been excluded as well, since – at that age – children still have an unstable circadian rhythm.

## 5. Conclusion

Sleep quantity and quality are insufficient in hospitalized patients. Sleep duration was 1–4 h shortened in hospitalized patients compared to home. Moreover, almost all studies reported poor sleep quality. Understanding determinants, including patient factors (e.g., disease related factors and psychological factors), socio-cultural and environmental factors, associated with quality of sleep in hospitalized patients is mandatory. Subsequently interventions may be devised and assessed, aiming to optimize sleep quality to enhance recovery from conditions that require clinical admission.

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## CRedit authorship contribution statement

**Pia Burger:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Visualization, Data curation, Project administration, Validation. **Eva S. Van den Ende:** Methodology, Data curation, Investigation, Formal analysis, Writing – review & editing, Validation, Visualization. **Wen Lukman:** Investigation, Data curation, Validation, Writing – review & editing. **George L. Burchell:** Investigation, Writing – review & editing. **Lindsay M.H. Steur:** Writing – review & editing. **Hanneke Merten:** Writing – review & editing. **Prabath W.B. Nanayakkara:** Writing – review & editing. **Reinoud J.B.J. Gemke:** Conceptualization, Writing – review & editing, Validation, Supervision.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sleepx.2022.100059>.

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