Nighttime Quiet in the Intensive Care Unit: An Integrative Review

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I have no known conflict of interest to disclose.

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List of Abbreviations

A-weighted decibels (dBA)

C-weighted decibels (dBC)

Centers for Disease Control and Prevention (CDC)

Decibels (dB)

Doctorate of Nursing Practice (DNP)

Environmental Protection Agency (EPA)

Intensive Care Unit (ICU)

Medical Intensive Care Unit (MICU)

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Rapid Eye Movement (REM)

Randomized Controlled Trials (RCT)

Richards Campbell Sleep Questionnaire (RCSQ)

The Joint Commission (JCAHO)

World Health Organization (WHO)

Abstract

Excessive environmental noise in the ICU often negatively impacts patient sleep. The World Health Organization (WHO) and Environmental Protection Agency (EPA) have published recommendations for hospital decibel levels, but the literature indicates that noise levels in the ICU often exceed these values. Patients experience disturbed sleep and rarely enter into N3 and REM sleep. The integrative review examined both the patients' and healthcare workers' perception of noise in the ICU environment to identify contributors and suggested interventions to mitigate these occurrences. In addition, this study evaluated objective measurements of patient sleep to further determine how well patients were sleeping in this environment. Utilizing the PRISMA model, 1,124 articles were screened and narrowed down according to the problem statement, questions, and inclusion and exclusion criteria. A total of 43 articles were included in this review. The articles identified multi-component bundles and strategies to be effective in decreasing environmental noise, although there was no standard intervention used across multiple studies. Objective measurements of sleep including polysomnography, actigraphy, and circadian rhythm studies revealed that patients are not sleeping well in this environment. While multiple studies have investigated different means of decreasing noise in the ICU environment, this is a complicated and multi-factorial issue. Additional research studies with more patients should be conducted to formulate a best-practice nighttime bundle for the ICU environment.

Key-words: noise, decibel level, sleep promotion, sleep intervention, intensive care unit, ICU, critical care and critical care unit.

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Nighttime Quiet in the Intensive Care Unit: An Integrative Review

Every day individuals are hospitalized with life-threatening illnesses. Many of these patients are placed in the intensive care unit (ICU). While in this environment, patients are surrounded by a considerable amount of noise and activity, causing fragmented sleep (Aitken et al., 2017; Naik et al., 2018). Nurses often fail to realize the elevated decibel levels to which their patients are constantly exposed (Johansson et al., 2016). Further study involving polysomnography revealed that patients rarely enter into recognized restorative rapid eye movement (REM) sleep or N3 sleep (Boyko, Jennum, Nikolic et al., 2017). Patel et al. (2014) revealed that many hospitals have implemented nighttime noise policies and sleep bundles in an effort to combat the increased stimulation patients experience at night.

Background

Environmental noise is not a new topic in healthcare. Multiple agencies have established guidelines to define safe decibel levels in the hospital environment. The World Health Organization (WHO) (1999) recommended that nighttime noise in the hospital remain below 40 decibels. The U.S. Environmental Protection Agency (EPA) (1974) stated that nighttime noise should not exceed 45 decibels. They go on to state that hearing loss may begin at 70 decibels (U.S. EPA, 1974), and the United States Department of Labor mandated that workers not be exposed to 90 decibels for greater than 8 hours per day (Occupational Safety and Health Administration, n.d.). As the decibel levels increase, the amount of time individuals may be exposed to the noise decreases. The Centers for Disease Control and Prevention (CDC) (2019) identified that hearing loss can occur with repeated exposure to everyday sounds. They stated that the decibel level of a normal conversation is roughly 60 decibels; shouting can exceed 100 decibels (CDC, 2019). Repeated exposure to things such as loud music, traffic, and electrical equipment may result in hearing loss after just a short amount of time (CDC, 2019). Excessive noise can become a patient safety issue if not appropriately addressed in the healthcare setting. The Joint Commission (JCAHO) (2018) has mandated alarm management be performed, recognizing this as an important intervention to patient safety and the reduction of nurse alarm fatigue (JCAHO, 2018). They understand that excessive alarms result in nurse desensitization (JCAHO, 2018). Alarm limits should be modified to each patient so that if the alarm sounds, it requires an actionable response. The Joint Commission (2018) has not yet identified a noise-reduction solution that will fit into every care facility. They recommended that each hospital have a systematic method to approaching clinical alarms (JCAHO, 2018).

Environmental noise is a problem in many ICUs today. One study found that the decibel levels in a pediatric ICU averaged 62.9 at the patient's bedside (Kramer et al., 2016). Kramer et al. (2016) stated that "patients experienced an average of 115 min/d where peak noise was greater than 100dBA" (p. 111). These numbers are unacceptable. This is not an isolated occurrence: a literature review of four ICUs also found the patients' decibel exposure level to be excessive (Halm, 2016). Multiple other studies supported the finding that nighttime decibel levels in the hospital environment generally exceed the WHO's goal of 40 decibels (Danielson et al., 2018; Guerra et al., 2018; Kramer et al., 2016; Ryan et al., 2016; Voigt et al., 2017). These studies identified that unpleasant noise proceeds from a noisy environment, alarms, human factors, ventilators, oxygen, etcetera. This is an issue that must be addressed.

Sleep is difficult to attain and maintain in the ICU environment. Nurse and patient perception of patient sleep can vary. Researchers have used the Richards Campbell Sleep Questionnaire (RCSQ) to quantify patients' lack of rest (Aitken et al., 2017; Naik et al., 2018). The results revealed that nurses often perceive patients are sleeping better than patients report

(Aitken et al., 2017). Polysomnography, actigraphy, and circadian rhythm studies are all objective means of identifying how well a patient is sleeping. Boyko, Jennum, Nikolic et al. (2017) used polysomnography to evaluate patient sleep characteristics. The results indicated that 53% of participants did not have identifiable sleep characteristics. Those who did, scored very low in REM and N3 sleep (Boyko, Jennum, Nikolic et al., 2017). Strategies must be employed to fix the poor sleep patterns of these patients.

Problem Statement

Quiet hospitals are healing hospitals, or so the saying goes. The truth is that hospitals are often anything but quiet. Patients in the ICU environment are especially at increased risk for overstimulation and insomnia. Many healthcare workers are unaware of this problem and do not make changes to the environment to make it a more restful place. This has resulted in patients being exposed to increased sound levels. The U.S. EPA (1974) stated that nighttime noise should not exceed 45 decibels, yet literature revealed that hospitalized patients are at times exposed to sound levels exceeding 100 decibels (Kramer et al., 2016). This is not healthy for patients, and most certainly does not contribute to a restful environment. Therefore, this integrative review was conducted to evaluate the literature to identify bundles and strategies whereby noise could be decreased in the ICU setting.

Purpose of the Project

The purpose of this project was to identify interventions that have successfully led to decreased decibel level exposure in the ICU environment. This integrative review analyzed literature for noise reduction bundles and strategies that have been specifically implemented in other hospitals. The literature review identified the patients' and nurses' subjective perception of environmental noise in the ICU. The project also evaluated objective measures of patient sleep by reviewing polysomnography, actigraphy and circadian rhythm studies. The study sought to identify noise reduction themes that could be used to create a sustainable decibel level change when implemented. Whittemore and Knafl (2005) identified that the integrative review is “the broadest type of research review” that will enable the examiner to synthesize data presented in both “experimental and non-experimental research” (p. 547). This in-depth analysis provided the information needed for further research to be conducted (Flanagan, 2018).

Clinical Questions

This review sought to answer the following questions:

- Does the literature reflect that decibel levels continue to be elevated in the ICU setting?
- Does the literature suggest noise reduction bundles or strategies that may be implemented to decrease noise in the ICU setting?

The following additional points have been addressed as well:

- What factors contribute to nighttime environmental noise in the ICU?
- Do patients or healthcare workers complain about nighttime environmental noise? Does it affect patient’s sleep?
- Do polysomnography, actigraphy, or circadian rhythm studies reflect that patients are not sleeping in the ICU?

Methods

Protocol and Framework/Model Used

The conceptual framework that was used for this project was the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model. The PRISMA model is a framework upon which systematic reviews, meta-analyses, and integrative reviews may be guided effectively. Moher et al. (2009) identified that PRISMA comprises a 27-item checklist and a four-phase flow diagram. The PRISMA model allowed the Doctorate of Nursing Practice (DNP) student to stay organized throughout the integrative review process. Headings in this model included “title,” “abstract,” “introduction,” “methods,” “results,” “discussion,” and “funding” (Moher et al., 2009, p. 4). There were multiple action points underneath these headings that guided the process along. The PRISMA model included a flowchart that allowed the project leader to identify the number of articles located in the search process. The author identified that while PRISMA cannot verify the quality of articles selected for review, it could “help authors improve the reporting of systematic reviews and meta-analyses” (Moher et al., 2009, p. 2). This flowchart included article “identification,” “screening,” “eligibility,” and those articles that were “included” in the study (Moher et al., 2009, p. 3).

Eligibility Criteria

The integrative review format allowed the researcher to succinctly identify the objective and purpose of the project. This integrative review specifically sought to find contributors to the environmental noise along with bundles and other strategies used to reduce noise levels in the ICU environment. The paper delved into whether or not patients and nurses perceived environmental noise to be a barrier to sleep. The review also sought to determine if objective measurements (such as polysomnography, actigraphy, and circadian rhythm studies) also reflected patients were not sleeping well in this environment. The target audience for this project was primarily ICU nursing staff, but might also include physicians, advance practice providers, respiratory therapists, and ancillary staff.

