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Developing, Implementing, and Evaluating a Multifaceted Quality Improvement Intervention to Promote Sleep in an ICU

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Abstract

Critically ill patients commonly experience poor sleep quality in the intensive care unit (ICU) because of various modifiable factors. To address this issue, an ICU-wide, multifaceted quality improvement (QI) project was undertaken to promote sleep in the Johns Hopkins Hospital Medical ICU (MICU). To supplement previously published results of this QI intervention, the present article describes the specific QI framework used to develop and implement this intervention, which consists of 4 steps: (*a*) summarizing the evidence to create a list of sleep-promoting interventions, (*b*) identifying and addressing local barriers to implementation, (*c*) selecting performance measures to assess intervention adherence and patient outcomes, and (*d*) ensuring that all patients receive the interventions through staff engagement and education and regular project evaluation. Measures of performance included daily completion rates of daytime and nighttime sleep improvement checklists and completion rates of individual interventions. Although long-term adherence and sustainability pose ongoing challenges, this model provides a foundation for future ICU sleep promotion initiatives.

Keywords

sleep; intensive care unit; quality improvement; program development; program evaluation; delirium; cognition; outcome assessment

Critically ill patients experience markedly disrupted sleep in the intensive care unit (ICU) setting, putting them at risk for deleterious physical and psychological sequelae.[1-3] Improved sleep is specifically recommended to improve delirium in the ICU,[4] which contributes to many adverse short-term and long-term outcomes.

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Although factors such as severity of illness and mechanical ventilation impair sleep in the ICU setting, many modifiable environmental variables also contribute to poor sleep, including noise, light, and patient care interactions.[3,5-8] Additionally, medications known to disrupt sleep, in particular benzodiazepines, are often prescribed in the ICU setting.[9-14]

Previous efforts to promote sleep in the ICU have demonstrated the feasibility and potential benefits of strategies to reduce noise and light,[15-17] along with earplugs,[18-20] eye masks,[19,20] white noise,[21] and ocean sounds.[22] Although these studies provided a foundation for future research, they did not address the full spectrum of modifiable factors using a multifaceted approach.

To address this issue, an established QI model was used to implement and evaluate a multifaceted sleep-promoting intervention in a medical ICU (MICU). As previously published,[23] this intervention demonstrated significant improvement in perceived noise ratings (mean ± standard deviation: 65.9 ± 26.6 vs 60.5 ± 26.3, $P = .001$), nonsignificant improvements in perceived sleep quality ratings (measured by Richards-Campbell Sleep Questionnaire [RCSQ][24]), and significant reductions in the incidence of delirium/coma (odds ratio = 0.46; 95% confidence interval = 0.23-0.89; $P = .02$), and increases in daily delirium/coma-free status (odds ratio = 1.64; 95% confidence interval = 1.04-2.58; $P = .03$) while in the ICU.

The objective of this article is to describe application of the QI model for design and implementation of a multifaceted sleep-promoting intervention in an MICU setting. In doing so, the study team discusses barriers encountered in the QI process and solutions to those barriers, along with issues concerning staff adherence and long-term sustainability in order to provide relevant information for other ICUs that may wish to undertake a similar type of project.

Methods

Context for the QI Project

The Johns Hopkins Hospital (JHH), located in Baltimore, Maryland, is a quaternary care, academic teaching hospital with approximately 1000 beds. The 16-bed MICU is staffed by 2 physician teams, each composed of 1 attending intensivist, 1 fellow, and 5 resident physicians. Other members of the MICU staff include registered nurses (RN-to-patient ratio of 1:2), clinical nursing technicians, respiratory therapists, pharmacists, and physical and occupational therapists. New admissions to the ICU are assigned to the first available bed; hence, each team's patients have comparable illness severity and receive identical standardized nursing care, consisting of twice-daily assessments of sedation and delirium and a nurse-titrated sedation protocol.

Use of an Established QI Model

This project was designed and implemented via an established QI model[25] (Figure 1). Used in prior QI projects,[26,27] this model involves framing the problem within the overall health care system and forming a collaborative team to carry out 4 steps: (*a*) summarizing the evidence to identify potentially beneficial interventions, (*b*) identifying local barriers to

implementation, (*c*) selecting and developing performance measures, and (*d*) ensuring that all patients receive the interventions. The last step follows an iterative "4 Es" algorithm to engage and educate staff, execute the intervention, and evaluate performance using objective measurement tools. Importantly, the steps of this model, while sequential, also can occur simultaneously.

