Evaluation and Management of Sleep-Disordered Breathing in Adult Nonsurgical Inpatients:

An American Academy of Sleep Medicine systematic review, meta-analysis, and GRADE assessment.

Introduction: The purpose of this systematic review is to provide supporting evidence for a clinical practice guideline on management of sleep-disordered breathing in medically hospitalized adults.
Methods: The American Academy of Sleep Medicine commissioned a task force of experts in sleep medicine. A systematic review was conducted to identify randomized controlled trials and observational studies that addressed interventions for the management of sleep-disordered breathing in medically hospitalized adults. Statistical analyses were performed to determine the clinical significance of critical and important outcomes. Finally, the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) process was used to assess the evidence for making recommendations.
Results: The literature search resulted in 4,893 studies out of which 27 studies provided data suitable for statistical analyses. The task force provided a detailed summary of the evidence along with the certainty of evidence, the balance of benefits and harms, patient values and preferences, and resource use considerations.
Keywords: obstructive sleep apnea, OSA, sleep-disordered breathing, hospital, inpatient, positive airway pressure, PAP
Citation:

INTRODUCTION

Sleep-disordered breathing (SDB) is highly prevalent[1] but remains underdiagnosed.[2, 3] There is a consistent association of SDB and adverse cardiopulmonary and neurologic outcomes[4] and the recognition and treatment of SDB has the potential to favorably impact these outcomes.[5, 6] The evaluation and management of SDB has traditionally been carried out in ambulatory settings, but there is a growing concern that SDB, both diagnosed and undiagnosed, may impact critical outcomes during hospitalization, in the immediate post-discharge period, and during subsequent care.[7, 8] While current American Academy of Sleep Medicine (AASM) guidelines provide recommendations specific to the diagnosis of SDB via the use of home sleep apnea tests (HSATs) and in-lab polysomnography (PSG),[9] and the use of positive airway pressure (PAP) therapies,[10] these guidelines are for an outpatient population. Implementation in the inpatient setting is problematic for a variety of reasons. For instance, hospitalized patients tend to have more complex and greater acuity of comorbidities that may require different, multi-disciplinary approaches to the evaluation and management of SDB than in the ambulatory setting. There are unique logistical in-hospital aspects to the evaluation and management of SDB related to risk management, insurance coverage, staffing and equipment availability. In addition, this complex patient population has special considerations that need to be addressed (e.g., inpatient sleep evaluation; criteria for PAP therapy initiation in the hospital; the role of inpatient sleep medicine consultation; and understanding which patients could be safely scheduled post-discharge in the outpatient clinic for further workup and management). Finally, consideration for which, if any, untreated patients might require additional monitoring via oximetry, surrogate arterial CO2 monitoring (capnography, transcutaneous CO2 monitoring) and arterial blood gas measures.

As to date, the AASM has not provided guidance on how to address SDB in this diverse and complicated patient population. Therefore, a task force (TF) of content experts was commissioned by the AASM to conduct this review of SDB in hospitalized patients. This systematic review is intended to provide supporting evidence, where available, for the screening, diagnosis and management of inpatient SDB, particularly obstructive sleep apnea (OSA), in adult patients, including screening, timing of and type of diagnostic evaluation, timing of initiation of treatment, role of inpatient monitoring, the role of sleep medicine consultation in the evaluation and management process, and post-

discharge care. The systematic review does not apply to hospitalized patients with acute or chronic respiratory failure requiring noninvasive ventilation support or for SDB considerations in perioperative surgical or procedural inpatient populations.

BACKGROUND

SDB is defined by breathing disturbances during sleep that are quantified by objective testing.[11] Respiratory events are used as the criteria to diagnose SDB, and these events are defined by the apnea-hypopnea index (AHI) or respiratory event index (REI) with threshold cutoffs of more than 15 events per hour, or more than 5 events per hour in conjunction with symptoms.[11] SDB is estimated to effect nearly 1 billion adults worldwide,[12] and the prevalence is expected to grow over time as rates of obesity, a primary risk factor for SDB, increase.[3] However, despite increasing awareness, more simplified testing technology, and better access to testing, SDB continues to be underdiagnosed,[12] particularly in populations at risk for health disparities.[3, 13] Far and away the most common form of SDB is obstructive sleep apnea (OSA). The majority of the literature regarding inpatient SDB involves OSA and as such the TF decided to use the term SDB understanding that this primarily equates to OSA, though recognizing that other forms of SDB exist. The reader should assume that OSA is implied when seeing the term SDB unless otherwise specified.

Demographic risk factors for OSA include obesity, older age, male sex, post-menopausal status in women, and race. OSA is also associated with a number of important co-morbidities, particularly cardiovascular and metabolic diseases which often lead to hospitalization or are commonly seen in inpatient populations. The prevalence rates of OSA in many cardiovascular diseases is often more than 50%, and thus the presence of these conditions places an individual in a high-risk category for having OSA.[19] **Table 1** lists medical co-morbidities that should be considered when risk stratifying an individual's OSA risk.

A number of studies have found OSA to be extremely common in certain inpatient populations.[8, 20-25] Utilizing various screening and diagnostic methodologies, studies have reported the following prevalence rates in inpatient populations; obese (defined by body mass index > 30 kg/m2) 84%,[24] obese African- Americans 60%,[23] cardiac disease 48%,[8] post-stroke 72%,[20] and COPD 46%.[26] As expected, the majority of these patients present with undiagnosed OSA.[8, 20, 21, 24, 25] Undiagnosed or unrecognized OSA may place patients at risk for a variety of adverse cardiopulmonary outcomes during admission or post-discharge due to the added stress of acute illness and/or the effects of certain medications utilized during hospitalization.[27, 28] Literature has suggested that inpatients with OSA may experience higher rates of escalation of care and rapid response activations,[27, 28] cardiac arrhythmias,[29] major adverse cardiac events,[30] need for ventilatory support,[22] and longer length of stay.[22] However, the data lacks consistency with some studies finding no difference in outcomes or contradicting these findings.[31-33] Acute illness and/or medications used during hospitalization may adversely impact near-term post-discharge outcomes in patients with diagnosed or undiagnosed OSA, particularly readmission rates,[26, 34-36] and unrecognized and/or untreated SDB may potentially influence longer-term health consequences and mortality.[37, 38]

In order to favorably impact outcomes in hospitalized patients, OSA needs to not only be diagnosed but treated. Existing data suggests PAP therapy is frequently underutilized in inpatients, even in those with a known preexisting diagnosis of OSA.[22, 29] Emerging data suggests that the initiation of treatment of newly diagnosed OSA during hospital admissions may be feasible and could potentially improve short-term outcomes.[28, 39, 40] However

randomized controlled trials reporting on clinically relevant outcomes are limited to studies performed in specific patient populations (i.e., acute coronary syndrome and post-stroke)[21, 41] and generally involved small sample sizes.[41]

Evidence supports the benefit of sleep consultative care in the ambulatory setting, and it would seem to follow that hospitalized patients would benefit from the same expertise. And indeed, some data suggests that inpatient sleep consultation may improve capture rates of SDB. However, a formal analysis of the existing literature is warranted in order to assess the impact of inpatient sleep consultation on clinically meaningful outcomes. Similarly, while the use of enhanced inpatient physiologic monitoring of key cardiopulmonary signals such as oximetry, carbon dioxide and/or electrocardiography may enable the ability to detect clinical deterioration in patients hospitalized with established or suspected OSA, a review of existing data is indicated to determine how enhanced monitoring may influence outcomes. Finally, issues related to the peri-discharge care of the hospitalized patient with established or suspected OSA, such as ensuring post-discharge evaluation (if indicated) and treatment of OSA, need additional guidance.

Given the above data, one might conclude that the evaluation and management of SDB in hospitalized patients should be broadly adopted. However, a synthesis and review of the available data is indicated, and thus this systematic review provides the current state of the evidence regarding the evaluation and management of SDB in the hospitalized setting.

Table 1 – Defining patients at increased risk for obstructive sleep apnea*

Comorbidities/Medical Conditions
• Cardiovascular disease (CAD, MI, CHF, atrial fibrillation) • Nocturnal dysrhythmias • Cerebrovascular disease (stroke, TIA) • Pulmonary hypertension • Chronic obstructive pulmonary disease (COPD) • Asthma • Obesity/metabolic syndrome (HTN, treatment-resistant HTN, DM type II) • BMI ≥30 kg/m^2 • Thyroid disorders • Preeclampsia • Mood disorders

* The following demographics and signs/symptoms should also be considered when risk stratifying individuals for SDB: Racial or ethnic groups, females after menopause, middle-aged/older populations, lower socioeconomic group; Daytime sleepiness/fatigue, morning headaches, loud, habitual snoring, choking/gasping, fragmented sleep, insomnia.

METHODS

Expert Task Force

The AASM commissioned a TF of sleep medicine clinicians with expertise in the management of medically hospitalized adults with SDB. The TF was required to disclose all potential conflicts of interest (COI), per the AASM's COI policy, prior to being appointed to the TF and throughout the research and writing of these documents. In accordance with the AASM's conflicts of interest policy, TF members with a Level 1 conflict were not allowed to participate. TF members with a Level 2 conflict were required to recuse themselves from any related discussion or writing responsibilities. All relevant conflicts of interest are listed in the Disclosures section.

PICO Questions

PICO (Patient, Intervention, Comparison, and Outcomes) questions were developed by the TF based on an examination of systematic reviews, meta-analyses, and guidelines published for adult populations. The AASM Board of Directors approved the final list of questions presented in **Table 2** before the literature searches were performed.

Through consensus, the TF then developed a list of patient-oriented, clinically relevant outcomes to determine the efficacy of the interventions. Input from stakeholders (patients, caregivers, and health care providers) was also taken into consideration. The TF rated the relative importance of each outcome to determine which outcomes were critical versus important for decision-making. A summary of these outcomes by PICO is presented in **Table 3**.

The TF set a clinical significance threshold (CST) for each outcome to determine whether the mean differences between treatment and control or before and after treatment in the outcomes assessed were clinically meaningful. The CST was defined as the minimum level of improvement in the outcome of interest that would be considered clinically important to clinicians and patients. CSTs were determined based on a TF literature review of commonly used thresholds. When no clearly established threshold values could be determined, the TF used their clinical judgment and experience to establish a CST based on consensus. If there was a range, the TF used the lower side of the range. This was done given the known low risk of PAP therapy, as well as due to concerns that the benefits of PAP therapy might not be as robust as in the outpatient setting due to other acute standard inpatient therapies potentially having a larger immediate impact on recovery (e.g., thrombolytics given for an acute stroke). A summary of the CSTs for the clinical outcome measures is presented in **Table 4**.

Table 2 – PICO Questions

1	**Population:** Medically hospitalized adult patients at increased risk[1] for sleep-disordered breathing[2] **Intervention:** Inpatient screening[3] **Comparison:** No inpatient screening **Outcomes[9]:** Critical - Sleep-disordered breathing diagnosis, prevention of escalation in level of care (e.g., intubation, RRT support), readmission, mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events); Important - Length of hospitalization, daytime sleepiness, quality of life, positive airway pressure adherence, time to treatment, time to post-discharge follow-up
2	**Population:** Medically hospitalized adult patients at increased risk[1] for sleep-disordered breathing[2,4] **Intervention:** Inpatient sleep diagnostics **Comparison:** No inpatient sleep diagnostics **Outcomes:** Critical - Prevention of escalation in level of care (e.g., intubation, RRT support), readmission, mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events), stroke recovery; Important - Length of hospitalization, daytime sleepiness, quality of life, positive airway pressure adherence, time to treatment, time to post-discharge follow-up
3	**Population:** Medically hospitalized adult patients with an established diagnosis of moderate-to-severe sleep-disordered breathing and not currently on treatment[2,5,6,10] **Intervention:** Inpatient treatment with positive airway pressure, supplemental oxygen or alternative therapies

	Comparison: No inpatient treatment **Outcomes[9]:** Critical - Prevention of escalation in level of care (e.g., intubation, RRT support), readmission, mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events), stroke recovery; Important - Length of hospitalization, daytime sleepiness, quality of life, positive airway pressure adherence, time to treatment, time to post-discharge follow-up
4	**Population:** Medically hospitalized adult patients diagnosed with sleep-disordered breathing and on pre-admission treatment[2,10] **Intervention:** Inpatient treatment with positive airway pressure, alternative therapies or supplemental oxygen **Comparison:** No inpatient treatment **Outcomes[9]:** Critical - Prevention of escalation in level of care (e.g., intubation, RRT support), readmission, mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events), stroke recovery; Important - Length of hospitalization, daytime sleepiness, quality of life, positive airway pressure adherence, time to treatment, time to post-discharge follow-up
5	**Population:** Medically hospitalized adult patients at increased risk[1] for or with an established diagnosis of sleep-disordered breathing (with or without therapy at home)[2,5,10] **Intervention:** Inpatient sleep consultation[8] **Comparison:** No inpatient sleep consultation **Outcomes:** Critical - Sleep-disordered breathing diagnosis, prevention of escalation in level of care (e.g., intubation, RRT support), readmission, mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events), stroke recovery; Important - Length of hospitalization, daytime sleepiness, quality of life, positive airway pressure adherence, time to diagnosis, time to treatment, time to post-discharge follow-up
6	**Population:** Medically hospitalized adult patients at increased risk[1] for or with an established diagnosis of sleep-disordered breathing[2,5,6] **Intervention:** Inpatient physiologic monitoring[7] **Comparison:** No inpatient physiologic monitoring **Outcomes:** Critical - Prevention of escalation in level of care (e.g., intubation, RRT support), mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events), Important - Length of hospitalization, readmission, stroke recovery, positive airway pressure adherence, time to treatment, time to post-discharge follow-up
7	**Population:** Medically hospitalized adult patients at increased risk[1] for or with an established diagnosis of sleep-disordered breathing[2,5,10] **Intervention:** Peri-discharge management with sleep medicine[11] **Comparison:** No peri-discharge management with sleep medicine **Outcomes:** Critical - Readmission, mortality, incidence of sleep-disordered breathing-related comorbidities (e.g., hypertension, cardiovascular events), stroke recovery; Important - Daytime sleepiness, sleep quality, dyspnea, time to treatment, time to post-discharge follow-up

136 [1] Patients at risk for SDB are defined in Table 1.