Efron and Ravid (2019) recommended that the search strategy be formulated in the following manner: “state research question, choose keywords for search, choose databases and identify subjects for your search, locate sources on your topic, expand or narrow the search as needed [and] record citations of sources; create bibliography" (p. 58). Multiple criteria were established to guide the literature review process of this project (Table I). Inclusion criterion for this study consisted of studies written in the English language, studies published on or after January 1, 2014, peer reviewed articles, and full text articles. Inclusion criteria specific to the topic included articles that addressed ICU noise, noise reduction, patient/nurse/family perspective of noise, and tests measuring patient sleep. This study was not limited to articles from the United States or a western world perspective, but included ICUs in multiple continents and countries. Exclusion criteria included unpublished articles, uncompleted clinical trials or trials that did not clearly lay out study results, articles that only gave an abbreviated overview of the study, letters to the editor, podium speeches, articles specifically addressing delirium, studies that did not take place in the ICU, studies that took place in the neonatal ICU, articles that focused on sleep improvement measured by physiological factors, and articles specifically addressing alarm fatigue.

Information Sources

A well-formulated search strategy was a necessary component for this integrative review process. It is necessary that the search strategy be broad enough to identify articles that should be included in the integrative review. A librarian was contacted at the beginning of this process and asked questions regarding how to perform the literature search in a systematic manner. It is paramount that those seeking to perform a literature review keep a detailed list of keywords and searches. Multiple databases were included in this literature review search. Articles were obtained from CINHAL, Medline, Proquest, and the Cochrane Library. Key words for the search included "noise," "decibel level," "sleep promotion," "sleep intervention," "intensive care unit," "ICU," "critical care" and "critical care unit." Boolean operator words "and-or" were used to narrow the search. PRISMA provided a flow diagram to guide the literature review process (Appendix A). The project leader described the process of identifying articles, screening them, determining if they were eligible for inclusion in the project, and adding them to the literature review (Moher et al., 2009).

Search

This study comprised multiple searches from various databases. One search, conducted through Proquest, used keywords of “noise” and “intensive care unit.” This, in addition to qualifiers of “full text article” and “peer review,” yielded 14,534 results. This was further narrowed to only include articles published on or after January 1, 2014 and articles written in the English language. This narrowed the results to 6,387. The keywords were then specified that they could be “anywhere except full text.” The option of “scholarly journal” was also selected. This yielded 117 results. These results were reviewed for inclusion in the integrative review.

Melnyk’s hierarchy of evidence was used as a tool to rank information according to its quality. Melnyk and Fineout-Overholt (2015) classified literature according to its study design. They identified that there are three useful components the literary sources must contain: validity, reliability, and applicability to practice (Melnyk & Fineout-Overholt, 2015). Melnyk and Fineout-Overholt (2015) provided questions to ask when trying to ascertain these qualities. The questions vary according to the study design. This literature review included 33 primary sources and 10 secondary sources. Three of these sources were Melnyk level I evidence: a systematic literature review of randomized controlled trials (RCTs) and quasi-RCTs. Eight of these sources were Melnyk level II evidence; these studies were RCTs. Eight of these studies were Melnyk level III evidence; these studies were controlled trials, but were not randomized. Three of these studies were Melnyk level IV evidence; these studies had a correlational design and sought to determine a relationship between at least two different variables. Seven of these studies were level Melnyk level V evidence; these studies were literature reviews. The remaining fourteen studies were Melnyk level VI evidence. These studies sought to describe the ICU environment and patient/nurse perspective of noise. Melnyk and Fineout-Overholt (2015) identified that a critical analysis of these articles will cause the project leader to ask if there were enough participants involved in the study, if there was crossover between the control and study group, if the writer had conflicting interests, and other pertinent questions (Melnyk & Fineout-Overholt, 2015).

Study Selection

This integrative review sought to locate and analyze the most recent literature that discussed a noisy ICU environment. The study also looked at measures some ICUs have taken to reduce this noise as well as nurse/patient perspective of the noise. For an article to be included in this study, it had to be written in English, full text, and peer reviewed. The screening process also involved removing studies that occurred outside of the ICU environment or in the neonatal ICU.

One-thousand one-hundred ninety articles article titles were screened for inclusion in this project, and two sources were identified through other sources. Of these, 68 were identified as duplicate articles and were removed leaving a total of 1,124 articles. Eight hundred sixty-nine articles were excluded due to not being applicable to the study. If the article title was unclear, the article was opened and the abstract was reviewed for clarity. An additional 212 articles were excluded due to multiple factors. The most common reasons articles were excluded was that the study took place in a neonatal ICU/non-ICU setting, the study was not detailed (example: an article, letter to the editor, podium speech, single article review, etcetera), the study was an incomplete clinical trial, the article focused on alarm fatigue, delirium, patient anxiety, medications, lighting, or the article was outdated. This left a total of 43 articles to be included in the integrative review.

Data Collection Process

Data was extracted from RCTs, controlled trials, case control studies, literature reviews, and descriptive studies. This data was extracted by one DNP student as part of the capstone project. The project leader completed Collaborative Institutional Training Initiative (CITI) training prior to the initiation of this project (Appendix B). The project leader also obtained IRB approval from Liberty University (Appendix C). No human subjects were involved in this project. Data was initially obtained through a search of key-words through multiple computerized scholarly journal databases. Sources were filtered through inclusion and exclusion criteria (Table I). These searches were recorded in a separate word document. In this manner, the student was able to keep track of which sources were included, which were excluded, and the reasons why.

Data Items

At first, the review process did not yield high-quality results. A majority of the articles populating to searches had nothing to do with the topic at hand. The student had already made multiple limitations including the selections of “peer reviewed” and “full text” articles while making the searches. More appropriate sources were obtained when the project leader eased on the restrictions and narrowed down the “keyword” field to search for the keywords anywhere but the full text document. The project leader selected “scholarly journal” as the source for article retrieval and limited the date to only include sources on or after January 1, 2014. More appropriate sources came up at this point, and inclusion/exclusion criteria used as a filter.

Variables specifically evaluated included “noise,” “decibel level,” “sleep promotion,” “sleep intervention,” “intensive care unit,” “ICU,” “critical care” and “critical care unit.

Risk of Bias in Individual Studies

PRISMA acted as a guide through the literature review process by describing how articles may be included in the project (Moher et al., 2009). In this manner the project leader was unable to “cherry pick” the articles that portrayed a certain result/finding. Each article was weighted using the same scoring system. Data was extracted as each source was reviewed.

Summary Measures

This literature review revealed that noise in the ICU continues to be an issue. Nighttime noise has yet to fall consistently under the WHO’s recommendations. In the meantime, patients and hospital staff are exposed to increased levels of noise. Patients and nurses themselves identified that this is an issue in the ICU environment. The article matrix (Table II) details specific studies. An integrative review was needed to synthesize the available literature and point to what could be done for noise reduction in the ICU in the future.

Synthesis of Results

The literature collected indicated that noise (elevated decibel levels) continues to be a problem in the ICU environment. Patient studies reveal that sleep is often not attained. This integrative review has evaluated the success of nighttime bundles and strategies to improving patient sleep.

Results

Study Selection

The studies selected for an integrative review should be an unbiased, good representation of the current state of literature in an area of interest. Whittemore and Knafl (2005) identified that “well-done integrative reviews present the state of science, contribute to theory development, and have direct applicability to practice and policy” (p. 546).

An extensive review of literature was conducted for this project. Articles from databases including CINAHL, MEDLINE Plus, Cochrane Library, and ProQuest were evaluated for applicable to this study. A separate Word documented was created to track database searches, articles included in the study, and reasons why certain articles were ruled out. The key-words entered into these databases yielded a total of 1,190 sources. Sixty-four of these were from CINAHL, 107 from MEDLINE Plus, 648 from Cochrane Library, and 371 from ProQuest. Two articles were included from a separate search that did not specifically use the identified key words or databases. Sixty-eight articles were noted to be duplicates and were removed from the study. This left a total of 1,124 articles. Of these, 869 studies did not apply to the project’s purpose statement - clinical questions and were removed. The remaining 255 titles, abstracts, and/or full-text were run through the inclusion/exclusion criteria. Two-hundred twelve of these were removed due to being a clinical trial, being held in a non-ICU setting, not being a complete research study, and otherwise failing to meet inclusion/exclusion criteria. The studies that remained were not selected based on the results they portrayed. Instead, the studies showcased agreement and disagreement as various project leaders approached the topic of nighttime noise in the ICU environment differently. Forty-three articles were included in the study. This chain of elimination can be viewed in a flowchart by Moher et al. (2009) in Appendix A.

Both qualitative and quantitative methodologies were included in this integrative review following PRISMA guidelines (Moher et al., 2009). It was important to this study that noise in the ICU environment be defined by objective means (decibel levels) and by subjective methods (patient/nurse/family member perspective). The level of evidence also varied from Melnyk’s level 1 evidence to Melnyk's level VI evidence. Both primary (n=33) and secondary studies (n=10) were included in this review.

Study Characteristics

This study addresses the issue of nighttime noise in the ICU environment. The first purpose was to identify noise-reduction bundles or strategies that may be implemented to decrease environmental noise in the ICU setting. The second purpose was to identify factors that contribute to nighttime noise in the ICU. The third and fourth objectives were to identify if patients, nurses, or family members identified that environmental noise affects patient sleep and to determine if polysomnography, actigraphy, or circadian rhythm studies gave an objective view of this.