In the context of ongoing efforts in the MICU to improve sleep quality, and in accordance with Office for Human Research Protections standards,[28] the institutional review board (IRB) chair at Johns Hopkins University deemed the ICU-based portion of this project "quality improvement" and therefore did not require IRB approval.

Applying the QI Model to Promote Sleep in the MICU

A key first step was the formation of a multidisciplinary team to design and implement the project. The QI effort was initiated by an ICU physician-researcher (DMN) with extensive QI experience who is director of the Johns Hopkins Outcomes After Critical Illness and Surgery (OACIS) group, adopted by a Pulmonary and Critical Care Medicine fellow (BBK), and guided by an internationally recognized sleep physician (NAC). The QI team also included the MICU director (RGB) and an MICU nurse champion (LMK) who provided valuable local leadership, support, and resources. Other members included experts in MICU nursing and pharmacy, psychiatry, biostatistics, and neuropsychology. Eighteen months was allotted to plan the project, including conducting a 3-week pilot study (Table 1).

Step 1: Summarize the Evidence—The MICU sleep team reviewed data regarding the causes and consequences of poor sleep in the ICU and devised a list of potential interventions based on their feasibility and potential benefits.[8,15-19,21,22] Based on evidence from prior QI studies,[27] the QI team adopted a bundled approach, implementing similar interventions together, in 3 successive, additive stages: Stage 1, Modification of environmental factors; Stage 2, Provision of nonpharmacologic sleep aids; and Stage 3, Provision of a pharmacologic sleep aid guideline (Table 2).

Step 2: Identify Local Barriers to Implementation—Monthly multidisciplinary and MICU staff meetings were used to identify barriers to achieving staff buy-in and performing specific interventions. To achieve buy-in, a number of strategies were adopted (as detailed in "Step 4: 4 Es Model" that follows), and a 22-day pilot study was conducted to assess feasibility.[29]

The majority of local barriers involved intervention implementation. Out of concern for overwhelming staff with multiple interventions, QI interventions were implemented in 3 sequential, additive stages (Table 2).

There also were structural and organizational barriers. Closely spaced patient rooms precluded complete noise elimination. Control over ICU-wide lighting and temperature also was limited. However, the interventions focused on other modifiable issues such as minimizing both in-room alarms and overhead pages and dimming both room and hallway lights. In lieu of white noise[21] and ocean sounds,[22] which were not available in the MICU,

the QI team substituted use of a television channel that played soothing music. Blinds that were inconvenient for staff to raise each day were tacked up permanently.

Step 3: Measure Performance—Adherence and outcome data were collected on a daily basis (Table 3). As in prior QI efforts,[27] daily reminder checklists were used to increase intervention implementation. Adherence data included completion rates of nurse and clerk checklists and of individual checklist items. The day shift and night shift nurse checklists documented completion of patient-focused daytime and nighttime interventions, respectively, while the evening (7 pm to 11 pm) and night (11 pm to 7am) clerk checklists documented completion of ICU-wide nighttime interventions. One hundred percent of checklist items had to be addressed for the checklist to be deemed "complete." Additionally, nurses completed a 1-time questionnaire for each patient assessing home sleep quality[30] and a daily questionnaire assessing patients' perceived sleep quality (see "RCSQ" below) and any medications given for sleep.

This project's 2 primary outcome measures were perceived sleep quality and patient cognition. Patient ratings of perceived sleep depth, latency, efficiency, and quality were evaluated each day using the RCSQ, a 5-item survey validated against polysomnography in an ICU population.[24] RCSQs were not completed for comatose or deeply sedated patients (Richmond Agitation Sedation Scale [RASS][31] score of −4 or −5). Patients who declined or were unable to complete the RCSQ (because of physical impairment or a language barrier) had it completed by their night shift nurse, based on previous efforts using nurse assessments.[32,33] Twice-daily assessments of delirium/coma in the ICU were performed by MICU nursing staff using the valid and reliable Confusion Assessment Method-ICU[34] for delirium and RASS[31] for sedation.

For the primary analysis, a pre-post design was used to compare outcomes during a baseline preintervention period versus Stage 3, when all QI interventions had been implemented. The 6-month study duration was chosen based on MICU sleep team staff availability.