[2] Special consideration of SDB subtypes, severity and comorbidities and their related outcomes (e.g., heart failure, atrial fibrillation, acute coronary syndrome, chronic obstructive pulmonary disease, pulmonary hypertension, stroke).
[3] Mode of screening such as questionnaire versus high resolution pulse oximetry (HRPO).
[4] Special consideration of HSAT versus PSG.
[5] Special consideration of those with inpatient diagnosis versus no inpatient diagnosis.
[6] Special consideration of positive airway pressure type (CPAP, auto PAP, Bilevel PAP, Bilevel PAP ST mode, autoBilevel PAP, AVAPS or adaptive servoventilation).
[7] Inclusive of continuous oximetry, carbon dioxide monitoring (end tidal or transcutaneous), cardiac telemetry and arterial blood gas.
[8] Special consideration of provider type, i.e., physician, PA, nurse practitioner, respiratory therapist.
[9] Special consideration of sex- and race-specific differences.
[10] Special consideration of the post-stroke rehabilitation population.
[11] Includes patients with a prior diagnosis but were untreated. Adult patients admitted to the hospital found to be at risk for SDB, newly diagnosed with SDB, or newly initiated on PAP therapy.

Table 3 – Outcomes by PICO Question

Outcomes	PICO Question #						
	1	2	3	4	5	6	7
SDB diagnosis	√*				√*		
Prevention of escalation in level of care (e.g., intubation, RRT support)	√*	√*	√*	√*	√*	√*	
Readmission†	√*	√*	√*	√*	√*	√	√*
Mortality†	√*	√*	√*	√*	√*	√*	√*
Incidence of SDB-related comorbidities (e.g., hypertension, CV events)†	√*	√*	√*	√*	√*	√*	√*
Stroke recovery		√*	√*	√*	√*	√	√*
Length of hospitalization	√	√	√	√	√	√	
Daytime sleepiness	√	√	√	√	√		√
Quality of life	√	√	√	√	√		
PAP adherence	√	√	√	√	√	√	√
Time to diagnosis					√		√
Time to treatment	√	√	√	√	√	√	√
Time to post-discharge follow-up	√	√	√	√	√	√	√
Sleep quality							√
Dyspnea							√

*****Outcomes considered critical for decision-making.
†Readmission data ranged from 6 months to 3 years. Mortality data ranged from 3 months to 5 years. Cardiovascular events data ranged from 1 month to 5 years.

Table 4 – Summary of Clinical Significance Thresholds for Outcome Measures

Outcome Measure	Clinical Significance Threshold*†
Mortality	-10 per 1,000 absolute risk difference
Incidence of SDB-related comorbidities (e.g., hypertension, cardiovascular events)	-10 per 1,000 absolute risk difference
Readmission	-30 per 1,000 absolute risk difference
Stroke recovery mRS score BI score	 -1 point[42] +1.45 points (20-point scale); +7.25 points (100-point scale)[43]

Length of hospitalization	-1 day
PAP adherence	+0.5 hours/night[10]
Daytime sleepiness ESS score	 -2 points[44]
Quality of life EQ-5D score PHQ-9 score SF-36 score	 +0.08 points[10] -3 points[45] +3 points[10]
Sleep quality PSQI score	 -3 points[46]

* References used to inform task force consensus.
† The clinical significance thresholds are for comparison of pre- versus post-treatment effects as well as between intervention and control.

mRS – Modified Rankin scale; BI – Barthel Index; ESS – Epworth Sleepiness Scale; EQ-5D – European Quality of Life-5D; PHQ-9 – Patient Health Questionnaire-9; SF-36 – 36-item Short Form Health Status Survey; PSQI – Pittsburgh Sleep Quality Index

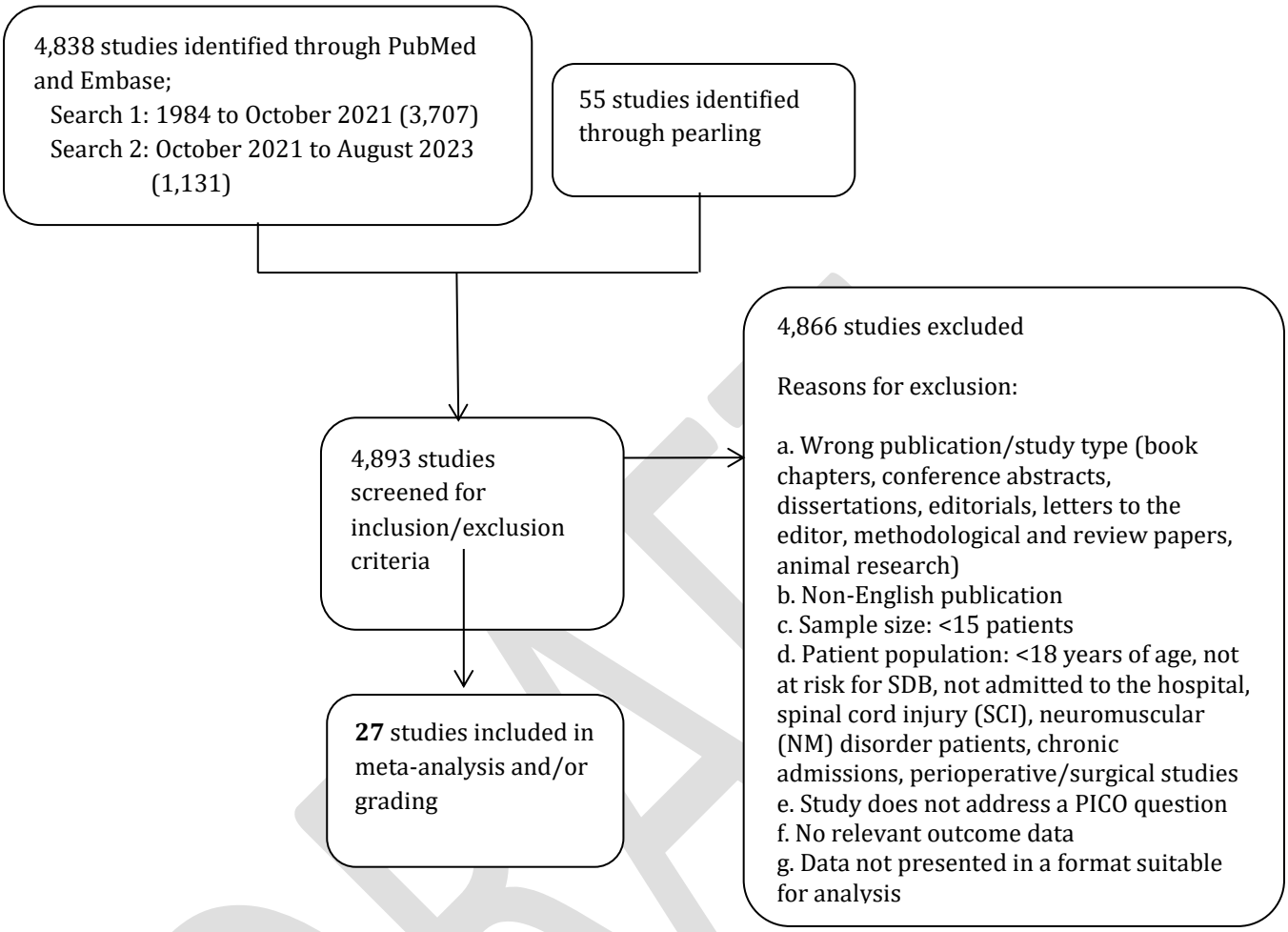
Literature Searches, Evidence Review and Data Extraction

The TF performed an extensive review of the scientific literature to retrieve articles that addressed the PICO questions. Literature searches were performed by the TF to address each PICO question using the PubMed and Embase databases (see **Figure 1**). Articles that met inclusion criteria but did not report outcomes of interest were rejected from the final evidence base. The key terms, search limits, and inclusion/exclusion criteria specified by the TF are detailed in the supplemental material.

The initial literature search was performed in October 2021. A second literature search was performed in August 2023 to identify studies that were published since the first literature search to update the body of evidence for the review. These searches identified a total of 4,838 articles. Lastly, the TF reviewed previously published guidelines, systematic reviews, and meta-analyses to spot check for references that may have been missed during the prior searches. The TF identified 55 additional articles that were screened for inclusion/exclusion in the guideline.

The TF set inclusion and exclusion criteria, which are presented in the supplemental material. All studies were reviewed based on inclusion/exclusion criteria by two TF members. Any discrepancies between the reviewers were discussed and resolved by the two reviewers or a third TF member. A total of 27 studies were determined to be suitable for meta-analysis and/or grading.

Figure 1 – Evidence Base Flow Diagram



Statistical and Meta-analysis and Interpretation of Clinical Significance

Meta-analysis was performed on outcomes of interest, when possible, for each PICO question. These are presented in a table format in the supplemental material (**Tables S1-S27**, **Figures S1-S22**). Comparisons of interventions to controls and/or assessment of efficacy before and after each intervention were performed. The analyses were performed using Review Manager 5.3 software by pooling data across studies for each outcome measure. Some studies had data presented in the form of median and interquartile range. These were converted into data expressed as means and standard deviation.[47, 48] Post-treatment data from each arm were used for meta-analysis of RCTs when change values were not reported and baseline values between the two study groups were statistically similar. Pre- and post-treatment data were used for meta-analyses of observational studies. The pooled results for each continuous outcome measure were expressed as the mean difference between the intervention and control for RCTs or pre-treatment versus post-treatment for observational studies. The pooled results for dichotomous outcome measures were expressed as the risk ratio or risk difference between the intervention and comparator or pre- versus post-treatment. The relative risk data were converted to an absolute risk estimate expressed as the number of

events/1000 patients treated. All analyses were performed using a random effects model with results displayed as a forest plot. Interpretation of clinical significance for the outcomes of interest was conducted by comparing the mean difference in effect size, or the risk difference for dichotomous outcomes, of each treatment approach to the CST (see **Table 4**).

GRADE Assessment for Developing Recommendations

The evidence was assessed according to the GRADE process for the purposes of making clinical practice recommendations. The TF considered the following four GRADE domains: certainty of evidence, balance of beneficial and harmful effects, patient values and preferences, and resource use, as described below:[49, 50]

1. **Certainty of evidence:** Based on an assessment of the overall risk of bias (randomization, blinding, allocation concealment, selective reporting), imprecision (95% confidence interval crosses the CST and/or sample size < 400 participants), inconsistency ($I^2 \geq 50\%$), indirectness (study population vs target patient population), and risk of publication bias, the TF determined their overall confidence that the estimated effect found in the body of evidence was representative of the true treatment effect that typical hospitalized patients with SDB would see. The certainty of the evidence was based on outcomes that the TF deemed critical for decision making; important outcomes are not considered when determining the overall certainty of evidence.
2. **Benefits vs harms:** Based on the meta-analysis of adverse effects reported within the accepted literature and on the clinical expertise of the TF, the TF determined whether the beneficial outcomes of using each intervention outweighed any harms.
3. **Patient values and preferences:** Based on the clinical expertise of the TF members and any data published on the topic relevant to patient preferences, the TF determined if patient values and preferences would be generally consistent across most patients, and if patients would use the intervention based on the relative harms and benefits identified.
4. **Resource use:** Based on the clinical expertise of the TF members and any data published on the topic relevant to resource use, the TF determined whether the accessibility and costs associated with each intervention compared favorably to those associated with alternative interventions. Information on costs to both patients and the health care system, impact on health equity, acceptability and feasibility to implement the interventions were considered.