Results of Individual Studies

The results of this study can be broken down into four sections: noise reduction bundles/strategies, factors contributing to ICU nighttime environmental noise, environmental noise and patient sleep, and sleep studies and patient sleep. These sections categorize the key literature regarding ICU environmental noise published from 2014-2020. Recommendations from this study have come from several different perspectives.

Noise Reduction Bundles / Strategies

Decibel Levels

The literature indicates that elevated decibel levels continue to be an issue in the ICU environment. Ryan et al. (2016) specifically sought to understand decibel levels in relation to location in the critical care unit. In this study investigators placed decibel level monitors in three locations: outside of two patient rooms and at the nurses' station desk (Ryan et al., 2016). The lowest average decibel levels recorded were 43.03-49.98 decibels between the hours of 3am-4am

(Ryan et al., 2016). Average decibel levels of 54.38-65.00 decibel levels were recorded during daytime hours (Ryan et al., 2016). The loudest location was the nurses' station desk. Oxygen saturation and heart rate alarms accounted for the greatest percentage of alarm occurrences (Ryan et al., 2016). Guerra et al. (2018) evaluated noise in a pediatric ICU involving 39 patients in open areas and an individual patient room for four weeks. The researchers discovered that nightly average decibel levels in the open areas were 59.4 decibels, and in the single room they were 59.5 decibels (Guerra et al., 2018). This study also evaluated the timing of patients receiving a PRN medication or sedative. They discovered that there was a positive association between patients needing/receiving medication and patient exposure to high levels of noise (patients needed medication within 2-5 hours of being exposed to high levels of noise). Patients were often given a sedative medication within two hours of exposure to peak noise levels (Guerra et al., 2018). Peak noise levels in this study were associated with morning rounds exceeding 90 decibels (though the average peak during the day was 75.1 decibels), while night time peak levels averaged 72.9 decibels (Guerra et al., 2018).

Knauert et al. (2016) sought to determine the difference between A and C-weighted decibel monitoring in the ICU environment. The study educated that A-weighted decibel (dBA) scales evaluate high-frequency sounds (and some low frequency sounds) while C-weighted decibel (dBC) scales more evenly evaluate high and low-frequency sounds (Knauert et al., 2016). Decibel levels were monitored in this observational study via dBA and dBC decibel monitors between the hours of 2000-0800. The results revealed an average of 53.5dBA and 63.1dBC over the course of the study. The discrepancy between values is likely due to the ability of the dBC monitor to record lower frequencies (Knauert et al., 2016). Peak decibels in dBA and dBC did not vary much over time, though they were significantly different when compared to each other.

Two decibel level monitors were placed in a central location in specifically-chosen rooms to record noise levels. The 59 private patient rooms chosen for this study were selected based on their likelihood to be most representative of noise levels throughout the entire ICU. Patient characteristics and illness severity did not influence decibel level in this study (Knauert et al., 2016).

Delaney et al. (2017) tried to identify the intensity and pattern of decibels to which their patients were exposed. The also wanted to identify if decibel levels were decreased in single-patient rooms as opposed to open-bed rooms (Delaney et al., 2017). Six decibel monitors monitored sound levels on three different days from 2200-0700. The study revealed that the average nighttime decibel level was 52.85 dBA (Delaney et al., 2017). Peak levels from the 18 separate clinical spaces were 85.5-98.3 dBA (Delaney et al., 2017). The study concluded that individual patient rooms were not quieter than open-bed areas. They identified that the loudest sources of noise were “staff conversation and monitor alarms, which accounted for 35.4 and 34.1% of noise per hour respectively” (Delaney et al., 2017, p. 3). The study’s literature review indicated that interventions could include staff education, behavior modification, modifying alarm parameters, and other activities (Delaney et al., 2017). Voigt et al. (2017) sought to obtain 1-hour dBA measurements in four different type of patient rooms (empty room during the day and at night and two other sessions involving patients during the day). This study found noise in an empty ICU patient room was roughly 45-46 decibels during the day and at night in comparison to levels of 61 dBA and 81 dBA that were measured in a stable and unstable simulated patient room (Voigt et al., 2017). Voigt et al. (2017) identified that environmental noise is present in the ICU even when patients are not present in every room.

Noise Reduction Bundles and Strategies

Bundled Interventions and Strategies. Ozlu and Ozer (2017) sought to improve patient sleep through environmental modification. This study divided 100 patients into a control and experimental group. A bundle of items including noise modification, light dimming, and patient comfort activities were implemented. The researchers found that when certain factors are adjusted, patients report better sleep duration and sleep quality via RCSQ (Ozlu & Ozer, 2017). Patients also filled out a "*Form Describing Environmental Factors That Negatively Affect Nocturnal Sleep in CSICU"* (Ozlu & Ozer, 2017, p. 90). The items that showed a statistically significant difference between the two groups were patient comfort with the bed/pillow, patient experience of bad odors in the room, room too bright to sleep, noisy environment, staff conversation, and being given care during hours of sleep (Ozlu & Ozer, 2017). By implementing the bundle, the experimental group experienced better rest than the control group who did not receive those modifications (Ozlu & Ozer, 2017). Another study including 32 patients asked for patient input regarding things that could be done to improve ICU sleep. They ranked "no unnecessary interruption," "pain medication during ICU stay," "lights off in the night time," "clock in the ICU," "television in the ICU," and having a "window bed" most highly on their list of recommendations (Naik et al., 2018, p. 5).

Patel et al., (2014) sought to improve patient sleep and reduce delirium through the implementation of a multicomponent nighttime bundle. The bundle included categories to control noise, light, and patient care. Noise measures included closing doors, reducing alarm levels-telephone ring tones, encouraging individuals to speak quietly, providing patients earplugs, etcetera (Patel et al., 2014). Patient care activities included clustering care, providing care before 2300 or after 0800, providing appropriate pain medication, etcetera (Patel et al., 2014). The study included 167 patients pre-intervention and 171 patients post-intervention. Noise levels in this study decreased from 68.8 dB to 61.8 dB (Patel et al., 2014). The study also indicated that patients were sleeping longer with fewer interruptions post bundle implementation (Patel et al., 2014).

Hu et al. (2018) conducted a systematic literature review to discover non-pharmacologic interventions that improved patient sleep in the ICU environment. This study ended up including 30 trials and 1,569 individuals in their study. They evaluated psychological interventions, environmental interventions, social interventions, equipment modification, and complementary interventions. The study evaluated the usage of earplugs and eye masks, music intervention, ventilator mode/types, relaxation techniques, massage, and other interventions. The researchers concluded that the level of evidence for non-pharmacologic interventions in the ICU was either low or very low. They determined that it was difficult to pool information to one solid conclusion since the studies were conducted using varied methods, and having conclusions that often conflicted (Hu et al., 2018).

Afshar et al. (2016) sought to identify the effectiveness of white noise in reducing patient perception of noise. The 60 participants in this study were asked to use the Pittsburg Sleep Quality Index scale to score their sleep upon arrival at the coronary care unit and then again after three nights. Participants were divided into the control and intervention group. Those in the intervention group were exposed to white noise from 2000-2100 and 2300-0000. The results indicated that patients who were exposed to white noise in the ICU perceived their sleep to be similar to at-home values (Afshar et al., 2016). Those who were not exposed to white noise found their sleep to significantly decline in length (Afshar et al., 2016).

Quiet Time. Knauert et al. (2018) discussed the creation, revision, and implementation of a naptime bundle to be used between the hours of 0000-0400. The goal was to allow patients an uninterrupted period of time to sleep by delaying or re-timing non-urgent activities such as bathing, medication administration, routine assessment/physical exam, lab draw, wound care, room tidy-up, etcetera (Knauert et al., 2018). The protocol included 26 components encompassing the implementation of a visitor policy, an alarm policy, closed patient door/curtain, dimmed lights, clustered care, etcetera (Knauert et al., 2018). Four hours of uninterrupted patient sleep was deemed to be infeasible in this patient population (Knauert et al., 2018). Instead, the researchers recommend placing an emphasis on rest blocks of 60-120 minutes at a time. After slight revisions, the protocol was rolled out to their unit. Patient outcomes were not specifically evaluated in this study (Knauert et al., 2018). Knauert et al. (2019) provided another view of the above study by randomizing patients into one of two groups: a control (n=30) and intervention group (n=26). The sleep promotion protocol was implemented for the intervention group. They received fewer in-room sleep interruptions between the hours of 0000-0400. The results indicated that patients in the intervention group were exposed to lower decibel levels and had fewer in-room interruptions than those in the control group (Knauert et al., 2019).

Halm (2016) conducted a literature review of four articles to determine the effectiveness of quiet time to the patient/nurse and the ability to reducing noise levels. Two of the articles analyzed quiet time during the day and two of them conducted quiet time at night. The evidence revealed that while decibel levels decreased during the daytime and nighttime, the results were not all statistically significant, nor did they contribute to the perception that the noise level had gotten quieter across all articles (Halm, 2016). The study identified several noises that interrupt sleep including IV pumps, ringing phones, staff conversation, “closing doors, electronic towel dispensers, and ice machines" (Halm, 2016, p. 554). Halm (2016) indicated that interventions implemented to reduce these levels included advertising the quiet time via posted signage, dimming lights, closing patient room doors, turning alarm sounds down (IV pumps, phone ring volume, monitor alarms), ensuring fluids would not run out (IV fluids or tube feeding), and turning off certain devices that were not essential (such as the television or suction) (Halm, 2016). Nursing staff were encouraged to avoid routine care during quiet time (Halm, 2016). Guests were either encouraged to not visit during quiet time, or to keep their voices low so patients could sleep (Halm, 2016). The nighttime articles revealed the perception that patients were able to sleep better with the quiet time intervention (Halm, 2016). Another multi-purpose literature review tried to determine if having a "quiet time" would improve patient sleep (Lim et al., 2018). This review included seven articles which evaluated the "quiet time" in either daytime or nighttime hours. Results were measured by a variety of methods including patient perception of sleep, "light and sound levels," physiological measurements, patient sleep pattern, etcetera (Lim et al., 2018, p. 43). The results were mixed. Some of the sources identified that the quiet time improved patient sleep, and others disagreed (Lim et al., 2018).