Step 4: Ensure All Patients Receive the Interventions: 4 Es Model—An iterative 4 Es Model was used to ensure all patients received the interventions.

Engage: Engagement of all stakeholders, from study leadership to frontline clinical staff, was necessary to ensure buy-in and sustained project adherence. The engagement process included (*a*) conducting in-service sessions during which evidence supporting sleep interventions was discussed; (*b*) presenting results from the 22-day pilot study, which included preintervention patient ratings of sleep quality in the MICU, patient testimonials regarding environmental barriers to sleep, and data showing the frequent use of deliriogenic medications for sleep; (*c*) recruitment of MICU nurse champions to collaborate on the project; and (*d*) monthly meetings with MICU nurses, clerks, and resident physicians to reinforce their role and brainstorm strategies for improvement.

Educate: Education of MICU staff took place throughout the project. Nurse champions attended multidisciplinary team meetings and were instrumental in project design. In preparation for the pilot study, MICU nurses were briefed on details of the QI project, the

daily checklist, and sleep surveys. During the pilot study, a member of the MICU sleep team met frequently with night shift staff to provide feedback, answer questions, and address barriers to future interventions and survey completion. During the baseline period of the QI project, each MICU clerk received a detailed explanation of the clerk checklist. Three nurse in-service slide presentations also were held for the nursing staff during this period to review sleep interventions in preparation for the next stage. At the launch of each stage, new interventions were discussed again with MICU staff. During the final stage, the pharmacologic sleep aid guideline was explained to all MICU staff, including all resident physicians who had newly rotated into the MICU, and posted throughout the MICU. By having 1 study team member (BBK) provide all structured presentations, the QI team ensured that all MICU staff received standardized and comprehensive education on the QI project.

Execute: As described in the QI model, there are 4 general approaches to overcoming implementation barriers.[25] First, the QI team standardized care by orienting all MICU staff to patient-centered and ICU-wide interventions. Second, the QI team used independent checks and reminders, in the form of a daytime and nighttime checklist, and daily verbal reminders from charge nurses and nurse champions to complete interventions. Third, to maximize convenience and simplicity, the QI team placed patient-centered checklists next to each room and incorporated ICU-wide clerk actions into an existing clerk checklist. Additionally, the QI team introduced a smaller number of interventions at one time using a staged approach. Fourth, to learn from problems, throughout the project obstacles were reviewed and addressed at monthly multidisciplinary sleep team meetings (see “Step 2: Identify Local Barriers to Implementation”).

Evaluate: Evaluation of the QI project used individual and group performance measures. Names were recorded on checklists to applaud individuals for excellent adherence and identify those with lower adherence who required further engagement and education. An “audit and feedback” approach was employed to assess group adherence, with presentation of standardized performance metrics during regular meetings with nurse champions, charge nurses, and clerks. Performance flyers displaying weekly adherence rates and positive patient feedback were posted at the end of each stage.

Results

The study population consisted of adult patients admitted to the JHH MICU from January 3 to July 22, 2010. All patients aged ≥18 years who spent ≥1 night in the MICU were eligible for interventions and outcomes analysis. The median patient age was 54 years (interquartile range = 44-66), and respiratory failure, gastrointestinal problems, and sepsis comprised the majority of ICU admission diagnoses. These demographic variables were similar between patients across all intervention stages. Additional baseline and ICU demographic data, along with results of daily perceived sleep quality and cognitive outcomes, were summarized briefly in the background section, with full details in a prior peer-reviewed publication.[23]

During Stages 1, 2, and 3 of the QI intervention, mean daily completion rates for daytime nurse checklists were 90% (SD = 12%), 87% (12%), and 84% (20%), respectively. Mean

nightly completion rates for nighttime nurse checklists were 85% (11%), 86% (14%), and 76% (17%), respectively. When clerks were present in the MICU, 94%, 79%, and 88% of evening and 86%, 80%, and 80% of night clerk checklists were completed during the 3 stages, respectively.

Table 4 displays MICU completion rates for individual QI interventions during each of the 3 stages. Chisquare or Fisher exact tests were used to compare unadjusted completion rates across the intervention stages. The lowest completion rates were observed for the nonpharmacologic sleep aids (<12%), as these interventions were not eligible to be completed on >60% of patients-days when patients were already asleep, delirious, or comatose, and >20% of patient-days when patients declined the intervention when offered. The proportion of administered sleep medications given that were favorable for sleep increased from 0% to 23% during Stages 1 and 2, respectively, and to 60% during Stage 3 after implementation of the pharmacologic sleep guide. Across intervention stages, there was no statistically significant difference in completion rates for 8 of the 17 (47%) interventions.