A summary of each GRADE domain is provided after the detailed evidence review for each PICO question.

Public Comment and Final Approval

Drafts of the systematic review and accompanying guideline were made available for public comment for a four-week period on the AASM website. AASM members, the general public and other relevant stakeholders were invited to provide feedback on the drafts. The TF took into consideration all the comments received and made decisions about whether to revise the draft based on the scope and feasibility of comments. The public comments and revised documents were submitted to the AASM Board of Directors who subsequently approved the final documents for publication.

The AASM expects this systematic review to have an impact on professional behavior, patient outcomes, and, possibly, health care costs. This review reflects the state of knowledge at the time of publication and will be reviewed and updated as new information becomes available.

RESULTS

The aims of the current systematic reviews and data analyses were to address PICO questions pertaining to SDB in adult patients undergoing hospitalization for medical indications. This review does not apply to patients admitted with acute or chronic respiratory failure requiring noninvasive ventilation support or for SDB considerations in perioperative surgical or procedural inpatient populations.

Below are detailed summaries of the evidence identified in the literature searches and the statistical analyses performed by the TF. Each evidence summary is accompanied by a discussion of the quality of evidence, balance of benefits and harms, patient values and preferences, and resource use considerations that contributed to the development of the clinical practice recommendations, which are provided in the accompanying clinical practice guideline.

INPATIENT SCREENING, DIAGNOSIS, & TREATMENT OF MEDICALLY HOSPITALIZED ADULTS WITH NO PRIOR DIAGNOSIS OR TREATMENT OF SLEEP-DISORDERED BREATHING

The literature search did not yield any studies that examined the impact on outcomes of only screening (PICO 1) or diagnosing (PICO 2) SDB in the absence of a treatment intervention (PAP therapy, PICO 3) (see **Table 5**). As such, the TF opted to combine PICOs 1-3 for analysis as part of an overarching screening, diagnosis and treatment approach to SBD in inpatients.

A total of 8 RCTs[51-58] investigated the use of an evaluation and management program for hospitalized adults with no prior diagnosis of SDB to improve one or more of the following outcomes: mortality, incidence of SDB-related comorbidities (cardiovascular events), stroke recovery, readmission, length of hospitalization, daytime sleepiness, and quality of life. Participants in the RCTs had a mean age of 61 years (18% female). Meta-analyses were performed to assess the efficacy of positive airway pressure as a treatment for hospitalized adults with SDB. The meta-analyses are provided in the supplemental material, **Tables S1-S7** and **Figures S1-S7**. A summary of the findings in a table format is provided in the supplemental material, **Table S8**. A summary of the evidence for each outcome is provided below.

Critical Outcomes

The following outcomes were determined by the TF to be critical for evaluating the efficacy of a screening, diagnosis, and treatment program for hospitalized adults at risk for SDB: mortality, incidence of SDB-related comorbidities (cardiovascular events), stroke recovery, and readmission. None of the studies identified in our literature review reported data for the following critical outcomes: SDB diagnosis, prevention of escalation in level of care (e.g., intubation, RRT support).

MORTALITY: The efficacy of a screening, diagnosis, and treatment program to reduce mortality was evaluated using a meta-analysis of 2 RCTs[52, 54] including a total of 1,381 participants. The duration of patient follow-up after treatment ranged from 3 to 5 years. The meta-analysis demonstrated a clinically meaningful reduction in mortality with a risk ratio of 0.83 (95% CI: 0.53 to 1.30) and an absolute risk difference of 10 fewer deaths/1,000 patients (95% CI: -28 to 18 events/1,000) **(Table S1, Figure S1)**. The certainty of evidence was low due to serious imprecision.

INCIDENCE OF SDB-RELATED COMORBIDITIES - CARDIOVASCULAR EVENTS: The efficacy of a screening, diagnosis, and treatment program to reduce the incidence of cardiovascular events was evaluated using a meta-analysis of 4 RCTs[52, 54, 56, 57] including a total of 1,452 participants. The duration of patient follow-up after treatment ranged from 1 month to 5 years. The meta-analysis demonstrated a clinically meaningful reduction in cardiovascular events with a risk ratio of 0.67 (95% CI: 0.38 to 1.20) and an absolute risk difference of 67 fewer events/1,000 patients (95% CI: -127 to 41 events/1,000) **(Table S2, Figure S2)**. The certainty of evidence was low due to serious imprecision.

STROKE RECOVERY: The efficacy of a screening, diagnosis, and treatment program to improve stroke recovery was evaluated using an analysis of 1 RCT[51] including a total of 150 participants. The duration of patient follow-up after treatment was 12 months. The analysis demonstrated a non-clinically meaningful improvement in change in modified Rankin scale score, reporting a mean difference of -0.70 points (95% CI: -1.14 to -0.26) **(Table S3, Figure S3)**. The certainty of evidence was low due to risk of bias and imprecision.

READMISSION: The efficacy of a screening, diagnosis, and treatment program to reduce readmission was evaluated using an analysis of 1 RCT[52] including a total of 1,255 participants. The duration of patient follow-up after treatment was 3 years. The analysis demonstrated a non-clinically meaningful reduction in readmission with a risk ratio of 0.82 (95% CI: 0.59 to 1.13) and an absolute risk difference of 21 fewer readmissions/1,000 patients (95% CI: -48 to 15 events/1,000) **(Table S4, Figure S4)**. The certainty of evidence was low due to serious imprecision.

Important Outcomes

The following outcomes were determined by the TF to be important outcomes but not critical for evaluating the efficacy of a screening, diagnosis, and treatment program for hospitalized adults at risk for SDB: length of hospitalization, daytime sleepiness, quality of life, and sleep quality. None of the studies identified in our literature review reported data for the following important outcomes: PAP adherence, time to diagnosis, time to treatment, or time to post-discharge follow-up.

LENGTH OF HOSPITALIZATION: The efficacy of a screening, diagnosis, and treatment program to reduce length of hospitalization was evaluated using an analysis of 1 RCT[55] including a total of 126 participants. The analysis demonstrated a non-clinically meaningful reduction in length of hospitalization, reporting a mean difference of -0.60 days (95% CI: -2.16 to 0.96) **(Table S5, Figure S5)**. The certainty of evidence was low due to risk of bias and imprecision.

DAYTIME SLEEPINESS: The efficacy of a screening, diagnosis, and treatment program to reduce daytime sleepiness was evaluated using an analysis of 1 RCT[53] including a total of 44 participants. The duration of patient follow-up after treatment was 1 month. The analysis demonstrated a clinically meaningful improvement in post-treatment Epworth sleepiness score, reporting a mean difference of -2.70 points (95% CI: -3.71 to -1.69) **(Table S6, Figure S6)**. The certainty of evidence was low due to risk of bias and imprecision.

QUALITY OF LIFE: The efficacy of a screening, diagnosis, and treatment program to improve quality of life as measured by mental SF-36 score was evaluated using an analysis of 1 RCT[55] including a total of 126 participants. The duration of patient follow-up after treatment was 3 months. The analysis demonstrated a non-clinically meaningful improvement in post-treatment mental SF-36 score, reporting a mean difference of 0.60 points (95% CI: -3.82 to 5.02) **(Table S7, Figure S7)**. The certainty of evidence for quality of life was very low due to risk of bias and serious imprecision.

OVERALL QUALITY OF EVIDENCE: The TF determined that the overall certainty of evidence for the use of a screening, diagnosis, and treatment program for hospitalized adults not previously diagnosed with SDB was low based on the critical outcomes and downgrading of the evidence due to risk of bias and imprecision. (**Table S8**).

BENEFITS VS HARMS: The potential benefits of a screening, diagnosis, and treatment program for hospitalized adults not previously diagnosed with SDB include clinically meaningful improvements in mortality, cardiovascular events, daytime sleepiness. In addition, non-clinically meaningful improvements in stroke recovery, readmission, length of hospitalization, and quality of life were also found. No specific harms from screening, diagnosis or initiation of SDB treatment were reported in any of the studies. Based on these findings and the TF's combined clinical experience, the TF judged that the potential benefits of a screening, diagnosis, and treatment program in hospitalized adults diagnosed with SDB outweigh the potential harms.

RESOURCE USE: The TF judged the costs for the use of a screening, diagnosis, and treatment program for hospitalized patients not previously diagnosed with SDB to vary, depending on the availability of staff and equipment. For example, for some institutions there may exist a wide range of resources that might include personnel (nurses, respiratory therapy) with the capability to easily embed systematic screening tools at little cost to time or workflow, and/or readily available home sleep apnea testing devices/PSG equipment that can be implemented by nursing, respiratory therapy or sleep technologist in a protocolized manner, and/or clinicians with dedicated time to interpret and provide guidance on test results. However, contrary to this, some institutions may lack any of these resources and need to determine what is feasible to implement from a personnel and equipment standpoint, which could carry substantial cost.

PATIENTS' VALUES AND PREFERENCES: The TF concluded that there is probably no important uncertainty or variability in how much patients value the main outcomes. The TF judged that most hospitalized adults not previously diagnosed with SDB would generally be accepting of a screening, diagnosis, and treatment program.

INPATIENT TREATMENT OF MEDICALLY HOSPITALIZED ADULTS WITH AN ESTABLISHED DIAGNOSIS OF SLEEP-DISORDERED BREATHING AND NOT CURRENTLY ON TREATMENT

A total of 16 RCTs[51-66] investigated the positive airway pressure treatment of hospitalized adults with an established diagnosis of SDB to improve one or more of the following outcomes: mortality, incidence of SDB-related comorbidities (cardiovascular events), stroke recovery, readmission, length of hospitalization, daytime sleepiness, quality of life, and sleep quality. Participants in the RCTs had a mean age of 61 years (19% female). Meta-analyses were performed to assess the efficacy of positive airway pressure as a treatment for hospitalized adults with SDB. The meta-analyses are provided in the supplemental material, **Tables S9-S17** and **Figures S8-S16**. A summary of the findings in table format is provided in the supplemental material, **Table S18**. A summary of the evidence for each outcome is provided below.

Critical Outcomes

The following outcomes were determined by the TF to be critical for evaluating the efficacy of positive airway pressure to treat hospitalized adults with SDB: mortality, incidence of SDB-related comorbidities (cardiovascular

events), stroke recovery, and readmission. None of the studies identified in our literature review reported data for the following critical outcomes: prevention of escalation in level of care (e.g., intubation, RRT support).

MORTALITY: The efficacy of positive airway pressure to reduce mortality was evaluated using a meta-analysis of 4 RCTs[52, 54, 61, 66] including a total of 1,531 participants. The duration of patient follow-up after treatment ranged from 3 months to 5 years. The meta-analysis demonstrated a clinically meaningful reduction in mortality with a risk ratio of 0.78 (95% CI: 0.52 to 1.18) and an absolute risk difference of 14 fewer deaths/1,000 patients (95% CI: -31 to 12 events/1,000) **(Table S9, Figure S8)**. The certainty of evidence was low due to serious imprecision.

INCIDENCE OF SDB-RELATED COMORBIDITIES - CARDIOVASCULAR EVENTS: The efficacy of positive airway pressure to reduce the incidence of cardiovascular events was evaluated using a meta-analysis of 4 RCTs[52, 54, 56, 57] including a total of 1,452 participants. The duration of patient follow-up after treatment ranged from 1 month to 5 years. The meta-analysis demonstrated a clinically meaningful reduction in cardiovascular events with a risk ratio of 0.67 (95% CI: 0.38 to 1.20) and an absolute risk difference of 67 fewer events/1,000 patients (95% CI: -127 to 41 events/1,000) **(Table S10, Figure S9)**. The certainty of evidence was low due to serious imprecision.

STROKE RECOVERY: The efficacy of positive airway pressure to improve stroke recovery was evaluated using a meta-analysis of 2 RCTs[51, 63] including a total of 190 participants. The duration of patient follow-up after treatment ranged from 3 weeks to 12 months. The meta-analysis demonstrated a non-clinically meaningful improvement in change in modified Rankin scale score, reporting a mean difference of -0.55 points (95% CI: -0.86 to -0.24) **(Table S11, Figure S10)**. The certainty of evidence was low due to risk of bias and imprecision.