Goeren et al. (2018) sought to implement a quiet time to reduce peak noise in their unit. The project leaders determined their quiet time initiative would be implemented between the hours of 0300-0500 and 1500-1700 (Goeren et al., 2018). They recorded decibel levels in four locations on their unit in 60 second increments every 30 minutes during the proposed quiet times. The project leader recorded the highest decibel level observed as the peak occurrence for each measurement. Eight days' worth of data were recorded prior to quiet time implementation and six months after implementation (Goeren et al., 2018). Healthcare professionals were encouraged to provide patient care needs (including toileting, bathing, medication administration, assessment, blood draws, etcetera) outside of quiet time hours (Goeren et al., 2018). The healthcare team reminded each other to keep their voices down, and multidisciplinary rounding was not performed during this time (Goeren et al., 2018). The data indicated that the initiative was successful in lowering peak decibel levels with pre-implementation levels exceeding 73 decibels and post implementation levels lower than 65 decibels. The article indicated that two of the four locations showed a statistically-significant decrease in decibel levels (Goeren et al., 2018).

Earplugs / Headphones and Eye Masks. Many studies have evaluated the effectiveness of using earplugs and eye masks as an intervention to decrease environmental stimuli in the ICU environment. Dave et al. (2015) randomized 50 patients into two groups that alternated between being the control group and the intervention group on two separate nights. Patients were asked to rate their quality of sleep on a visual analogue scale of 0-100mm based off of the RCSQ to evaluate the patient's perspective of sleep quality (Dave et al., 2015). The results indicated that eye masks and earplugs improved patient perception of their sleep (Dave et al., 2015). An objective measure of sleep was not obtained in this study (Dave et al., 2015). Yazdannik et al. (2014) evaluated the usage of earplugs and eye masks sought to identify the patient's perspective of sleep. Fifty patients were enrolled in this study and separated into two groups alternating between being the control and intervention group on two consecutive nights (Yazdannik et al., 2014). Patient perception regarding their quality of sleep was examined via the Verran and Snyder-Halpern measurement tool. This is a tool that measures sleep effectiveness, sleep disturbance, and supplemental sleep (Yazdannik et al., 2014). The results of this study regarding sleep effectiveness and sleep disturbance were inconsistent (Yazdannik et al., 2014). While these numbers were statistically significant, the project leaders expressed concern that the washout period was not long enough and the patient population not large enough for the results to be generalizable (Yazdannik et al., 2014). The study did conclusively indicate that when patients wore earplugs and an eye mask, they were less likely to need supplemental sleep (Yazdannik et al., 2014). They recommend further study be conducted in this area.

Litton et al. (2017) sought to determine the feasibility of using earplugs as an intervention in the ICU setting by including 40 patients who were randomized to the control or intervention group. The study concluded that while the findings may not be generalizable, earplugs in the ICU setting were a viable option (Litton et al., 2017). They revealed that decibel levels, of which their maximum average was 69 decibels, could be reduced by 9-12 decibels when individuals wore earplugs (Litton et al., 2017). They concluded “In our study, sound levels were reduced by about half with the use of earplugs” (Litton et al., 2017, p. 131). Patients in this study also filled out the RCSQ. There was not a statistical difference between the two groups (Litton et al., 2017). One literature review that analyzed four articles identified that though the RCTs had been conducted in different manners and with different patient populations; there was insufficient evidence to support using earplugs and eye masks in the ICU setting (Vieira et al., 2018). This conclusion was made due to the severe limitations these studies experienced. Limitations included small sample size, increased attrition rate, small study timeframe, and inability to determine the patient’s baseline sleep (Vieira et al., 2018). The studies reviewed encouraged the usage of earplugs and eye masks. This literature review called for further investigation into this issue.

Huang et al. (2015) sought to determine the effectiveness of eye masks and earplugs when compared to melatonin supplementation in a simulated ICU environment. Participants were given the first night to acclimate to the new environment. The second night, individuals were divided into one of two groups (these groups traded places the next night). One group was exposed to a simulated ICU environment with light and noise; the other group slept in a dark and quiet environment. The second portion of the study involved randomly dividing patients into four groups. The groups included noise/light, noise/light + placebo medication, noise/light + melatonin, and noise/light + earplugs/eye mask. Two baseline polysomnography readings were obtained the night before this portion of the study and two readings were obtained on night eight, the last night of the study (Huang et al., 2015). Melatonin levels were obtained via blood samples nightly. Patients rated their sleep perception on a visual analog scale of 0-10 (0=excellent, 10=poor). The first portion of this study revealed that participants' sleep was statistically worse (sleep latency, awakening times, arousal time index, and non-REM sleep were increased) in an environment stimulated with light and noise (Huang et al., 2015). Patients also perceived their sleep as being worse and anxiety levels being higher in this environment (Huang et al., 2015). The study determined that eye masks, earplugs, and melatonin supplementation decreased participant awakening time, decreased sleep-onset latency, and resulted in lower sleep arousal (Huang et al., 2015). Melatonin also specifically increased the participants' total sleep time and REM sleep (Huang et al., 2015). Earplugs, eye masks, and melatonin improved the patients' subjective view of their sleep quality as well (Huang et al., 2015).

Hu et al. (2015) conducted a similar study which sought to identify the efficacy of using earplugs, an eye mask, and music to improve post-cardiac surgery patients' perspectives of sleep. This study also performed daily urine tests to evaluate the patient's cortisol level and 6-SMT. Fifty patients initially signed up and were evenly divided into the control and intervention group. Five individuals in the intervention group were withdrawn from the study. The intervention group was given eye masks and earplugs and asked to wear them from 9pm until morning (Hu et al., 2015). Patients were also instructed to listen to relaxing music via headphones for 30 minutes at 0730-0830 the morning after their cardiac surgery and nightly from 2000-2100 (Hu et al., 2015) Patients gave a subjective measurement of their sleep via the RCSQ. The intervention group reported better sleep characteristics in all six measurements than those in the control group (Hu et al., 2015). This study did not identify a statistically significant difference between melatonin and cortisol secretion between the two groups (Hu et al., 2015). The study did indicate that melatonin levels were found to be lower in this environment (Hu et al., 2015).

Demoule et al. (2017) sought to determine the impact of earplugs and eye masks in improving N3 sleep. Sixty-four patients were randomized evenly into two different groups. Of these patients, only 9 of 32 patients in the intervention group and 25 of 32 patients in the control group completed the study and were able to be included in the results (Demoule et al., 2017). Some of these patients withdrew their consent to be in the study, others failed to wear the eye mask and earplugs all night, and others were lost due to faulty polysomnography equipment. Both groups underwent polysomnography the first day and night after their inclusion in the study (Demoule et al., 2017). The intervention group was instructed to wear earplugs and an eye mask from 2200-0800. The results were unable to demonstrate an improvement in N3 sleep except in the small proportion of patients who were compliant with their earplugs and eye masks all night (Demoule et al., 2017). This, however, was not statistically significant. The study also demonstrated a decrease in prolonged awakenings in patients wearing earplugs and eye masks (Demoule et al., 2017). The study did not yield statistical significance on other secondary outcomes such as sleep quality, patient comfort, presence of delirium, anxiety/depression, ICU length of stay or hospital mortality (Demoule et al., 2017).

Gallacher et al. (2017) evaluated the effectiveness of using noise-cancelling headphones in a 10-day study to decrease exposure to excessive decibel levels in the ICU. Three polystyrene heads were set up side-by-side in an ICU. Microphones were placed into a control head, a head wearing noise-cancelling headphones (noise-cancelling function turned off), and another head wearing noise-cancelling headphones (noise-cancelling function turned on) (Gallacher et al., 2017). The results indicated that the average decibel level for the control head were 57.16 dBA, the headphones without noise cancellation 54.49 dBA, and the headphones with noise cancellation 50.36 dBA (Gallacher et al., 2017). A non-associated finding was that decibel levels were most decreased between the hours of 0000-0500 (Gallacher et al., 2017).

Factors Contributing to ICU Nighttime Environmental Noise

There are several factors that contribute to ICU nighttime noise. Younis et al. (2020) directed 103 patients to fill out the Freedman Quality of Sleep Scale and Richards-Campbell Sleep Scale. The study found that there was a correlation between a participant's perception of sleep and "noise, light, nursing interventions, vital signs measurement, administration of medications, talking and phones ringing" (Younis et al., 2020, p. 300). Younis et al. (2020) recommended nurses be educated regarding patient sleep and that they implement sleep promoting interventions (such as earplugs and eye masks) in the ICU environment. In another study, a survey was given to nursing staff and patient family members to identify noise-creating factors and ways to mitigate these issues in the pediatric ICU environment (Kaur et al., 2016). A two-fold 28-question survey was given to 115 participants who ranked noise-creating factors on a Likert scale of 1-8, and they then ranked the effectiveness of different interventions in reducing environmental noise (Kaur et al., 2016). A decibel monitor was used to evaluate sound levels in this unit. Findings indicated that patients in the unit were exposed to an average decibel levels of

49-59 decibels (Kaur et al., 2016). The survey identified that medical alarms and medical equipment accounted for the largest amount of perceived noise levels in the PICU environment (Kaur et al., 2016). Responders indicated that noise could be mitigated by closing patient doors, incorporating quiet times, and "silencing inappropriate alarms" (Kaur et al., 2016, p. 80). Other, less popular responses included the following: decreasing telephone ring volume, improving nursing staff education regarding noise, and having signs on the doors regarding noise reduction (Kaur et al., 2016).