Discussion

In this project, the QI team used an established QI model to implement a sleep-promoting intervention in an MICU. This model employed a previously successful 4 Es algorithm (engage, educate, execute, and evaluate). Essential to this effort was implementation of multifaceted environmental, nonpharmacologic, and pharmacologic interventions in successive stages to allow for incremental adoption of interventions. Using this approach, the QI team demonstrated that ICU-wide and patient-focused interventions to promote sleep in the MICU were feasible to perform on a daily basis and did not distract from normal ICU staff workflow.

Although the project was feasible, adherence with the project was challenging for 2 main reasons. First, there were a large number of interventions (3 daytime and 14 nighttime) that required daily implementation and documentation via the checklist, as reflected by lower rates of daily completion of nighttime checklists compared to daytime checklists (76% to 85% vs 83% to 90%, respectively). Second, adherence rates for the majority of individual interventions ranged from 60% to 80%, but interventions requiring greater time and effort, such as promoting daytime wakefulness and giving a warm bath before 10 pm, had expectedly lower adherence rates (40% to 50%).

Sustainability of QI projects also is challenging. Sustainability is encouraged by immediate, visible results,[25] which can be difficult in sleep-related projects. Continued staff education on the consequences of poor sleep, frequent positive and negative feedback, and patient testimonials were felt to help with adherence during the project. Ongoing collection of data, after the end of funding for the project, has not continued.

Limitations

There were several limitations to this project. First, as with other QI projects, generalizability of these results is not certain. This project was implemented in an academic

MICU and led by clinical experts and team members with training and experience in QI projects. However, many of the implementation challenges surmounted in this project, such as completing interventions as part of routine care, are universal to all ICUs. Furthermore, the established QI model used and the commonsense appeal of these evidence-based sleep-promoting interventions (ie, dimming lights, turning off TVs, minimizing alarms) may facilitate implementation and buy-in in other settings.

Second, the QI team observed statistically significant between-stage differences in completion rates for more than half of interventions, likely because of trends in staffing, fatigue, or seasonality. Nevertheless, the team was encouraged that the completion rates for a majority of these interventions (ie, caffeine avoidance, interruptions, overhead pages) improved over time.

Third, the QI team did not objectively measure whether the interventions produced clinically significant changes in noise, light, and patient disturbances. However, MICU staff reported noticeable reductions in overhead pages, unnecessary alarms, and nighttime television watching. Post hoc analysis also revealed a significant association between the RCSQ noise rating and the overall sleep quality rating that excluded the noise question, suggesting improvements in perceived noise correlated with improvements in sleep.[23]

Fourth, the QI team did not objectively measure sleep quality using polysomnography, the gold standard in sleep measurement, which was not logistically or financially feasible in this project. Instead, although the RCSQ was found to be easy to collect on a large scale, this instrument may have been inadequate for this project given that it was validated as a measure in awake, nondelirious ICU patients.[24] Furthermore, during this project, nurses often completed RCSQs on their patients' behalf, based on previous studies.[32,33] However, in a separate subanalysis of this study, the QI team found that nurses tended to overestimate patient sleep quality using the RCSQ.[35] Given these limitations, further research may be needed regarding practical instruments to assess ICU sleep quality on a large-scale basis.

Conclusion

Using an established QI model, a multifaceted, ICU-wide intervention to promote sleep is feasible. Future directions include strategies to address sustainability and extension of similar efforts to other ICUs.