READMISSION: The efficacy of positive airway pressure to reduce readmission was evaluated using a meta-analysis of 2 RCTs[52, 61] including a total of 1,381 participants. The duration of patient follow-up after treatment ranged from 6 months to 3 years. The meta-analysis demonstrated a non-clinically meaningful reduction in readmission with a risk ratio of 0.92 (95% CI: 0.70 to 1.20) and an absolute risk difference of 10 fewer readmissions/1,000 patients (95% CI: -39 to 26 events/1,000) **(Table S12, Figure S11)**. The certainty of evidence was low due to serious imprecision.

Important Outcomes

The following outcomes were determined by the TF to be important outcomes but not critical for evaluating the efficacy of positive airway pressure to treat hospitalized adults with SDB: length of hospitalization, daytime sleepiness, quality of life, and sleep quality. None of the studies identified in our literature review reported data for the following important outcomes: PAP adherence, time to diagnosis, time to treatment, or time to post-discharge follow-up.

LENGTH OF HOSPITALIZATION: The efficacy of positive airway pressure to reduce length of hospitalization was evaluated using a meta-analysis of 3 RCTs[55, 63, 64] including a total of 196 participants. The meta-analysis demonstrated a non-clinically meaningful reduction in length of hospitalization, reporting a mean difference of -0.33 days (95% CI: -1.82 to 1.15) **(Table S13, Figure S12)**. The certainty of evidence was low due to serious imprecision.

DAYTIME SLEEPINESS: The efficacy of positive airway pressure to reduce daytime sleepiness was evaluated using a meta-analysis of 2 RCTs[61, 63] including a total of 166 participants. The duration of patient follow-up after treatment ranged from 3 weeks to 6 months. The meta-analysis demonstrated a non-clinically meaningful improvement in

change in Epworth sleepiness score, reporting a mean difference of -1.30 points (95% CI: -2.58 to -0.02) **(Table S14, Figure S13)**. The certainty of evidence was very low due to risk of bias and imprecision.

QUALITY OF LIFE: The efficacy of positive airway pressure to improve quality of life as measured by EQ-5D was evaluated using a meta-analysis of 2 RCTs[61, 63] including a total of 166 participants. The duration of patient follow-up after treatment ranged from 3 weeks to 6 months. The meta-analysis demonstrated a non-clinically meaningful improvement in change in EQ-5D score, reporting a mean difference of 0.03 points (95% CI: -0.04 to 0.1) **(Table S15, Figure S14)**.

The efficacy of positive airway pressure to improve quality of life as measured by PHQ-9 was evaluated using an analysis of 1 RCT[61] including a total of 126 participants. The duration of patient follow-up after treatment was 6 months. The analysis demonstrated a non-clinically meaningful decline in change in PHQ-9 score, reporting a mean difference of 1.8 points (95% CI: -0.5 to 4.1) **(Table S16, Figure S15)**.

The certainty of evidence for quality of life was low due to risk of bias and imprecision.

SLEEP QUALITY: The efficacy of positive airway pressure to improve sleep quality as measured by PSQI was evaluated using an analysis of 1 RCT[61] including a total of 126 participants. The duration of patient follow-up after treatment was 6 months. The analysis demonstrated a non-clinically meaningful decline in change in PSQI score, reporting a mean difference of 0.6 points (95% CI: -1.1 to 2.3) **(Table S17, Figure S16)**. The certainty of evidence was low due to risk of bias and imprecision.

OVERALL QUALITY OF EVIDENCE: The TF determined that the overall certainty of evidence for the use of positive airway pressure in hospitalized adults diagnosed with SDB was low based on the critical outcomes and downgrading of the evidence due to risk of bias and imprecision. **(Table S18)**.

BENEFITS VS HARMS: The potential benefits of positive airway pressure in hospitalized adults diagnosed with SDB include clinically meaningful improvements in mortality and cardiovascular events. In addition, non-clinically meaningful improvements in stroke recovery, readmission, length of hospitalization, daytime sleepiness, and quality of life (EQ-5D) were also seen. The potential harms include a non-clinically meaningful decline in quality of life (PHQ-9) and sleep quality. Based on these findings and their combined clinical experience, the TF judged that the potential benefits of positive airway pressure in hospitalized adults diagnosed with SDB outweigh the potential harms.

RESOURCE USE: The TF judged the costs for the use of positive airway pressure in the hospital to be moderate.

PATIENTS' VALUES AND PREFERENCES: The TF judged that there is probably no important uncertainty or variability in how much patients value the main outcomes. The TF judged that most hospitalized adults diagnosed with SDB would generally be accepting of treatment with positive airway pressure.

INPATIENT SLEEP CONSULTATION OF MEDICALLY HOSPITALIZED ADULTS AT INCREASED RISK OR WITH AN ESTABLISHED DIAGNOSIS OF SLEEP-DISORDERED BREATHING

One observational study[24] investigated the use of inpatient consultation for hospitalized adults at risk or with a diagnosis of SDB to improve the number of follow-up polysomnography diagnoses. Participants in the study had a mean age of 59 years (50% female). Analyses were performed to assess the efficacy of inpatient consultation for hospitalized adults with SDB. The analyses are provided in the supplemental material, **Tables S19** and **Figure S17**. A summary of the findings in table format is provided in the supplemental material, **Table S20**. A summary of the evidence for each outcome is provided below.

Critical Outcomes

The following outcomes were determined by the TF to be critical for evaluating the efficacy of inpatient consultation for hospitalized adults with SDB: number of follow-up polysomnography diagnoses. None of the studies identified in our literature review reported data for the following critical outcomes: prevention of escalation in level of care (e.g., intubation, RRT support), readmission, mortality, incidence of SDB-related comorbidities (e.g., hypertension, CV events), or stroke recovery.

NUMBER OF FOLLOW-UP POLYSOMNOGRAPHY DIAGNOSES: The efficacy of inpatient consultation to improve the number of follow-up polysomnography diagnoses was evaluated using an analysis of 1 observational study[24] including a total of 1,272 participants. The duration of patient follow-up was 1 year. The analysis demonstrated a clinically meaningful increase in follow-up polysomnography diagnoses with a risk ratio of 149 (95% CI: 21 to 1,061) and an absolute risk difference of 233 more diagnoses/1,000 patients (95% CI: 200 to 266 events/1,000) **(Table S19, Figure S17)**. The certainty of evidence was very low due to risk of bias associated with observational studies.

OVERALL QUALITY OF EVIDENCE: The TF determined that the overall certainty of evidence for the use of inpatient consultation in hospitalized adults at risk or diagnosed with SDB was very low based on the critical outcomes and downgrading of the evidence due to risk of bias associated with observational studies. **(Table S20)**.

BENEFITS VS HARMS: The potential benefits of inpatient consultation for hospitalized adults at risk or diagnosed with SDB include clinically meaningful improvements in follow-up polysomnography diagnoses. Based on their combined clinical experience, the TF judged that the potential benefits of inpatient consultation in hospitalized adults at risk or diagnosed with SDB outweigh the potential harms.

RESOURCE USE: The TF judged the costs of inpatient consultation to vary, depending on the availability of staff and equipment. Cost will also depend on the decided-upon structure of how inpatient sleep consultation would look at a given institution (see discussion section). For example, for some institutions the infrastructure including personnel and equipment may be readily available and starting more formalized inpatient consultation may be feasible at little additional investment. In other less resource-rich institutions, substantial investment in personnel and equipment might be required and thus a more informal and less costly approach (i.e., screening, no testing, ensuring outpatient follow-up) may be more practical and economically viable.

PATIENTS' VALUES AND PREFERENCES: The TF judged that there is probably no important uncertainty or variability in how much patients value the main outcomes. The TF judged that most hospitalized adults at risk or diagnosed with SDB would generally be accepting of inpatient consultation.

PERI-DISCHARGE MANAGEMENT OF MEDICALLY HOSPITALIZED ADULTS AT INCREASED RISK OR WITH AN ESTABLISHED DIAGNOSIS OF SLEEP-DISORDERED BREATHING

One RCT[67] and 6 observational studies[40, 68-72] investigated the use of a discharge management plan for hospitalized adults at risk or with a diagnosis of SDB to improve one or more of the following outcomes: mortality, incidence of SDB-related comorbidities (recurrent myocardial infarction, cardiovascular events), and readmission. Participants in the studies had a mean age of 62 years (40% female). Meta-analyses were performed to assess the efficacy of a discharge management plan for hospitalized adults with SDB. The meta-analyses are provided in the supplemental material, **Tables S21-S26** and **Figures S18-S22**. A summary of the findings in table format is provided in the supplemental material, **Table S27**. A summary of the evidence for each outcome is provided below.

Critical Outcomes

The following outcomes were determined by the TF to be critical for evaluating the efficacy of a discharge management plan for hospitalized adults with SDB: mortality, incidence of SDB-related comorbidities (recurrent myocardial infarction, cardiovascular events), stroke recovery, and readmission.

MORTALITY: The efficacy of a discharge management plan to reduce mortality was evaluated using a meta-analysis of 3 observational studies[40, 71, 72] including a total of 634 participants. The duration of patient follow-up ranged from 12 months to 5 years. The meta-analysis demonstrated a clinically meaningful reduction in mortality with a risk ratio of 0.60 (95% CI: 0.40 to 0.90) and an absolute risk difference of 68 fewer deaths/1,000 patients (95% CI: -102 to -17 events/1,000) **(Table S21, Figure S18)**. The certainty of evidence was very low due to risk of bias associated with observational studies and imprecision.

INCIDENCE OF SDB-RELATED COMORBIDITIES – RECURRENT MYOCARDIAL INFARCTION: The efficacy of a discharge management plan to reduce the incidence of recurrent myocardial infarction was evaluated using an analysis of 1 observational study[68] including a total of 123 participants. The duration of patient follow-up after treatment was 1 year. The analysis demonstrated a clinically meaningful reduction in recurrent myocardial infarction with a hazard ratio of 0.16 (95% CI: 0.03 to 0.76) and an absolute risk difference of 83 fewer events/1,000 patients (95% CI: -97 to -23 events/1,000) **(Table S22)**. The certainty of evidence was very low due to risk of bias associated with observational studies and imprecision.

INCIDENCE OF SDB-RELATED COMORBIDITIES – CARDIOVASCULAR EVENTS: The efficacy of a discharge management plan to reduce the incidence of cardiovascular events was evaluated using an analysis of 1 observational study[70] including a total of 96 participants. The duration of patient follow-up after treatment was 5 years. The analysis demonstrated a clinically meaningful reduction in cardiovascular events with a risk ratio of 0.47 (95% CI: 0.20 to 1.09) and an absolute risk difference of 203 fewer events/1,000 patients (95% CI: -306 to 34 events/1,000) **(Table S23, Figure S19)**. The certainty of evidence was very low due to risk of bias associated with observational studies and imprecision.

STROKE RECOVERY: The efficacy of a discharge management plan to improve stroke recovery was evaluated using an analysis of 1 RCT[67] including a total of 29 participants. The duration of patient follow-up after treatment was 3 months. The analysis demonstrated a non-clinically meaningful decline in post-treatment Barthel index score, reporting a mean difference of -3.40 points (95% CI: -14.21 to -7.41) **(Table S24, Figure S20)**. The certainty of evidence was low due to imprecision.

READMISSION: The efficacy of a discharge management plan to reduce readmission was evaluated using an analysis of 1 observational study[69] including a total of 81 participants. The duration of patient follow-up after treatment was 3 months. The analysis demonstrated a clinically meaningful reduction in readmission with a risk ratio of 0.38 (95% CI: 0.18 to 0.82) and an absolute risk difference of 334 fewer readmissions/1,000 patients (95% CI: -442 to -97 events/1,000) **(Table S25, Figure S21)**. The certainty of evidence was very low due to risk of bias associated with observational studies and imprecision.

Important Outcomes

The following outcomes were determined by the TF to be important outcomes but not critical for evaluating the efficacy of a discharge management plan for hospitalized adults with SDB: PAP adherence. None of the studies identified in our literature review reported data for the following important outcomes: length of hospitalization, daytime sleepiness, time to diagnosis, time to treatment, or time to post-discharge follow-up, sleep quality, or dyspnea.

PAP ADHERENCE: The efficacy of a discharge management plan to improve PAP adherence was evaluated using an analysis of 1 RCT[67] including a total of 29 participants. The duration of patient follow-up after treatment was 3 months. The analysis demonstrated a clinically meaningful increase in PAP adherence, reporting a mean difference of 76 minutes (95% CI: 16.7 to 135.2) **(Table S26, Figure S22)**. The certainty of evidence was moderate due to imprecision.