Grimm (2020) reviewed the current literature to identify reasons for patient sleep deprivation in the ICU. This author reviewed 54 articles and compiled an "ICU Sleep Deprivation Clinical Resource" the healthcare team could utilize in assessing and treating sleep deprivation (Grimm, 2020, p. e17). Some recommendations included frequent sleep assessment, consideration of sleep medications, nighttime quiet hours, earplugs and eye mask usage, daytime-nighttime light differences, clustering care-minimal nighttime sleep interruption, and psychological assessment (Grimm, 2020). Grimm (2020) identified that there are patient factors that may not be modified in the ICU environment including sleep history, present illness, respiratory illness-ventilator needs, and emergent procedures. Grimm (2020) also provides interventions the healthcare team can implement to prevent delirium and promote sleep.

Medryzcka-Dabrowska et al. (2018) conducted a review of eight articles to identify factors that contribute to sleep disturbance in ICU environment. This study identified that patients were awakened due to nursing activity roughly 42.7 times during a nightshift nurse's 12-hour shift (Medrzycka-Dabrowska et al., 2018). The study further identified that of all the patient's awakenings, 11.5-17% of them were due to noise in the environment (Medrzycka-Dabrowska et al., 2018). This article indicated that white noise was unsuccessful in reducing awakenings. Instead, nursing staff were encouraged to decrease light levels, reduce the number of staff interruptions, and reduce alarm sounds to improve patient sleep (Medryzcka-Dabrowska et al., 2018).

Elliott and McKinley (2014) sought to develop and implement a clinical practice guideline to assist healthcare workers in promoting patient rest in the ICU. Over 130 ICU healthcare workers gave over 320 suggestions toward the development of this new guideline (Elliott & McKinley, 2014). This resulted in a 22-page guideline with 10 recommendations. The four foundations were "provide optimal conditions for night-time sleep, optimize circadian rhythm, manage pain well, [and] promote a daytime rest period" (Elliott & McKinley, 2014, p. 250). The summary provided gave 10 action points underneath three of these headings. It included components such as talking quietly, providing "optimal conditions for night-time sleep," supporting the patient's natural circadian rhythm, and providing sleep medication as appropriate (Elliott & McKinley, 2014). Ten audits of 264 patients were conducted after implementation regarding the effectiveness of this new protocol. The results indicated that the guideline was being adopted, but had not been fully integrated (Elliott & McKinley, 2014).

Environmental Noise and Patient Sleep

The literature revealed that both patients and healthcare workers complain about nighttime environmental noise. In their study of 74 patients, Nicola et al. (2019) focused primarily on stressors affecting patient sleeping the ICU, and identified that 23% of patients reported the ICU as being a noisy environment. "Fifty-three patients (n=53, 71.6%) reported waking up in the middle of the night and 21 (28.3%) of them were unable to fall asleep again" (Nicola et al., 2019, p. 73). After an intervention of massage, aromatherapy, and nighttime music, patients reported a decrease in noise interruption, decrease in awakening from sleep, improved ability to fall asleep, and an improved depth of sleep (Nicola et al., 2019). This study indicated that “awakenings” were positively correlated with “unusual sounds” including noise from healthcare professionals. (Nicola et al., 2019, p. 76).

Nesbitt et al. (2014) completed a literature review of 25 articles focused on nurse perspective of patient sleep in the ICU. The article suggested that nurses may not be well educated about this issue: they may not see sleep as a priority or even understand sleep architecture (Nesbitt et al., 2014). Patients may experience physiological consequences as a result of a lack of sleep. One article stated that nurses could categorize patient sleep using the Richard Campbell Sleep Questionnaire, and another article indicated that the results of nurse categorization (using another method) of sleep was inaccurate when compared to polysomnography (Nesbitt et al., 2014). The study identified that sleep problems in the ICU are multifactorial, and are “most likely caused by a combination of intrinsic and extrinsic factors” (Nesbitt et al., 2014, p. 234). Nurse should be educated to maintain a restful ICU environment and to prioritize patient sleep (Nesbitt et al., 2014).

Kramer et al. (2016) completed a study of noise in the pediatric ICU. They sought to identify the decibel level to which pediatric patients were exposed and to determine whether there was a difference in noise between the closed and open side of the unit, and to understand nurse and patient family perception of this noise (Kramer et al., 2016). The results indicated that the average decibel level for this pediatric ICU was 82.2 decibels (Kramer et al., 2016). There were times when the decibel level exceeded 100 decibels (Kramer et al., 2016). The study did not note a significant difference between the closed and open side of the unit. Nurses and parents identified that the main sources of noise in the ICU were monitors, noise from the ICU, the adjacent bedside, ventilators, pumps, and nursing staff (Kramer et al., 2016). Nighttime shift change was noted by nurses to be the loudest time of day (Kramer et al., 2016).

Johansson et al. (2016) attempted to use qualitative and quantitative measures to identify staff perception of noise in the ICU. A 10-question survey regarding noise in the ICU environment was administered to 305 healthcare professionals. The median number of questions answered correctly was 4 questions (Johansson et al., 2016). In addition to this, 20 healthcare professionals from nine different facilities were interviewed regarding their perception of noise in the ICU setting. The interviewees noted that some noise could be alleviated through behavior/plan of care modification, through encouraging other staff members to be active participants in noise abatement strategies, and by asking management to restructure the ICU in a way to reduce noise (Johansson et al., 2016). The nurse and nursing team could proactively or quickly care for alarms, decrease the alarm volume, cluster care activities, close patient doors, give patients stretches of time to rest/sleep, handle care or environmental equipment quietly, give patients earplugs, reduce their volume during staff conversation, remind other staff members to keep their volume low, etcetera (Johansson et al., 2016). Some interviewees relayed their belief that staff needed more education regarding noise abatement measures and that management should be included in these conversations (Johansson et al., 2016). The last large component of these individual interviews was the belief that modifying the care environment could have an impact on the noise level patients experienced. The interviewees suggested having one-patient ICU rooms and incorporating sound-absorbing surfaces into the environment (Johansson et al., 2016). They also identified that alarm manufacturers might create a difference in sound between critical and non-critical alarms (Johansson et al., 2016).

Ding et al. (2017) conducted a study to describe the perception of patient sleep and stressors according to healthcare workers and patient/patient families. Thirty-eight individuals including healthcare staff (24), patients (8) and patient surrogates (6) were interviewed for this study (Ding et al., 2017). Several themes emerged from these interviews. It was first determined that the environment in the ICU does impact patient sleep (Ding et al., 2017). This theme was most strongly emphasized by healthcare staff who noted that the environment is noisy and sleep interruptions are frequent (Ding et al., 2017). The most frequently-identified noise makers included alarms, talking, and other noise (television, telephone, computer, etcetera) (Ding et al., 2017). This study also pointed out that psychological factors such as stress, worry, chronic sleep loss, and acute illness may account for sleep loss (Ding et al., 2017). Over 50% of the healthcare workers believed that their patients only slept 2-4 hours during the night (Ding et al., 2017). Patient reports regarding their sleep was mixed, with 57% reporting they had and 36% reporting they had not received enough sleep (Ding et al., 2017). An environmental suggestion for improving patient sleep is that the nurse should cluster care and reschedule non-essential care activities. Other suggestions included providing sleep education for staff, teaching staff to reassure patients suffering from psychological issues, and providing a medication to help with sleep (Ding et al., 2017).

Aitken et al. (2017) conducted a study to assess patient perspective of sleep in the ICU environment, interventions that may help to improve sleep in this setting, and the feasibility of completing the RCSQ. The study also sought to determine the nurse's perspective of patient sleep in this environment. The results revealed that while the median number of patients (n=151) perceived their sleep as poor, nurses (n=101) were more likely to report that patients had obtained a moderate amount of sleep (Aitken et al., 2017). Poor sleep was most frequently attributed to staff or equipment noise, patient care activities, pain and discomfort, and un-controlled light levels. Participants identified several categories of activities that could help make the ICU environment more restful including environmental modifications (specifically noise and light), patient care changes, pharmacological treatment, and psychosocial care (Aitken et al., 2017).

Cicek et al. (2014) attempted to identify the quality of patient sleep and sleep-interrupting factors in the ICU environment. In this study, 100 patients were asked to answer nine questions regarding their sleep on three separate days: on the first night of their stay, during the middle of their time in ICU, and before discharge from the ICU (Cicek et al., 2014). The results in this study were not statistically significant. They indicated that while the quality of patient sleep decreased from at-home values initially, it thereafter trended back toward at-home values (Cicek et al., 2014). The patients' feelings of sleepiness increased throughout their ICU stay (Cicek et al., 2014). The largest contributors to sleep disruption were identified as alarms (ventilator, telephone, monitor), lighting, nurse interruption, and blood draws (Cicek et al., 2014). The study encouraged nurses to decrease environmental noise and to give patients long rest periods. They suggested the usage of earplugs, reducing phone/monitor alarms, and decreasing conversation volume (Cicek et al., 2014).