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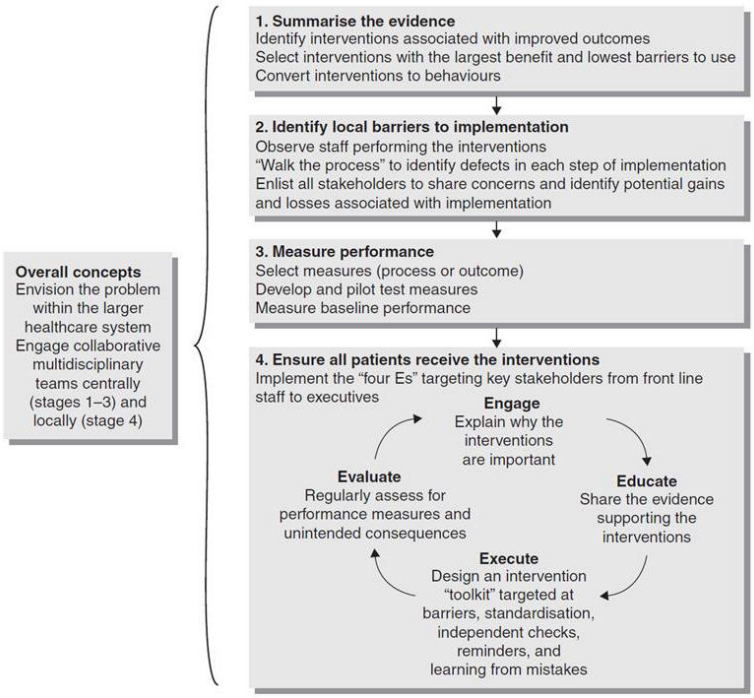

Figure 1.

A model for conducting quality improvement within the health care setting.

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Table 1

Timeline of Sleep QI.

Timing	Event	Activities
November 2008 to December 2009	Preproject Planning	
November 2008 to December 2009	Multidisciplinary Sleep QI Monthly Meetings[a]	Review literature on sleep interventions; outline project goals, design, and methods; assess barriers to implementation; determine process and outcome measures
September to October 2009	MICU Nursing Staff Meetings	Orientation to project and sleep surveys
September 17 to October 9, 2009 (22 days)	Pilot Project	Pilot test of baseline and daily sleep surveys in MICU with evaluation for feasibility, clarity, completeness, and accuracy
January 3 to July 22, 2010 (201 days)	Sleep QI Project	
	Ongoing Event	Daily log of MICU admission/discharge data and survey completion rates; daily survey collection with evaluation for completeness and accuracy
	Ongoing Event	Post-ICU cognitive testing on eligible consenting subjects identified through daily screening of MICU census (4-6 patients each week)
January and February 2010	Baseline Assessment (8 weeks)	Regular meetings with MICU staff to discuss surveys and upcoming sleep interventions and answer questions
March 1 to 28, 2010	Stage 1 (4 weeks)	Environmental interventions
March 29 to April 25, 2010	Stage 2 (4 weeks)	Nonpharmacologic sleep aids (in addition to Stage 1 interventions)
April 26 to July 22, 2010	Stage 3 (13 weeks)	Pharmacologic sleep aid guideline (in addition to Stage 1 and 2 interventions)

Abbreviations: MICU, medical intensive care unit; QI, quality improvement.

[a]Sleep Improvement Team consisted of MICU physicians, a sleep medicine physician, a psychologist, psychiatrists, an MICU pharmacist, MICU nurses, research support staff, and data analysts.

Table 2

Sleep QI Interventions.

Stage	Interventions
Stage 1: Environmental Interventions	*Daytime*: Raise blinds, minimize caffeine, and encourage activities to prevent napping
	Nighttime: Close room curtain, dim room lights, prevent unnecessary alarms, minimize nurse interruptions, provide warm bath before 10 pm, turn television off, control pain, and optimize temperature
	ICU-wide nighttime: Dim hallway lights, minimize overhead pages
Stage 2: Nonpharmacologic Sleep Aids (in addition to Stage 1 interventions)	Offer ear plugs, eye masks, and tranquil music at bedtime for nondelirious patients
Stage 3: Pharmacologic Sleep Aid Guideline (in addition to Stage 1 and 2 interventions)	Discourage medications known to alter sleep and precipitate delirium (eg, benzodiazepines); recommended zolpidem for patients without delirium and haloperidol/atypical antipsychotic for patients with delirium

Abbreviations: QI, quality improvement; ICU, intensive care unit.

Table 3

Process and Outcome Measures.