OVERALL QUALITY OF EVIDENCE: The TF determined that the overall certainty of evidence for the use of a discharge management plan in hospitalized adults at risk or diagnosed with SDB was very low based on the critical outcomes and downgrading of the evidence due to risk of bias associated with observational studies and imprecision **(Table S27)**.

BENEFITS VS HARMS: The potential benefits of a discharge management plan for hospitalized adults at risk or diagnosed with SDB include clinically meaningful improvements in mortality, recurrent myocardial infarction, cardiovascular events, readmission, and PAP adherence. Based on their combined clinical experience, the TF judged that the potential benefits of a discharge management plan in hospitalized adults at risk or diagnosed with SDB outweigh the potential harms.

RESOURCE USE: The TF judged the costs of a discharge management plan to vary, depending on the availability of staff and equipment. The cost will depend on the existing infrastructure at a given institution and how well embedded sleep medicine services are with the institution. For example, if formal Inpatient Sleep Consultation exists at an institution, then the transition to outpatient follow-up and care should be associated with minimal additional cost. However, if there is no clear pathway to outpatient testing, treatment and follow-up at a given institution, then instituting the protocols and pathways necessary to successfully transition patients to outpatient care may carry some significant investment in personnel and equipment.

PATIENTS' VALUES AND PREFERENCES: The TF judged that there is probably no important uncertainty or variability in how much patients value the main outcomes. The TF judged that most hospitalized adults at risk or diagnosed with SDB would generally be accepting of a discharge management plan.

DISCUSSION & FUTURE DIRECTIONS

Overall important considerations for interpreting the evidence (e.g., resource use, patients' values and preferences)

The SR and its accompanying CPG provide a comprehensive evaluation of the available literature addressing SDB management in hospitalized medical adult patients. In clinical practice, clinicians are increasingly asked to address questions about the appropriate diagnostic approach, treatment and follow-up for patients with known or suspected SDB in the inpatient setting. Despite an increasing body of literature examining this topic, the TF found an overall small number of acceptable studies characterized by heterogeneity regarding hospital settings, populations, and outcomes, and an overall low quality of evidence. These factors contributed to substantial imprecision and low certainty of evidence for each of the PICOs evaluated. Acknowledging these limitations, the TF offers clinical recommendations whenever possible to help guide sleep clinicians in navigating this complex and relatively new frontier of inpatient sleep medicine. Overall, the TF recommends diagnosis and treatment of SDB in hospitalized patients with a high pretest probability of having SDB or who are at high risk for SDB-related complications, and that sleep consultative services be available with discharge management planning to facilitate transition to outpatient care.

The TF recognizes that strong consideration be given to local resource needs, logistics, clinical judgment, and patient values and preferences when determining how to apply the recommendations in any given healthcare facility and/or for a given patient. For instance, many healthcare settings may not have the personnel or equipment resources to perform systematic patient screening, testing or treatment interventions in the inpatient setting. Reimbursement for diagnostic testing in hospitalized patients may be an issue depending on insurance policies, and some patients might decline testing and/or treatment during their hospitalization.

Strengths of the existing body of literature include the following: 1) researchers have utilized a variety of different approaches for screening (questionnaires, oximetry) and diagnosing (limited channel studies, polysomnography (PSG)) SDB in hospitalized patients; 2) different patient populations, mostly focused on those where SDB is prevalent, have been studied; 3) standardized treatment approaches were utilized; and 4) a spectrum of clinically relevant outcomes have been examined. However, these strengths are balanced by significant limitations that make it challenging to provide strong clinical recommendations. Study design is a problem in this field as there is a lack of appropriately sized RCTs for all the PICOs, and much of the observational data is missing suitable control populations for comparison. Many of the studies are underpowered for the outcomes of interest, and/or evaluate only a small subset of outcomes. Others fail to include important patient-related outcomes thus limiting conclusions. The majority of the studies examined patients admitted for cardiovascular disease or stroke, thereby limiting generalizability to other hospitalized populations.

For each of the PICO sections listed below, the findings will be discussed and placed in the context of clinical practice. Gaps in the evidence will also be reviewed and areas where future research is warranted will be discussed.

As the TF reviewed the literature based on each PICO, it became evident that screening, testing and treatment were all steps in an overall care pathway or approach to dealing with SDB in hospitalized patients, and that assessing outcomes based on each part of this process would not be possible. As a result, the TF combined PICOs 1-3 for analysis of outcomes. For patients with a known diagnosis of SDB and are adherent with therapy prior to admission (PICO 4), a Good Practice Statement was issued. PICOS 5-7 were analyzed individually and are discussed separately.

PICOs 1-3: SCREENING, EVALUATION AND MANAGEMENT FOR PATIENTS WITHOUT A KNOWN DIAGNOSIS OF SDB

While the TF analyzed data for PICOs 1-3 (inpatient screening, testing and treatment for medically hospitalized patients at risk for SDB) together, the discussion will still address each aspect of the overall patient care pathway to highlight important aspects of each component.

Table 5. RCTs that investigated the use of a screening, diagnosis, and treatment program for hospitalized adults with no prior diagnosis of SDB

Study	Screening	Diagnosis	PAP Treatment	PAP Initiation
Bravata 2018[51]		X	X	< 3 months
Sánchez-de-la-Torre 2020[52]		X	X	Inpatient
Ryan 2011[53]		X	X	< 3 months
Parra 2015[54]	X	X	X	Inpatient
Parra 2011[55]	X	X	X	Inpatient
Bravata 2011[56]		X	X	Inpatient
Bravata 2010[57]		X	X	Inpatient
Aaronson 2016[58]		X	X	Inpatient

Comments regarding the studies included in the Meta-Analysis for PICOs 1-3

Only RCTs were included for the meta-analyses for PICOs 1-3. Observational studies were not included due to the potential for significant bias and concerns that the timing of initiation of PAP treatment was either not clearly stated or beyond the 3-month post-discharge window, a time period that the TF felt represented an inpatient driven process. Database studies were deemed to be too biased to include in the meta-analyses given the high rates of underdiagnosis in the inpatient population, suspected bias toward treating sicker patients, and uncertainty about treatment and adherence to treatment.

Given the limited number of studies with treatment initiated during a medical hospitalization, additional studies were included if treatment was implemented within 3 months post-discharge as a result of SDB identification during acute hospitalization, and relevant short-term outcomes were reported. Studies with treatment initiated in inpatient stroke rehabilitation facilities were included.

Screening

While the direct impact of screening medically hospitalized patients on outcomes has not been fully investigated, screening alone could be beneficial if other mitigating interventions that do not require objective testing are implemented for patients screening as high risk for SDB. Examples of this include lateral positioning, pain medicine regimen modification and/or enhanced physiological monitoring. There is data in the perioperative literature to

suggest benefit from identifying those at risk for OSA,[73] however data in medically hospitalized patients are not currently available.

The studies in this analysis did not compare screening approaches. Screening questionnaires validated in the outpatient setting may not be as accurate for hospitalized patients. Studies attempting to validate screening questionnaires in some hospitalized patient populations (i.e. post-stroke) have found relatively poor accuracy.[74, 75] This, in part, results from patients with stroke, as well as those with heart failure, tending to be less sleepy and less likely to report other typical symptoms of SDB such as snoring or witnessed apneas when compared to the general population.[76,77] In the outpatient setting, asymptomatic patients may be less likely to benefit from therapy compared to symptomatically sleepy patients, however, translation to the inpatient setting is unclear .[78, 79] Conversely, a high percentage of hospitalized medical patients are likely to screen positive with questionnaires like the STOP-Bang, many of whom will have mild SDB and thus unlikely to need urgent evaluation. In a setting of limited resources, more objective screening such as use of a high-resolution pulse-oximetry (HRPO) offers a reasonably low-cost option that might help prioritize patients needing expedited formal diagnostic testing and treatment.[80] However, prescriptions for PAP therapy based solely on the results of HRPO are usually not covered.

The US Preventive Services Task Force (USPSTF) has recommended against screening for SDB in stable asymptomatic ambulatory patients.[81] However, these recommendations do not apply to persons with symptoms or concerns about OSA. In that regard the current guideline is not in conflict with USPSTF as the TF recommends screening in hospitalized patients with high-risk comorbidities that indicate moderate to severe SDB.[19] Acknowledging the potential limitations inherent to screening for SDB, the TF decided that screening as part of an overarching evaluation and management patient care pathway will lead to much higher rates of detection of SDB compared to standard clinical practice. Systematic screening of high-risk inpatient populations should be pared with clinical judgement, and the use of additional screening tools such as HRPO may help with clinical decision making.

Diagnostic Testing

For hospitalized patients suspected of having SDB, objective testing can formally diagnose as well as ascertain severity of SDB, factors important to inform indication for and timing of treatment. Testing for SDB includes formal attended or unattended full montage PSG as well as limited channel sleep study devices. While formal PSG testing can be done in the inpatient setting,[82, 83] the resource requirement and concerns about reimbursement often render it impractical. However, limited channel devices are more feasible options for inpatient testing, and there are a small number of studies validating the accuracy of certain limited channel studies in hospitalized patients, though more validation studies are needed.

Diagnostic sleep testing during acute illness in the hospitalized setting may not accurately reflect the chronic stable state and may lead to the overdiagnosis of SDB. Conversely, poor and fragmented sleep in a hospitalized patient could result in underestimation of the presence and/or severity of SDB. However, available literature suggests that patients diagnosed with SDB by objective testing during admission will continue to have SDB upon retesting following recovery from their acute illness.[21, 84]

Recognizing the concerns of testing for SDB during hospitalization, the TF concluded that inpatient sleep study testing, as part of a comprehensive evaluation and management patient care pathway, will allow for the diagnosis and risk stratification of SDB in hospitalized patients, something that is currently systematically lacking in standard clinical practice. Sleep study testing of high-risk inpatient populations should consider engagement and/or involvement of local sleep medicine expertise to optimize clinical decision-making.

PAP Therapy

Overall, the evidence was largely derived from studies in patients with a moderate to severe degree of SDB hospitalized with stroke, heart failure, or other cardiovascular disease. Most of the studies evaluated CPAP or bilevel PAP while only one evaluated adaptive servo ventilation (ASV). There were no studies that evaluated alternative therapies to PAP therapy for SDB treatment.

Based on RCTs, clinically meaningful improvements with treatment were found in the critical outcomes of mortality and cardiovascular events while non-clinically meaningful improvements were observed with readmissions and stroke recovery.[51-58] The quality of evidence for all critical outcomes suffered from imprecision and was downgraded to low certainty. Important outcomes were clinically meaningful for daytime sleepiness while non-clinically meaningful improvements were observed with length of hospitalization and quality of life. Similar to the critical outcomes, evidence for the important outcomes was found to be very low to low due to the small sample size and lack of blinding, thereby resulting in major imprecisions.

Despite the small effect size for the critical outcomes, the TF weighed these outcomes favorably given the consistent direction across outcomes and the perceived clinically relevant effect size of SDB-related cardiovascular event reduction. The TF also considered costs and resource requirements in their decision making. There were no undesirable effects of treatment in the trials examined. These factors guided the recommendation in favor of treatment with a low degree of certainty.

The TF also examined non-randomized studies addressing the question of treatment in the hospitalized setting, but due to residual confounding, selection bias, and misclassification bias, these did not impact the decision.