Alsulami et al. (2019) sought to identify the feasibility of daily patient self-reported sleep via RCSQ while in the ICU. The study also aimed to identify the patients' quality of sleep and factors that negatively influenced it. This study included a total of 120 patients, 14 of whom did not complete the study and 43 of whom were, at some point during the study, mechanically ventilated. The study had an 92.5% completion rate and therefore concluded that it was feasible to obtain this type of information from ICU patients. Overall, patient perception of sleep was poor; those who were mechanically ventilated reported even worse sleep than those who were not. Mechanically ventilated patients identified that noise, clinical interventions, talking, machines' alarms, fear, etcetera interfered with their sleep (Alsulami et al., 2019). These factors continued to interfere with sleep to a lesser degree after patients were extubated. Medications such as Versed and Propofol also negatively affected patient sleep quality (Alsulami et al., 2019). Overall, this study suggested patient perception of sleep was poor indicating the need for patient specific sleep strategies.

Sleep Studies and Patient Sleep

The literature indicated that objective measurements of sleep such as polysomnography, actigraphy, and circadian rhythm studies show abnormal sleep characteristics in ICU patients. One systematic review specifically focused on patient sleep time via actigraphy in the ICU setting (Schwab et al., 2018). Actigraphy is a means of measuring sleep by evaluating a patient's movement. This study reviewed 13 articles and identified a broad range in patient sleep time (Schwab et al., 2018). The analysis revealed that patients were obtaining roughly 4.4-7.8 hours of nighttime sleep (Schwab et al., 2018). One limitation the study mentioned is that though actigraphy seems to indicate patients are sleeping better than other sleep measurements, it has not been extensively studied in ICU patients. There is more research available in healthy individuals. The study did reveal that patient sleep in the ICU is often disrupted. This synthesis indicated that the total number of patient awakenings could range from 1.4 to 49 awakenings during the study period (Schwab et al., 2018). In a separate independent study of 32 patients, Naik et al. (2018) sought to determine if patients were sleeping well in the ICU environment. They also wanted to identify sleep disrupting factors on their unit (Naik et al., 2018). Actigraphy and the RCSQ were used to evaluate patient sleep. The results displayed that patient nighttime sleep only accounted for roughly 55.64% of their total sleep time. Patients reported that they slept poorly 40.6% of the time (Naik et al., 2018). Some of the factors they attributed to this included indwelling catheters, ventilator endotracheal tube suctioning, diagnostic tests, nursing care/medications, invasive procedures, light, etcetera (Naik et al., 2018). The top five suggestions patients gave for improving sleep include the following: “no unnecessary interruption,” “pain medication during ICU stay,” “lights off in the night time,” “clock in the ICU,” and “television in the ICU” (Naik et al., 2018, p. 26).

Korompeli et al. (2017) conducted a literature review of 37 articles. They identified that not only are patients not sleeping, but their circadian rhythm dysregulation may be affecting a host of other physiological and psychological issues. This study identified multiple causes of circadian dysregulation including excessive light, excessive noise, irregular feeding habits (such as continuous tube feeding), irregular melatonin secretion, and sleep disruption (Korompeli et al., 2017). The article suggested that interventions be implemented to restore a proper circadian rhythm. These interventions may include providing cycled lighting, controlling environmental noise (by decreasing alarm levels, giving the patient earplugs, using white noise, etcetera), or giving the patient melatonin to assist with sleep (Korompeli et al., 2017).

Danielson et al. (2018) sought to identify if the ICU environment contributes to circadian rhythm disruption. This study evaluated patient/family impression and recorded light levels and decibel levels (dBA and peak dBC). Light levels were collected on 14 different days in five different months. The goal was to see the difference among seasons. The study revealed that light levels were not very different between daytime and nighttime hours. Light was not used to its fullest capacity during the day (only 24.9% of full capacity used) (Danielson et al., 2018). The study also revealed excessive decibel levels for day and night (Danielson et al., 2018). The median nightshift decibel level average was 47.9 decibels (72 hours of decibels measured). The median peak at night was 98.2 decibels. The study indicated that noise levels were roughly the same across the study areas with the exception of unoccupied rooms (which were slightly quieter). The study also revealed that ventilated patients and closing patient doors did not significantly change the level of decibels recorded (Danielson et al., 2018). As far as noise is concerned, Danielson et al. (2018) stated “patients are exposed continuously to excessive noise levels generated mostly within their own room” (p. 4). This noise level may be attributed to background noise, “human activity and medical devices” (Danielson et al., 2018, p. 4). Nurses and patients had varying perspectives on these values. Nurses believed that the ICU environment was too loud and bright at night. Patient families were less critical of the environment. This study recommended healthcare workers do what they can to support the patients’ normal circadian rhythm while in the ICU environment (Danielson et al., 2018).

Foreman et al. (2015) attempted to identify the impact of giving patients noise-cancelling headphones, an eye mask, and melatonin to improve their total sleep time. This study included a total of 12 patients that were divided evenly into a control and intervention group. The study indicated that 65% of the patient’s EEG results were unable to be scored and that three patients were unable or unwilling to complete the study (one in control group and two in intervention group). Sleep data was only able to be obtained on one patient from each group (Foreman et al., 2015). The results indicated that patients spent most of their sleep time in N1. REM sleep and N3 sleep were decreased. There was not a statistically significant difference between the total sleep time of the control and intervention group (Foreman et al., 2015).

Boyko, Jennum, Nikolic et al. (2017) evaluated the effectiveness of modifying the ICU environment between 2200-0600 to patient sleep quality. Seventeen mechanically-ventilated patients were randomized to one of two groups. They were in the control group and intervention group on subsequent alternating nights. They underwent environmental modifications and polysomnography to evaluate their sleeping pattern (Boyko, Jennum, Nikolic et al., 2017). Environmental changes included “reduced alarm sound levels, dim lighting, no visits after 10PM, and only strictly necessary diagnostic (eg, arterial blood gas, chest x-ray) or treatment (eg, endotracheal suction, ventilator adjustment, pain treatment), procedures between 10PM and 6AM” (Boyko, Jennum, Nikolic et al., 2017, p. 100). Earplugs and eye masks were also provided to patients who desired them. Decibel levels were an average of 47.57 dBA during the control period and 46.92 during the intervention phase (Boyko, Jennum, Nikolic et al., 2017). Maximum decibel levels were 86.3 dBA during the control period and 84.9 dBA during the intervention period (Boyko, Jennum, Nikolic et al., 2017). The changes in decibel levels were not statistically significant. The study revealed that sleep characteristics could not be categorized on 53% of the participants. The remaining patients had very low incidence of REM and N3 sleep on polysomnography readings. This study concluded that the environmental interventions did not lead to a significant change in decibel level exposure (Boyko, Jennum, Nikolic et al., 2017).

Elbaz et al. (2017) sought to objectively identify factors in the ICU that cause sleep disruption. This study recorded 11 mechanically-ventilated patients’ 24-hour sleep patterns via a polysomnography device and a decibel C monitor (Elbaz et al., 2017). The study determined that these individuals slept a median of 5 hours 56.9 minutes at night (Elbaz et al., 2017). The results indicated that only 6.5% of this median sleep time was spent in the N3 sleep stage and 3.9% in REM sleep (Elbaz et al., 2017). This study showed that “sound levels above 77 dBC are associated with awakenings 60% of the time during the night” (Elbaz et al., 2017, p. 7). Median sound peaks of 70.2 decibels were observed. Ventilator and monitor alarms accounted for the largest portion of noise, though staff conversation and other sounds also contributed (Elbaz et al., 2017).

The last study, a literature review, sought to "summarize the present knowledge about sleep and circadian rhythm in critically ill patients" (Boyko, Jennum, & Toft, 2017, p. 277). This study included 21 articles that reviewed contributing factors to poor sleep in the ICU environment. The results indicated that there are several means of describing patient sleep in the ICU. These include the RCSQ, actigraphy, bispectral index, and polysomnography. These approaches all come with their own unique set of challenges (such as patient recall bias, faulty equipment, and depending on patient movement for a reading). The study also addressed sleep in relation to the ICU environment, mechanical ventilation, medications, melatonin, and critical illness. The study concluded that poor sleep and circadian rhythm imbalance are multifactorial issues "due to a number of factors such as intensive care environment, including noise and procedures, mechanical ventilation, and medication" (Boyko, Jennum, & Toft, 2017, p. 282). They go on to state that "there are no validated methods of sleep scoring for this patient population, resulting in the difficulties in testing sleep promoting interventions" (Boyko, Jennum, & Toft, 2017, p. 282).

Risk of Bias within Studies

There can be a measure of unintended bias within any study. Authors will often indicate if there is a conflict of interest at the end of their text. Six of the studies included in this integrative review did not indicate whether or not there was a conflict of interest. These studies included Cicek et al., (2014); Dave et al., (2015); Foreman et al., (2015); Korompeli et al., (2017); Nesbitt & Goode, (2014); and Vieira et al., (2018). Two studies indicated that they did not have any financial disclosures to make. These included Goeren et al., (2018) and Grimm, (2020). Three studies indicated that their project was awarded funding: Halm, (2016); Schwab et al., (2018); and Ryan et al., (2016). Ryan et al. (2016) specified that while funding was awarded, there was no conflict of interest. Four articles expressed a monetary conflict of interest. These included Demoule et al., (2017); Ding et al., (2017); Hu et al., (2015); and Knauert et al., (2016).