Measure	Mode of Assessment	Rationale
Process measures		
Use of checklist	Proportion of complete checklists[a]	Documents completion of nurse and clerk checklists in their entirety
Intervention adherence	Completion of individual checklist items	Documents completion of specific daytime/nighttime interventions
Outcome measures[b]		
Daily perceived sleep quality	RCSQ with nighttime noise item	Reliable and validated against polysomnographic sleep efficiency index[24]; high interrater reliability[32]
Daily delirium status	CAM-ICU	Reliable and valid measure[34]
Daily sedation/coma status	RASS	Reliable and valid measure[31]

Abbreviations: ICU, intensive care unit; CAM-ICU, Confusion Assessment Method–ICU; RASS, Richmond Agitation-Sedation Scale; RCSQ, Richards-Campbell Sleep Questionnaire.

[a]Checklists were recorded as complete only if 100% of items were answered.

[b]Also included 1-time questionnaire regarding patients' baseline home sleep quality (adapted from Pittsburgh Sleep Quality Index[30]) to address an important potential confounder.

Table 4

Adherence With Sleep Quality Improvement Interventions.

	Stage 1[a]	Stage 2[b]	Stage 3[c]
Patient daytime interventions, number of patient-days, n (%)[d,e]	268	251	735
Blinds raised	219 (82)	197 (78)	578 (79)
Caffeine avoided after 3 PM[f,g,h]	80 (49)	79 (51)	248 (54)
Less than 50% of day shift spent napping[i]	109 (51)	104 (50)	287 (45)
Patient nighttime interventions, number of patient-nights, n (%)[d]	292	264	826
Room lights dimmed before 10 PM[g]	230 (79)	220 (83)	642 (78)
Room curtain closed before 10 PM[g,h]	174 (60)	174 (66)	528 (64)
Warm bath before 10 PM	160 (55)	151 (57)	403 (49)
Unnecessary alarms prevented	237 (81)	220 (83)	640 (77)
Room temperature optimized	240 (82)	213 (81)	637 (77)
Pain appropriately controlled[h]	181 (62)	183 (69)	559 (68)
Television off[g,h]	210 (72)	166 (63)	486 (59)
Estimated number of nurse interruptions between 10 pm and 7 AM[g,h]			
0-5 interruptions	63 (22)	63 (24)	231 (28)
6-10 interruptions	105 (36)	80 (30)	177 (21)
>10 interruptions	50 (17)	59 (22)	111 (13)
Not reported	74 (25)	62 (23)	307 (37)
Soft music offered and accepted[j]		20 (12)	62 (11)
Eye mask offered and accepted[j]		5 (3)	10 (2)
Earplugs offered and accepted[h,j]		6 (3)	5 (1)
Medication given[g,h]			
Favorable for sleep	0 (0)	3 (23)	80 (60)
Unfavorable for sleep	18 (100)	10 (77)	53 (40)
ICU-wide nighttime interventions, number of nights, n (%)	28	28	88

	Stage 1[a]	Stage 2[b]	Stage 3[c]
Hallway lights dimmed by 10 pm	24 (86)	23 (82)	78 (89)
Overhead pages after 10 PM[g,h]			
None	6 (21)	2 (7)	13 (15)
1-3	5 (18)	5 (18)	32 (36)
>3	8 (29)	9 (32)	7 (8)
Unknown	9 (32)	12 (43)	36 (41)

Abbreviations: ICU, intensive care unit; RASS, Richmond Agitation-Sedation Scale.

[a] Environmental interventions.

[b] Nonpharmacologic sleep aid intervention AND Stage 1 interventions.

[c] Pharmacologic sleep aid guideline intervention AND Stage 1 and 2 interventions.

[d] In calculating proportions for checklist item adherence, items with missing data were considered not completed.

[e] Excludes patient-days where MICU admission took place after daytime interventions could be performed.

[f] Proportions calculated after exclusion of patient-days where patients' clinical status prohibited oral intake.

[g] $P < .05$ with missing data included; calculated using χ^2 or Fisher exact tests, as appropriate.

[h] $P < .05$ with missing data excluded; calculated using χ^2 or Fisher exact tests, as appropriate.

[i] Proportions calculated after exclusion of patient-days where activities to promote wakefulness were not performed because of deep sedation/coma status (RASS −4 or −5).

[j] Proportions calculated after exclusion of patient days where nonpharmacologic interventions were not offered because of sedation status (RASS −3, −4, or −5). Across all stages, nonpharmacologic interventions were not offered on between 32% and 57% of patient nights when patients were already asleep and between 29% and 36% of patient nights when patients were delirious or comatose. When offered, patients declined nonpharmacologic interventions on 26% to 47% of patient nights.