Some RCTs were not included in the meta-analysis as they did not report on outcomes of interest, yet they do provide some useful information. One small RCT demonstrated that implementing a PAP therapy protocol in patients admitted with heart failure exacerbation and pulmonary hypertension resulted in improved pulmonary pressures and ejection fraction within 48 hours.[85] In another RCT of heart failure patients, no significant difference was observed in the intent-to-treat (ITT) population though patients who were adherent with PAP therapy showed a dose-dependent improvement in ejection fraction and a reduced 6-month readmission rate.[86] RCT studies of PAP treatment in post-stroke patients have shown improvement in several outcomes including depression,[60] and motor outcomes.[53]

The Barthel Index scale and modified Rankin scale score in the setting of stroke were considered as outcome assessments in this SR given these measures were most consistently reported and represent overall functional improvement. Neither of these scales, however, capture more subtle motor or neurocognitive improvements. Patients with stroke receiving thrombolytics may be less likely to manifest improvements from PAP therapy due to better clinical outcomes following thrombolytics. The ongoing Sleep SMART trial of post-stroke SDB initiates treatment in the hospital with PAP therapy and should help to more definitively address these knowledge gaps.[87]

There were some studies that initiated PAP therapy during the hospitalization,[52, 54-58] while others initiated PAP therapy within 3 months of discharge.[51, 53] Most studies used limited channel sleep testing to diagnosis OSA prior to starting therapy,[51-55, 57, 58] but others initiated treatment empirically with delayed testing to determine whether ongoing treatment was necessary.[56] The immediate treatment of SDB with PAP therapy has the potential to improve recovery by protecting at-risk brain or heart following stroke and myocardial infarction, thus mitigating the extent of acute injury. In a multicenter RCT of patients with acute myocardial infarction who underwent percutaneous

coronary intervention with moderate to severe SDB (AHI > 15), early initiation of ASV was associated with improved myocardial salvage index and reduced infarct size compared to standard therapy alone.[88] Patient safety is also a major inpatient issue related to SDB and PAP therapy. In a study of acute heart failure inpatients those with undetected OSA who receive opioids during admission were at increased risk for escalation of care.[27] Another study found that patients screened as high risk for OSA had a higher incidence of Rapid Response Team (RRT) events during the hospital stay that were reduced by PAP therapy during hospitalization.[28] More studies are needed to evaluate these potential near-term benefits.

Some of the potential benefits of PAP therapy started during or shortly after hospitalization may only be seen with longer term treatment. For example, reduced readmission to the hospital and ED have been observed up to 12 months.[89] However, these findings need to be placed in the context of multiple RCTs of outpatient PAP therapy for SDB that have failed to show a reduction in the prevention of cardiovascular outcomes, though those RCTs excluded patients with substantial nocturnal hypoxemia as well as sleepy patients and suffer from overall low adherence to PAP therapy. Further research is required to ascertain if long term benefits over 5-10 years are observed from PAP therapy initiated during or following hospitalization.

Concern has been raised about the potential for lower PAP adherence in those that start treatment in the hospital. Possible reasons include higher acuity patients being targeted for therapy in the hospital, patients receiving less encouragement and support with PAP therapy initiation (e.g., acclimation, desensitization), and less equipment resources in the hospital (i.e., limited mask selection, use of humidification). Patient engagement and empowerment is key to the success of any medical intervention.[90, 91] Preliminary data suggest that patients diagnosed with SDB during hospitalization who were educated about SDB and PAP therapy and showed a positive disposition towards use of inpatient PAP therapy, may have improved adherence.[72, 92, 93] Higher inpatient PAP therapy adherence has been shown to predict post-discharge adherence.[92] Therefore, with appropriate support and patient motivation, starting inpatient therapy provides the opportunity to counsel patients and help them acclimatize to the therapy. In the RCTs that included inpatient initiation of PAP therapy with adherence data, two studies showed that better PAP adherence resulted in improved stroke recovery at 30 days,[56] and reduced vascular event rates at 90 days,[57] while another did not find a correlation between PAP adherence and 3-year cardiovascular outcomes.[52] Patient discharge disposition is another factor to consider regarding timing of PAP therapy initiation. Patients being discharged to long term care facilities (LTC) may not be permitted to undergo outpatient sleep diagnostics while residing in the LTC, thereby necessitating pre-discharge inpatient sleep testing and initiation of PAP therapy. LTC facilities often utilize facility-owned PAP devices, and therefore adherence data is less likely to be available to monitor and adjust treatment.[69] And there are inherent challenges of arranging for follow-up with a sleep medicine specialist for patients admitted to LTC facilities. The impact that patient discharge disposition has on outcomes is an area in need of future research.

Potential Risk of a Screening, Diagnosis and Treatment Pathway

The diagnostic accuracy of screening questionnaires for OSA is variable. The low specificity of the STOP-Bang questionnaire for example leads to a high false positive rate.[94] Conversely, HRPO and limited channel sleep testing may lead to false negative test results due to the inability to directly measure sleep.[95] Both of these may result in increased emotional burden for patients and potentially increased costs due to pursuing sleep testing which may not be necessary.

There are potential risks to early treatment with PAP therapy. Both stroke and heart failure patients are at risk for central sleep apnea (CSA) and inpatient initiation of PAP therapy, particularly in the absence of an attended PAP

titration study, may worsen the SDB by increasing central events. In addition, sleep may become more disrupted during initial acclimation to PAP therapy, which could negatively impact outcomes. Both OSA and CSA may temporarily worsen in the short term due to enforced supine positioning during admission, worsened underlying morbidity or medication use limited to the inpatient setting (i.e., pain medications). It is therefore conceivable that some patients may be started on treatment that is not needed long-term. Use of PAP devices in some patients (i.e., poor mental status) could increase the risk of aspiration. Despite these concerns, no adverse events were reported in the studies evaluating PAP therapy in hospitalized patients.

Resource use will vary substantially depending on the type of patient care pathway developed and implemented, with the least inpatient resources used when positively screened patients are referred for urgent outpatient evaluation and management. The use of HRPO or limited channel sleep study devices may help triage patients to maximize resource allocation. There may also be financial implications for the patient. In one study, 28% of the reasons for poor adherence with CPAP appeared to be due to the high cost of acquisition.[96]

Future Directions / Gaps in the evidence

While the data suggests that inpatient screening, testing and treatment of high-risk patients may be beneficial in increasing diagnoses and potentially reducing mortality, cardiovascular events, and daytime sleepiness in the hospital, future studies should be designed to identify the subset of patients most likely to benefit from this patient care pathway. Most of the studies included patients with high-risk comorbidities of stroke, heart attack or heart failure, or involved elderly patients on medical wards, and thus the potential benefits may not be generalizable. Gaps also exists in locations other than cardiac and medical units, including hospitalized patients with pregnancy complications such as preeclampsia,[97] and in other locations such as the emergency department. and in other locations such as the emergency department.

These guidelines are closely aligned with the goals of the Patient-Centered Outcomes Research Institute (PCORI), which emphasizes patient-centered outcomes research (PCOR) aimed at the early detection and intervention of diseases (https://www.PCORI.org). PCORI also prioritizes addressing the needs of the underserved, underrepresented, and historically excluded populations within healthcare. Sleep health disparities have persisted over decades with racial/ marginalized minorities and rural communities having high prevalence but less diagnosis and treatment of SDB. Implementation of an inpatient SDB screening program has resulted in more equitable screening and testing opportunities in underserved populations.[23,98]

Optimization and validation of screening and testing tools is needed, including validation in different inpatient populations. RCTs comparing immediate versus delayed evaluation and/or treatment with PAP therapy are warranted to determine optimal timing of testing and treatment, with consideration of inpatient and post-discharge outcomes, and identifying subgroups of patients that would most benefit from these management approaches. Clarifying approaches in patients who have a high risk for CSA or sleep-related hypoventilation is also warranted.

Economic cost-benefit analysis comparing inpatient versus outpatient evaluation and management pathways is needed taking into account the well-established economic burden of undiagnosed and untreated OSA,[99] which will continue to be a problem in the absence of systematic patient care pathways.

INPATIENT SLEEP CONSULTATION

Acknowledging limited data of very low certainty, the TF suggests that sleep-medicine consultation be available for medical hospitalized adults at risk for SDB or with known SDB diagnoses who need testing or therapy optimization, rather than no sleep medicine consultation. Recognizing the significant variability in resources across institutions and locations, and the lack of research examining the specific elements necessary to optimize inpatient sleep medicine consultation, the TF feels that inpatient sleep medicine consultation can be implemented in a variety of manifestations, from care coordinators with some sleep training / oversight to a clinician available for telehealth consultations to more traditional consultation with sleep fellows and an attending seeing patients on an inpatient service. As such, sleep medicine consultation may include any or all of a multidisciplinary team of physicians, advanced practitioners, nurses, sleep technologists, respiratory therapist, health educators, care coordinators, care managers, or other available resources within the institution. In ideal circumstances, sleep medicine consultation would be overseen by an AASM-accredited sleep disorders center in which e-consult and telehealth may be available in addition to more traditional consultation.

There is a lack of research on the direct influence of sleep medicine consultation on early detection and management of SDB and its subsequent impact on post-discharge outcomes. Only one observational study involving 636 participants designed to examine the number of follow-up PSG diagnoses post-discharge was available for review.[24] After one year of follow-up, there was a clinically meaningful increase in follow-up PSG diagnosis with an absolute risk difference of 233 more diagnoses/1,000 patients (95% CI: 200 to 266 events/100) after patients were screened during admission. These data suggest that the inpatient setting represents an opportunity to facilitate OSA diagnosis in high-risk patients.

The role of sleep medicine consultation has not been well-described and should be tailored based on available resources and needs as noted earlier. Close collaboration with other subspecialties, such as pulmonary medicine, and partnering with established programs, such as heart failure and stroke programs, could mitigate the need for extra resources and additional personnel.

RCTs are needed to better understand the impact of establishing sleep medicine consultation on critical outcomes such as mortality, hospital readmissions, and the incidence of SDB-related comorbidities. Additionally, the impact of sleep medicine consultation on healthcare costs (i.e. healthcare utilization and hospital readmissions)[100] requires further investigation.

INPATIENT PHYSIOLOGICAL MONITORING

There was absence of evidence to inform the use of physiological monitoring for medically hospitalized patients with or at risk for SDB. Clinical trials on the use of respiratory monitoring, such as continuous oximetry or capnography, have been conducted in anesthesia, surgical and emergency department settings. Post-operative continuous oximetry surveillance has been shown to reduce rates of rescue events and ICU transfer,[101] but not to improve post-operative mortality or complications.[102] Meta-analysis comparing continuous oximetry with routine monitoring also did not show differences in ICU transfer or non-invasive ventilation use.[103]

Extrapolation from the post-operative literature is problematic given that these populations are distinctly different from medically hospitalized patients: surgical patients typically have fewer co-morbidities and lower illness acuity than hospitalized medical patients, and the risk of respiratory depression due to use of anesthesia agents, anxiolytics and opioids administered in the peri-operative period may not apply to a medical population. Patients with SDB

have sleep-related respiratory events chronically, and it is not evident that monitoring and detection of this during hospitalization changes the patient outcomes acutely. Further research on this topic in the inpatient medical setting is warranted.

PERI-DISCHARGE MANAGEMENT

Clinical pathways consist of multidisciplinary care plans meant to incorporate evidence-based medicine into processes of clinical care that respect the unique culture, resources and environment of each healthcare institution.[104] Healthcare systems should develop a discharge management pathway rather than having no plan for patients who are at risk or diagnosed with SDB during a recent inpatient admission. This would expedite the management of SDB leading to improvement in post-discharge outcomes in select high risk subgroups.[40, 67-72, 105] In particular, observational data has shown that peri-discharge pathways for OSA management may potentially lead to reductions in mortality,[40, 71, 72] post-discharge MIs,[68] post-discharge cardiovascular events, [70] and readmission rates.[69] Though RCTs are needed to determine if OSA is a modifiable risk factor for readmission, limited data suggests OSA is such a risk factor.[106] In addition, a small single RCT of peri-discharge management in patients with newly diagnosed OSA following stroke showed improved PAP adherence and stroke recovery with implementation of a proactive telemedicine monitoring program. [67]

A Veterans' Health Administration database study showed higher health care utilization due to ER visits (37% vs. 32% vs. 15%, respectively; p-value <0.05) and hospitalizations (24% vs. 17% vs. 7%, respectively; p-value <0.05) in newly diagnosed OSA when compared to chronic OSA versus no OSA. This suggests that early OSA recognition may reduce healthcare utilization, though the impact of treatment is unknown.[107] In patients identified with OSA and started on PAP during admission, studies have found that those nonadherent to PAP versus those adherent to PAP were more likely to be readmitted or seen in the ER post-discharge,[89] and had worse recovery following stroke / more vascular events.[56, 57] These results should be interpreted with caution given the low prevalence of SDB and potential of healthy adherer bias.