Most of the studies in this integrative review did an excellent job identifying their limitations and poor results. Knauert et al., (2018) and Knauert et al., (2019) completed one study then jumped into another study that was seemingly an extension of the first study. Another potential bias for this study is that investigators may attribute a patient’s lack of sleep to something (such as environmental noise) without considering other factors that may be affecting the patient.

Discussion

Noise Reduction Bundles / Strategies

Decibel Levels

The studies conclusively identified that nighttime decibel levels continue to be elevated above the WHO’s recommendations (Delaney et al., 2017; Knauert et al., 2016; Guerra et al., 2018; Ryan et al., 2016; & Voigt et al., 2017). Average decibel levels across multiple articles in this review ranged from 43.03-82.2 decibels (Boyko et al., 2017; Danielson et al., 2018; Delaney et al., 2017; Elbaz et al., 2017; Gallacher et al., 2017; Goeren et al., 2018; Guerra et al., 2018; Hu et al., 2015; Kaur et al., 2016; Knauert et al., 2016; Korompeli et al., 2017; Kramer et al., 2016; Litton et al., 2017; Medrzycka-Dabrowska et al., 2018; Ryan et al., 2016; & Voigt et al., 2017). Peak decibel levels at times exceeded 100 decibels (Kramer et al., 2016). These decibel monitors were placed in various locations including the nurses’ station desks and inside patient rooms (Delaney et al., 2017; Knauert et al., 2016; Guerra et al., 2018; Ryan et al., 2016; & Voigt et al., 2017). Various timeframes were associated with higher noise levels including medication administration and nighttime shift change (Guerra et al., 2018 & Kramer et al., 2016).

Noise Reduction Bundles and Strategies

At this point there is no standardized noise reduction bundle or strategy. Therefore, the literature approached this issue from several different perspectives. White noise was implemented in one study of 60 patients (Afshar et al., 2016.) While the results indicated that patients slept better in this environment, they were limited to the patients' perspectives of their own sleep and a small sample size (Afshar et al., 2016). Medryzcka-Dabrowska et al. (2018) stated that white noise was not successful in reducing patient awakenings.

Several articles sought to either create or implement some form of quiet time or noise reduction bundle (Elliott & McKinley, 2014; Goren et al., 2018; Grimm, 2020; Halm, 2016; Knauert et al., 2018; Knauert et al., 2019; Lim et al., 2018; Ozlu & Ozer, 2017; & Patel et al., 2014.), There were multiple items contained in these bundles that overlapped among studies. Some of the bundle components included dimming patient room lights, providing patient care activities, reducing staff conversation, reducing/re-timing care activities to not occur during hours of sleep, implementing a visitation policy, providing alarm management (of monitors, telephones, IV pumps, etcetera), providing patients with rest blocks/periods of time, and a closing the patient's door/curtain to their room (Elliott & McKinley, 2014; Goren et al., 2018; Grimm, 2020; Halm, 2016; Knauert et al., 2018; Knauert et al., 2019; Ozlu & Ozer, 2017; & Patel et al., 2014). Once again, while these articles indicated that patients experienced sleep improvement (Halm, 2016; Ozlu & Ozer, 2017; & Patel et al., 2014) and that the decibel level decreased in the environment (Goeren et al., 2018; Knauert et al., 2019; & Patel et al., 2014), they could not pinpoint the specific intervention that created this improvement. The literature above indicates patient sleep is improved with environmental interventions, but when multiple things are implemented at once it is difficult to identify which intervention helped. Not all studies were positive. Lim et al. (2018) conducted a literature review that had mixed results to environmental modifications. Hu et al.'s (2018) systematic review of 30 randomized controlled trials concluded that the level of evidence for non-pharmacologic interventions in the ICU was very low (Hu et al., 2018). Elliott and McKinley (2014) revealed that their sleep guideline was not full implemented at the time of their audit.

Earplugs/Headphones and Eye Masks

Eight articles discussed using earplugs (or headphones) and eye masks as an intervention in the ICU environment (Dave et al., 2015; Demoule et al., 2017; Gallacher et al., 2017; Hu et al., 2015; Huang et al., 2015; Litton et al., 2017; Vieira et al., 2018; & Yazdannik et al., 2014). The studies' results were obtained by different means with four articles depending upon patient self-report via two different tools (Dave et al., 2015; Hu et al., 2015; Litton et al., 2017; & Yazdannik et al., 2014), two articles relying on polysomnography (Demoule et al., 2017 & Huang et al., 2015), one article relying on decibel level readings (Gallacher et al., 2017), and one article depending on an appropriate synthesis of literature (Vieira et al., 2018). The results were inconsistent across these studies. Four studies indicated that earplugs and/or eye masks helped to improve patient sleep (Dave et al., 2015; Gallacher et al., 2017; Hu et al., 2015; Huang et al., 2015), whereas four studies indicated that results were either inconclusive, insufficient, or did not improve patient sleep (Demoule et al., 2017; Litton et al., 2017; Vieira et al., 2018; & Yazdannik et al., 2014). As mentioned previously, the articles were inconsistent in their means of determining whether or not this intervention was effective. Several articles identified limitations such as small sample size, faulty equipment, or patient non-compliance with the intervention. The quality of the available evidence is low.

Factors Contributing to ICU Nighttime Environmental Nosie

The reviewed literature identified a variety of factors that contributed to environmental noise in the ICU. The largest contributors to environmental noise appear to be medical alarms, nursing activity, and staff conversation (Delaney et al., 2017; Kaur et al., 2016; & Medryzcka-Dabrowska et al., 2018). Further factors include nurse care activities (ex. physical assessment, vital sign measurement, giving medications), telephones ringing, staff conversation, etcetera (Grimm, 2020; Kaur et al., 2016; & Younis et al., 2020). Several studies created a nighttime noise policy or bundle to combat these and other issues (Elliott & McKinley, 2014 & Grimm, 2020). These bundles included components such as sleep assessment, sleep medications-pain management, implementation of nighttime quiet hours, earplugs and eye mask usage, daytime-nighttime light differences, clustering care-minimal nighttime sleep interruption, quiet staff conversation, and psychological assessment (Elliott & McKinley, 2014 & Grimm, 2020). While environmental noise factors often overlapped across studies, the means by which they have been addressed varied. The protocols that have been developed to combat noise have not been validated outside of their individual studies. Therefore, further study must be conducted to draw conclusive evidence that these new protocols are effective in a variety of ICU settings.

Environmental Noise and Patient Sleep

Alsulami et al. (2019) conducted a study to determine the feasibility of having ICU patients report their sleep. The study had a high completion rate (92.5%) indicating that it is reasonable to expect patients to describe their subjective sleep experience in the ICU setting (Alsulami et al., 2019). Aitken et al. (2017) also identified that patient self-report of sleep was feasible. The literature indicated that ICU patients have difficulty both falling and staying asleep (Nicola et al., 2019). More than 50% of patients (taken from two primary studies and two articles in one literature review) reflected that patient sleep was poor in the ICU environment (Aitken et al., 2017; Nesbitt et al., 2014; & Nicola et al., 2019). Both patients and healthcare workers complain that nighttime environmental noise affects patient sleep. Johansson et al. (2016) and Nesbitt et al. (2014) reflected that nurses may not be aware of the extent to which patients are exposed to noise in the ICU environment. Aitken et al (2017) revealed that nurse and patient report of sleep may significantly differ. When asked, nurses and family members identified that sources of ICU environmental noise included monitors, ventilators, pumps, and nursing staff (Cicek et al., 2014; Ding et al., 2017; Johansson et al., 2016; & Kramer et al., 2016). Suggestions for improving patient sleep include clustering care, rescheduling non-essential care activities, decreasing staff conversation, reducing alarm volume, and using earplugs (Cicek et al., 2014; Delaney et al., 2017; Ding et al., 2017; & Johansson et al., 2016). Complementary interventions that may improve patient sleep include massage, aromatherapy, and music (Nicola et al., 2019). Ding et al. (2017) recommended that sleep education be provided for staff and that the healthcare team consider the impact of other factors such as psychological issues that prevent sleep in the ICU setting.

Sleep Studies and Patient Sleep

Multiple tests including polysomnography, actigraphy, and circadian rhythm studies have been performed to identify objective sleep measurements in ICU patients. Multiple studies evaluated either polysomnography readings or EEG readings to identify patient sleep characteristics with fewer than 30 patients in each of these studies (Boyko, Jennum, Nikolic et al., 2017; Elbaz et al., 2017; & Foreman et al., 2015). The results of these studies were inconclusive: two of the studies had a large percentage (>50%) of data that was either unable to be scored or unable to be classified as a certain type of sleep; the other study was unable to identify a normal sleep pattern over a 24-hour period (Boyko, Jennum, Nikolic et al., 2017; Elbaz et al., 2017; & Foreman et al., 2015). Schwab et al. (2018) and Naik et al. (2018) used actigraphy as a means of measuring patient sleep. These studies determined that patients experienced a large number of awakenings throughout the night and that their overall nighttime sleep was poor (Naik et al., 2018 & Schwab et al., 2018). Danielson et al. (2018) and Korompeli et al (2017) identified that noise and light were two factors that specifically impacted the patients' circadian rhythm. Other factors included irregular feeding habits, irregular melatonin secretion, and sleep disruption (Korompeli et al., 2017). The literature recommended that nurses do what they can to support a normal circadian rhythm pattern (Danielson et al., 2018). In their review of RCSQ, actigraphy, bispectral index, and polysomnography studies, Boyko, Jennum, and Toft (2017) identified that the available literature lacked a consistently used, validated tool to accurately measure patient sleep in the ICU setting.