For the purposes of peri-discharge management, identifying the key stakeholders is essential. These include, but are not limited to, discharge coordinators, sleep board certified clinicians, respiratory therapists, nurses, patients, caregivers and durable medical equipment companies. Identifying the outpatient sleep clinics and understanding the outpatient workflow including types of sleep studies that are available and processes for prior authorization of sleep studies or PAP therapy is also clinically important. Sleep medicine is often under-resourced,[108] therefore using telemedicine opportunities[109] when feasible could bridge the gap during the transition of care and contribute to fewer sleep health disparities.[3, 13] Implementation of these types of clinical pathway care pathways will initially require upfront allocation of resources, but it will likely have positive effects on downstream patient outcomes while reducing hospital costs and readmission.[36]

REFERENCES

1. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol*. 2013;177(9):1006-14.
2. Kapur V, Strohl KP, Redline S, Iber C, O'Connor G, Nieto J. Underdiagnosis of sleep apnea syndrome in U.S. communities. *Sleep & breathing = Schlaf & Atmung*. 2002;6(2):49-54.
3. Redline S, Sotres-Alvarez D, Loredo J, et al. Sleep-disordered breathing in Hispanic/Latino individuals of diverse backgrounds. The Hispanic Community Health Study/Study of Latinos. *Am J Respir Crit Care Med*. 2014;189(3):335-44.
4. Javaheri S, Barbe F, Campos-Rodriguez F, et al. Sleep Apnea: Types, Mechanisms, and Clinical Cardiovascular Consequences. *J Am Coll Cardiol*. 2017;69(7):841-58.
5. Javaheri S, Martinez-Garcia MA, Campos-Rodriguez F, Muriel A, Peker Y. Continuous Positive Airway Pressure Adherence for Prevention of Major Adverse Cerebrovascular and Cardiovascular Events in Obstructive Sleep Apnea. *Am J Respir Crit Care Med*. 2020;201(5):607-10.
6. Mazzotti DR, Waitman LR, Miller J, et al. Positive Airway Pressure, Mortality, and Cardiovascular Risk in Older Adults With Sleep Apnea. *JAMA Netw Open*. 2024;7(9):e2432468.
7. Sharma S, Stansbury R. Sleep-Disordered Breathing in Hospitalized Patients: A Game Changer? *Chest*. 2022;161(4):1083-91.
8. Suen C, Wong J, Ryan CM, et al. Prevalence of Undiagnosed Obstructive Sleep Apnea Among Patients Hospitalized for Cardiovascular Disease and Associated In-Hospital Outcomes: A Scoping Review. *J Clin Med*. 2020;9(4).
9. Kapur VK, Auckley DH, Chowdhuri S, et al. Clinical Practice Guideline for Diagnostic Testing for Adult Obstructive Sleep Apnea: An American Academy of Sleep Medicine Clinical Practice Guideline. *J Clin Sleep Med*. 2017;13(3):479-504.
10. Patil SP, Ayappa IA, Caples SM, Kimoff RJ, Patel SR, Harrod CG. Treatment of Adult Obstructive Sleep Apnea with Positive Airway Pressure: An American Academy of Sleep Medicine Clinical Practice Guideline. *J Clin Sleep Med*. 2019;15(2):335-43.
11. Medicine AAoS, Sateia M. *International Classification of Sleep Disorders, 3rd Edition: Text Revision*. American Academy Of Sleep Medicine; 2023.
12. Benjafield AV, Ayas NT, Eastwood PR, et al. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. *Lancet Respir Med*. 2019;7(8):687-98.
13. Stansbury R, Strollo P, Pauly N, et al. Underrecognition of sleep-disordered breathing and other common health conditions in the West Virginia Medicaid population: a driver of poor health outcomes. *J Clin Sleep Med*. 2022;18(3):817-24.
14. Peppard PE, Young T, Palta M, Dempsey J, Skatrud J. Longitudinal study of moderate weight change and sleep-disordered breathing. *JAMA*. 2000;284(23):3015-21.
15. Greenburg DL, Lettieri CJ, Eliasson AH. Effects of surgical weight loss on measures of obstructive sleep apnea: a meta-analysis. *Am J Med*. 2009;122(6):535-42.
16. Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. *JAMA*. 2004;291(16):2013-6.
17. Glasser M, Bailey N, McMillan A, Goff E, Morrell MJ. Sleep apnoea in older people. *Breathe*. 2011;7(3):248-56.
18. Dudley KA, Patel SR. Disparities and genetic risk factors in obstructive sleep apnea. *Sleep Med*. 2016;18:96-102.
19. Yeghiazarians Y, Jneid H, Tietjens JR, et al. Obstructive Sleep Apnea and Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation*. 2021;144(3):e56-e67.
20. Johnson KG, Johnson DC. Frequency of sleep apnea in stroke and TIA patients: a meta-analysis. *J Clin Sleep Med*. 2010;6(2):131-7.

21. Khayat RN, Jarjoura D, Patt B, Yamokoski T, Abraham WT. In-hospital testing for sleep-disordered breathing in hospitalized patients with decompensated heart failure: report of prevalence and patient characteristics. *Journal of cardiac failure*. 2009;15(9):739-46.
22. Lindenauer PK, Stefan MS, Johnson KG, Priya A, Pekow PS, Rothberg MB. Prevalence, treatment, and outcomes associated with OSA among patients hospitalized with pneumonia. *Chest*. 2014;145(5):1032-38.
23. Rives-Sanchez M, Quintos A, Prillaman B, et al. Sleep Disordered Breathing in Hospitalized African-Americans. *J Natl Med Assoc*. 2020;112(3):262-67.
24. Sharma S, Mather PJ, Efird JT, et al. Obstructive Sleep Apnea in Obese Hospitalized Patients: A Single Center Experience. *J Clin Sleep Med*. 2015;11(7):717-23.
25. Shear TC, Balachandran JS, Mokhlesi B, et al. Risk of sleep apnea in hospitalized older patients. *J Clin Sleep Med*. 2014;10(10):1061-6.
26. Naranjo M, Willes L, Prillaman BA, Quan SF, Sharma S. Undiagnosed OSA May Significantly Affect Outcomes in Adults Admitted for COPD in an Inner-City Hospital. *Chest*. 2020;158(3):1198-207.
27. Niroula A, Garvia V, Rives-Sanchez M, et al. Opiate Use and Escalation of Care in Hospitalized Adults with Acute Heart Failure and Sleep-disordered Breathing (OpiatesHF Study). *Annals of the American Thoracic Society*. 2019;16(9):1165-70.
28. Sharma S, Chowdhury A, Tang L, Willes L, Glynn B, Quan SF. Hospitalized Patients at High Risk for Obstructive Sleep Apnea Have More Rapid Response System Events and Intervention Is Associated with Reduced Events. *PloS one*. 2016;11(5):e0153790.
29. Gill J, Wu C. In-hospital Outcomes and Arrhythmia Burden in Patients with Obstructive Sleep Apnea and Heart Failure with Preserved Ejection Fraction. *J Innov Card Rhythm Manag*. 2022;13(6):5033-40.
30. Desai R, Mellacheruvu SP, Akella SA, et al. Major Adverse Cardiac and Cerebrovascular Events in Geriatric Patients with Obstructive Sleep Apnea: An Inpatient Sample Analysis. *Med Sci (Basel)*. 2023;11(4).
31. Brgdar A, Yi J, Awan A, et al. Impact of Obstructive Sleep Apnea On In-Hospital Outcomes in Patients With Atrial Fibrillation: A Retrospective Analysis of the National Inpatient Sample. *Cureus*. 2021;13(12):e20770.
32. Joshi AA, Hajjali RH, Gokhale AV, et al. Outcomes of patients hospitalized for acute pulmonary embolism by obstructive sleep apnea status. *Pulm Circ*. 2021;11(2):2045894021996224.
33. Lyons PG, Zadravecz FJ, Edelson DP, Mokhlesi B, Churpek MM. Obstructive sleep apnea and adverse outcomes in surgical and nonsurgical patients on the wards. *J Hosp Med*. 2015;10(9):592-8.
34. Channick JE, Jackson NJ, Zeidler MR, Buhr RG. Effects of Obstructive Sleep Apnea and Obesity on 30-Day Readmissions in Patients with Chronic Obstructive Pulmonary Disease: A Cross-Sectional Mediation Analysis. *Annals of the American Thoracic Society*. 2022;19(3):462-68.
35. Khayat RN, Porter K, Germany RE, McKane SW, Healy W, Randerath W. Clinical and financial impact of sleep disordered breathing on heart failure admissions. *Sleep & breathing = Schlaf & Atmung*. 2023;27(5):1917-24.
36. Scalzitti NJ, O'Connor PD, Nielsen SW, et al. Obstructive Sleep Apnea is an Independent Risk Factor for Hospital Readmission. *J Clin Sleep Med*. 2018;14(5):753-58.
37. Bassetti CLA, Randerath W, Vignatelli L, et al. EAN/ERS/ESO/ESRS statement on the impact of sleep disorders on risk and outcome of stroke. *Eur Respir J*. 2020;55(4).
38. Khayat R, Jarjoura D, Porter K, et al. Sleep disordered breathing and post-discharge mortality in patients with acute heart failure. *Eur Heart J*. 2015;36(23):1463-9.
39. Konikkara J, Tavella R, Willes L, Kavuru M, Sharma S. Early recognition of obstructive sleep apnea in patients hospitalized with COPD exacerbation is associated with reduced readmission. *Hosp Pract (1995)*. 2016;44(1):41-7.

40. Sharma S, Mukhtar U, Kelly C, Mather P, Quan SF. Recognition and Treatment of Sleep-Disordered Breathing in Obese Hospitalized Patients May Improve Survival. The HoSMed Database. *Am J Med*. 2017;130(10):1184-91.
41. Dharmakulaseelan L, Boulos MI. Sleep Apnea and Stroke: A Narrative Review. *Chest*. 2024.
42. Savitz SI, Benatar M, Saver JL, Fisher M. Outcome analysis in clinical trial design for acute stroke: physicians' attitudes and choices. *Cerebrovasc Dis*. 2008;26(2):156-62.
43. Hsieh YW, Wang CH, Wu SC, Chen PC, Sheu CF, Hsieh CL. Establishing the minimal clinically important difference of the Barthel Index in stroke patients. *Neurorehabil Neural Repair*. 2007;21(3):233-8.
44. Crook S, Sievi NA, Bloch KE, et al. Minimum important difference of the Epworth Sleepiness Scale in obstructive sleep apnoea: estimation from three randomised controlled trials. *Thorax*. 2019;74(4):390-96.
45. Lynch CP, Cha EDK, Jenkins NW, et al. The Minimum Clinically Important Difference for Patient Health Questionnaire-9 in Minimally Invasive Transforaminal Interbody Fusion. *Spine (Phila Pa 1976)*. 2021;46(9):603-09.
46. Hughes CM, McCullough CA, Bradbury I, et al. Acupuncture and reflexology for insomnia: a feasibility study. *Acupunct Med*. 2009;27(4):163-8.
47. Luo D, Wan X, Liu J, Tong T. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. *Stat Methods Med Res*. 2018;27(6):1785-805.
48. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol*. 2014;14:135.
49. Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol*. 2011;64(4):383-94.
50. Morgenthaler TI, Deriy L, Heald JL, Thomas SM. The Evolution of the AASM Clinical Practice Guidelines: Another Step Forward. *J Clin Sleep Med*. 2016;12(1):129-35.
51. Bravata DM, Sico J, Vaz Fragoso CA, et al. Diagnosing and Treating Sleep Apnea in Patients With Acute Cerebrovascular Disease. *J Am Heart Assoc*. 2018;7(16):e008841.
52. Sánchez-de-la-Torre M, Sánchez-de-la-Torre A, Bertran S, et al. Effect of obstructive sleep apnoea and its treatment with continuous positive airway pressure on the prevalence of cardiovascular events in patients with acute coronary syndrome (ISAACC study): a randomised controlled trial. *Lancet Respir Med*. 2020;8(4):359-67.
53. Ryan CM, Bayley M, Green R, Murray BJ, Bradley TD. Influence of continuous positive airway pressure on outcomes of rehabilitation in stroke patients with obstructive sleep apnea. *Stroke*. 2011;42(4):1062-7.
54. Parra O, Sánchez-Armengol Á, Capote F, et al. Efficacy of continuous positive airway pressure treatment on 5-year survival in patients with ischaemic stroke and obstructive sleep apnea: a randomized controlled trial. *Journal of sleep research*. 2015;24(1):47-53.
55. Parra O, Sánchez-Armengol A, Bonnin M, et al. Early treatment of obstructive apnoea and stroke outcome: a randomised controlled trial. *Eur Respir J*. 2011;37(5):1128-36.
56. Bravata DM, Concato J, Fried T, et al. Continuous positive airway pressure: evaluation of a novel therapy for patients with acute ischemic stroke. *Sleep*. 2011;34(9):1271-7.
57. Bravata DM, Concato J, Fried T, et al. Auto-titrating continuous positive airway pressure for patients with acute transient ischemic attack: a randomized feasibility trial. *Stroke*. 2010;41(7):1464-70.
58. Aaronson JA, Hofman WF, van Bennekom CA, et al. Effects of Continuous Positive Airway Pressure on Cognitive and Functional Outcome of Stroke Patients with Obstructive Sleep Apnea: A Randomized Controlled Trial. *J Clin Sleep Med*. 2016;12(4):533-41.
59. Hsu CY, Vennelle M, Li HY, Engleman HM, Dennis MS, Douglas NJ. Sleep-disordered breathing after stroke: a randomised controlled trial of continuous positive airway pressure. *J Neurol Neurosurg Psychiatry*. 2006;77(10):1143-9.

60. Sandberg O, Franklin KA, Bucht G, Eriksson S, Gustafson Y. Nasal continuous positive airway pressure in stroke patients with sleep apnoea: a randomized treatment study. *Eur Respir J*. 2001;18(4):630-4.
61. O'Connor CM, Whellan DJ, Fiuzat M, et al. Cardiovascular Outcomes With Minute Ventilation-Targeted Adaptive Servo-Ventilation Therapy in Heart Failure: The CAT-HF Trial. *J Am Coll Cardiol*. 2017;69(12):1577-87.
62. Minnerup J, Ritter MA, Wersching H, et al. Continuous positive airway pressure ventilation for acute ischemic stroke: a randomized feasibility study. *Stroke*. 2012;43(4):1137-9.
63. Kim H, Im S, Park JI, Kim Y, Sohn MK, Jee S. Improvement of Cognitive Function after Continuous Positive Airway Pressure Treatment for Subacute Stroke Patients with Obstructive Sleep Apnea: A Randomized Controlled Trial. *Brain sciences*. 2019;9(10).
64. Khot SP, Davis AP, Crane DA, et al. Effect of Continuous Positive Airway Pressure on Stroke Rehabilitation: A Pilot Randomized Sham-Controlled Trial. *J Clin Sleep Med*. 2016;12(7):1019-26.
65. Brown DL, Chervin RD, Kalbfleisch JD, et al. Sleep apnea treatment after stroke (SATS) trial: is it feasible? *Journal of stroke and cerebrovascular diseases : the official journal of National Stroke Association*. 2013;22(8):1216-24.
66. Barlinn K, Jakubicek S, Siepmann T, et al. Autotitrating Bilevel Positive Airway Pressure in Large Vessel Steno-Occlusive Stroke Patients With Suspected Sleep Apnea: A Multicenter Randomized Controlled Study. *Frontiers in neurology*. 2021;12:667494.
67. Kotzian ST, Saletu MT, Schwarzinger A, et al. Proactive telemedicine monitoring of sleep apnea treatment improves adherence in people with stroke- a randomized controlled trial (HOPES study). *Sleep Med*. 2019;64:48-55.
68. Garcia-Rio F, Alonso-Fernández A, Armada E, et al. CPAP effect on recurrent episodes in patients with sleep apnea and myocardial infarction. *International journal of cardiology*. 2013;168(2):1328-35.
69. Johnson KG, Rastegar V, Scuderi N, Johnson DC, Visintainer P. PAP therapy and readmission rates after in-hospital laboratory titration polysomnography in patients with hypoventilation. *J Clin Sleep Med*. 2022.
70. Martínez-García MA, Campos-Rodríguez F, Soler-Cataluña JJ, Catalán-Serra P, Román-Sánchez P, Montserrat JM. Increased incidence of nonfatal cardiovascular events in stroke patients with sleep apnoea: effect of CPAP treatment. *Eur Respir J*. 2012;39(4):906-12.
71. Martínez-García MA, Soler-Cataluña JJ, Ejarque-Martínez L, et al. Continuous positive airway pressure treatment reduces mortality in patients with ischemic stroke and obstructive sleep apnea: a 5-year follow-up study. *Am J Respir Crit Care Med*. 2009;180(1):36-41.
72. Sharma S, Chakraborty A, Chowdhury A, Mukhtar U, Willes L, Quan SF. Adherence to Positive Airway Pressure Therapy in Hospitalized Patients with Decompensated Heart Failure and Sleep-Disordered Breathing. *J Clin Sleep Med*. 2016;12(12):1615-21.
73. Namen AM, Forest D, Saha AK, et al. Reduction in medical emergency team activation among postoperative surgical patients at risk for undiagnosed obstructive sleep apnea. *J Clin Sleep Med*. 2022;18(8):1953-65.
74. Takala M, Puustinen J, Rauhala E, Holm A. Pre-screening of sleep-disordered breathing after stroke: A systematic review. *Brain Behav*. 2018;8(12):e01146.
75. Boulos MI, Wan A, Im J, et al. Identifying obstructive sleep apnea after stroke/TIA: evaluating four simple screening tools. *Sleep Med*. 2016;21:133-9.
76. Martynowicz H, Jodkowska A, Skomro R, et al. The estimation of excessive daytime sleepiness in post-stroke patients - a polysomnographic study. *Respir Physiol Neurobiol*. 2019;267:1-5.
77. Arzt M, Young T, Finn L, et al. Sleepiness and sleep in patients with both systolic heart failure and obstructive sleep apnea. *Arch Intern Med*. 2006;166(16):1716-22.

78. Allen AJH, Jen R, Mazzotti DR, et al. Symptom subtypes and risk of incident cardiovascular and cerebrovascular disease in a clinic-based obstructive sleep apnea cohort. *J Clin Sleep Med*. 2022;18(9):2093-102.
79. Mazzotti DR, Keenan BT, Lim DC, Gottlieb DJ, Kim J, Pack AI. Symptom Subtypes of Obstructive Sleep Apnea Predict Incidence of Cardiovascular Outcomes. *Am J Respir Crit Care Med*. 2019;200(4):493-506.
80. Sharma S, Mather P, Efird JT, et al. Photoplethysmographic Signal to Screen Sleep-Disordered Breathing in Hospitalized Heart Failure Patients: Feasibility of a Prospective Clinical Pathway. *JACC Heart failure*. 2015;3(9):725-31.
81. Mangione CM, Barry MJ, Nicholson WK, et al. Screening for Obstructive Sleep Apnea in Adults: US Preventive Services Task Force Recommendation Statement. *Jama*. 2022;328(19):1945-50.
82. Pena-Orbea C, Wang L, Srisawart P, Foldvary-Schaefer N, Mehra R. Sex-specific differences in diagnostic approaches of inpatient sleep testing for obstructive sleep apnea. *Sleep Med*. 2023;102:157-64.
83. Al-Jawder S, Bahammam A. Utility of daytime polysomnography for in-patients with suspected sleep-disordered breathing. *Neurol Neurochir Pol*. 2009;43(2):140-7.
84. Szucs A, Vitrai J, Janszky J, et al. Pathological sleep apnoea frequency remains permanent in ischaemic stroke and it is transient in haemorrhagic stroke. *Eur Neurol*. 2002;47(1):15-9.
85. Sharma S, Fox H, Aguilar F, et al. Auto positive airway pressure therapy reduces pulmonary pressures in adults admitted for acute heart failure with pulmonary hypertension and obstructive sleep apnea. The ASAP-HF Pilot Trial. *Sleep*. 2019;42(7).
86. Khayat RN, Javaheri S, Porter K, et al. In-Hospital Management of Sleep Apnea During Heart Failure Hospitalization: A Randomized Controlled Trial. *Journal of cardiac failure*. 2020;26(8):705-12.
87. Brown DL, Durkalski V, Durmer JS, et al. Sleep for Stroke Management and Recovery Trial (Sleep SMART): Rationale and methods. *Int J Stroke*. 2020;15(8):923-29.
88. Arzt M, Fox H, Stadler S, et al. Treatment of sleep apnoea early after myocardial infarction with adaptive servo-ventilation: a proof-of-concept randomised controlled trial. *Eur Respir J*. 2024;64(3).
89. Sharma S, Stansbury R, Srinivasan P, et al. Early recognition and treatment of OSA in hospitalized patients and its impact on health care utilization in rural population: a real-world study. *J Clin Sleep Med*. 2024;20(8):1313-19.
90. Karazivan P, Dumez V, Flora L, et al. The patient-as-partner approach in health care: a conceptual framework for a necessary transition. *Acad Med*. 2015;90(4):437-41.
91. Al-Jabri FYM, Turunen H, Kvist T. Patients' Perceptions of Healthcare Quality at Hospitals Measured by the Revised Humane Caring Scale. *J Patient Exp*. 2021;8:23743735211065265.
92. Sharma S, Stansbury R, Badami V, Rojas E, Quan SF. Inpatient CPAP adherence may predict post-discharge adherence in hospitalized patients screened high risk for OSA. *Sleep & breathing = Schlaf & Atmung*. 2022.
93. Srinivasan PN, Rojas E, Olgers K, et al. Patient Perception of CPAP During Hospitalization and Treatment of Newly Diagnosed Sleep Apnea. *A37 SLEEP MEDICINE IN THE 21ST CENTURY*. American Thoracic Society; 2024:A1448-A48.
94. Bernhardt L, Brady EM, Freeman SC, et al. Diagnostic accuracy of screening questionnaires for obstructive sleep apnoea in adults in different clinical cohorts: a systematic review and meta-analysis. *Sleep & breathing = Schlaf & Atmung*. 2022;26(3):1053-78.
95. Sharma S, Del Prado-Rico C, Stansbury R, et al. How to interpret a negative high-resolution pulse oximetry in hospitalized patients screened for obstructive sleep apnea: an exploratory analysis. *Sleep & breathing = Schlaf & Atmung*. 2023;27(5):1935-38.
96. Gabryelska A, Sochal M, Wasik B, Szczepanowski P, Bialasiewicz P. Factors Affecting Long-Term Compliance of CPAP Treatment-A Single Centre Experience. *J Clin Med*. 2021;11(1).

97. Edwards N, Blyton DM, Kirjavainen T, Kesby GJ, Sullivan CE. Nasal continuous positive airway pressure reduces sleep-induced blood pressure increments in preeclampsia. *Am J Respir Crit Care Med*. 2000;162(1):252-7.
98. Stansbury R, Badami V, Rojas E, et al. Addressing rural health disparity with a novel hospital sleep apnea screening: Precision of a high-resolution pulse oximeter in screening for sleep-disordered breathing. *Sleep & breathing = Schlaf & Atmung*. 2022;26(4):1821-28.
99. Faria A, Allen AH, Fox N, Ayas N, Laher I. The public health burden of obstructive sleep apnea. *Sleep Sci*. 2021;14(3):257-65.
100. Patel N, Porter K, Englert J, Khayat R. Impact of Central Sleep Apnea on the Cost of Heart Failure Readmissions. *Journal of cardiac failure*. 2020;26:S116.
101. Taenzer AH, Pyke JB, McGrath SP, Blike GT. Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: a before-and-after concurrence study. *Anesthesiology*. 2010;112(2):282-7.
102. Moller JT, Johannessen NW, Espersen K, et al. Randomized evaluation of pulse oximetry in 20,802 patients: II. Perioperative events and postoperative complications. *Anesthesiology*. 1993;78(3):445-53.
103. Khanna AK, Banga A, Rigdon J, et al. Role of continuous pulse oximetry and capnography monitoring in the prevention of postoperative respiratory failure, postoperative opioid-induced respiratory depression and adverse outcomes on hospital wards: A systematic review and meta-analysis. *J Clin Anesth*. 2024;94:111374.
104. European Observatory Health Policy Series. In: Busse R, Klazinga N, Panteli D, Quentin W, eds. *Improving healthcare quality in Europe: Characteristics, effectiveness and implementation of different strategies*. Copenhagen (Denmark): European Observatory on Health Systems and Policies© World Health Organization (acting as the host organization for, and secretariat of, the European Observatory on Health Systems and Policies) and OECD (2019). 2019.
105. McDermott KW, Roemer M. Most Frequent Principal Diagnoses for Inpatient Stays in U.S. Hospitals, 2018. *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (MD): Agency for Healthcare Research and Quality (US); 2006.
106. Agrawal R, Jones MB, Spiegelman AM, Bandi VD, Hirshkowitz M, Sharafkhaneh A. Presence of obstructive sleep apnea is associated with higher future readmissions and outpatient visits-a nationwide administrative dataset study. *Sleep Med*. 2022;89:60-64.
107. Diaz K, Faverio P, Hospenthal A, Restrepo MI, Amuan ME, Pugh MJ. Obstructive sleep apnea is associated with higher healthcare utilization in elderly patients. *Ann Thorac Med*. 2014;9(2):92-8.
108. Singh R, Juarez PD, Redline S, Jackson CL. Shortage of sleep medicine specialists in federally qualified health centers: an illustrative example of differential access to care. *J Clin Sleep Med*. 2023;19(10):1849-50.
109. Fields BG, Dholakia SA, Ioachimescu OC. Sleep telemedicine training in fellowship programs: a survey of program directors. *J Clin Sleep Med*. 2020;16(4):575-81.

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