Limitations

There were several limitations for this integrative review. First, there was only one researcher involved in the data retrieval and collection process. Initially, it was difficult to narrow down the searches to obtain appropriate articles for this review. Many articles were obtained, portions of which were skimmed for applicability to the integrative review study. Another limitation was the content of articles obtained. Though the patients across all studies were ICU patients, the demographic varied widely from pediatric patients, to geriatric patients, to surgical patients, to respiratory failure patients, to myocardial infarction patients, etcetera. Many of the studies included several interventions to improve nighttime noise. It was therefore difficult to determine which intervention caused the improvement. The studies evaluated nighttime noise and lack of sleep from widely different vantage points, some using patient, family, or nurse self-report and others using more objective sleep measurement technologies. At times, a single article in this review addressed environmental noise from multiple perspectives. These sources were not integrated into each discussion heading of this integrative review. Instead, they were included underneath only one or more categories to which they well applied.

The articles were selected through the filter of the problem statement-questions and limited according to inclusive/exclusive criteria. This issue, however, is larger than these restrictions and was unable to be examined in its entirety. There was a risk of selection bias across the studies as many articles used a convenience sample in their study. Many of the studies were also limited due to small sample size and/or equipment malfunction, though most of the studies listed their limitations and recommendation for further study.

Implications for Practice

This integrative review provides several considerations for practice. Average and peak ICU decibel levels continue to be well above the WHO's recommendation of 40 decibels (Kramer et al., 2016 & Ryan et al., 2016). Noise reduction bundles and strategies have been somewhat effective in reducing decibel levels in the past, but the interventions and the patient population/demographic has not been consistent across studies. The literature indicated that important noise considerations include reducing staff conversation, clustering care, closing curtains/doors, etcetera (Goren et al., 2018; Halm, 2016; Knauert et al., 2018; Knauert et al., 2019; & Ozlu & Ozer, 2017). Earplugs and eye masks are interventions that may be considered in the ICU patient population, but the literature had mixed results regarding their effectiveness (Dave et al., 2015; Demoule et al., 2017; Gallacher et al., 2017; Hu et al., 2015; Huang et al., 2015; Litton et al., 2017; Vieira et al., 2018; & Yazdannik et al., 2014). The literature did consistently identify factors that contributed to nighttime environmental noise. These factors included alarms, nursing care intervention, and staff conversation among other items (Grimm, 2020; Kaur et al., 2016; & Medryzcka-Dabrowska et al., 2018). Patients identified that environmental factors did interrupt their sleep and gave improvement suggestions. Sleep studies such as polysomnography, actigraphy, and circadian rhythm studies confirmed that patients do not sleep well in the ICU environment (Boyko, Jennum, Nikolic et al., 2017; Elbaz et al., 2017; & Foreman et al., 2015). Further study should be conducted with a greater patient population to create results that are both generalizable and sustainable.

DNP Essentials

The American Association of Colleges of Nursing (2006) has set forth eight essentials for the DNP student to meet prior to program completion. The DNP integrative review gave the DNP student the opportunity to accomplish several of these goals. The first essential was that the DNP-prepared advanced practitioner would use “scientific underpinnings for practice” (AACN, 2006, p. 1). These scientific underpinnings come from an appropriate gleaning and application of available literature. The DNP student accessed several databases to review current literature for this integrative review. The second essential is that the DNP student would use “organizational and systems leadership for quality improvement and systems thinking” (AACN, 2006, p. 1). This essential was applicable as the DNP student evaluated how a nighttime noise reduction bundle could be implemented into a local hospital’s ICU. The DNP student recognized that it was important to gain buy in from organizational leadership prior to implementing any change. The third essential was that the DNP student would use “clinical scholarship and analytical methods for evidence-based practice” (AACN, 2006, p. 1). The DNP student used analytical methods to sift through the available literature and synthesize it for the integrative review. The fourth essential was that the DNP student would use "information systems/technology and patient care technology for the improvement and transformation of health care" (AACN, 2006, p. 1). The DNP student used information technology to electronically sift through literature, and write out findings for the integrative review.

Conclusion

Nighttime decibel levels continue to be elevated in the ICU environment. Though interventions have been conducted to improve these values, more improvement is needed. The literature indicates environmental noise is a multi-factorial issue. While environmental modification may improve noise levels in the ICU, this will likely have to be added to other interventions for there to be a sustainable change. This integrative review provides the reader a snapshot of the current state of noise in the intensive care unit. Many of the included studies had a limited sample size and patient population. Further study should be conducted to identify noise reduction bundles and strategies that will be both effective and generalizable in the ICU environment.

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Tables

Table I

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles written in English	Articles written in any language other than English
Articles dated between 2014-2020	Articles written prior to 2014
Full text article	Unpublished manuscripts, letter to editor, short article, abstract only, uncompleted clinical trials, podium speeches.
Studies that took place in an ICU	Studies that took place outside of the ICU or in a Neonatal ICU
Articles addressing decibel levels or addressing noise reduction techniques/bundles to use in the ICU	Articles focusing solely on alarm fatigue or delirium. Articles that focus primarily on pharmacologic intervention for sleep promotion. Articles that focus on environmental modification for physiological or psychological improvement
Peer reviewed article	Article has not gone through the peer review process
Studies that seek to understand nighttime noise and sleep	Studies that address daytime sleep or noise
Nightshift Nurses	Dayshift nurses

Table II

Article Matrix

Focus of Article, Author/Year	**Level of Evidence/Source**	**Background**	**Conclusions/Practice Implications/Recommendations**
This study sought to determine if the usage of white noise would improve patient sleep in the ICU environment (Afshar, 2016).	Level III, Primary Study	• This quasi-experimental study took place included 60 patients with 30 patients in the control group and 30 patients in the intervention group. • Sleep was measured via the Pittsburg Sleep Quality Index (PSQI) at admission and then again on day three. • The control group had white noise of 40-50 decibels playing for three separate hours during the loudest parts of the night	• The results of the control and intervention group taking the PSQI were not statistically significant on the day of admission • The results of the PSQI were statistically significantly different on day three of the hospitalization. The intervention group indicated that they slept better than the control group. • This study indicates that white noise can improve patient sleep in the ICU environment.
The purpose of this study was to obtain patient perception of sleep for multiple nights and to identify patient suggestions to improve their sleep (Aitken et al., 2017).	Level VI, Primary Source	• 151 participants were included in the study from two level 1 tertiary ICUs in Sydney, Australia. • Sleep was reported via survey 356 times. • Inclusion criteria: age >18 years, ICU stay >24 hours, and English speaking. Exclusion criteria: known or suspected sleeping disorder, known or suspected dementia, known or suspected excessive alcohol intake or substance abuse, and prisoners.	• "Average sleep quality during ICU admission was described as poor by the participant cohort with median scores for each of the elements of sleep depth, latency, awakenings, time spent awake and overall sleep quality being below 50mm" (p. 8). • 50% of patients reported their sleep for multiple nights. • Nurses ranked patients sleep as being better than the patient's indicated. • Sleep facilitators: clustered care/medications and reduced noise/lights.

		• Nurses were asked to document their perception of patient sleep.	• Sleep deterrents: pain, discomfort, patient care, noise, and lights
The study sought to identify the "acceptability to ICU patients of completing daily self-reports on sleep quality during their ICU stay and to assess ICU patients' self-reported sleep quality and sleep disruptive factors during their time in ICU" (Alsulami et al., 2019, p. 1).	Level VI, Primary Source	• This observational prospective study was comprised of 120 patients • The study took place in Saudi Arabia • ICU patients performed a daily assessment of their sleep. The study involved self-report of sleep using the Richards-Campbell Sleep Questionnaire and "self-reported sleep disruptive factors were identified" (p. 1).	• This study revealed that it was feasible to for ICU patients to complete daily sleep reports. • Every patient described their sleep as poor. • Intubated patients ranked their sleep as poorer than non-intubated patients. • Factors identified as sleep disruptors included noise, clinical intervention, light, machines' alarm, talking, telephone, fear, pain, and attachment to devices (p. 8). • The top four sleep disruptors were talking, noise, clinical intervention, and machines' alarms (p. 8).
The purpose of this study was to "determine if improving intensive care unit (ICU) environment would enhance sleep quality" (Boyko, Jennum, Nikolic et al., 2017, p. 99).	Level II, Primary	• This study took place in an 8-bed ICU in Denmark in 48-hour increments between September 2012-November 2013. • Quiet time was initiated between 10pm-6am on the second night (the first night was used as a control night). • Patients who exhibited the following signs were excluded from the study: "comatose patients, delirium, clinical signs of acute intracerebral events under current admission, and circulatory shock" (p. 100).	• The results revealed that "We did not observe a significant effect of the intervention on noise reduction, probably due to an already existing low noise level" (p. 102). • Of the fifteen patients who were able to complete the study, staff had difficulty implementing the bundle for seven participants due to unpredictable events surrounding the patients. • Peak sound levels were 86.3 dBA for control nights and 84.9 dBA for intervention nights (p. 102).

		• Changes included "reduced alarm sound levels, dim lighting, no visits after 10pm, and only strictly necessary diagnostic (eg, arterial blood gas, chest x-ray) or treatment (eg endotracheal suction, ventilator adjustment, pain treatment) procedures between 10 pm and 6 am" (p. 100). • Noise was measured by a sound monitor located at the patient's head and sleep was measured via polysomnography.	• Mean sound levels were 47.57 dBA for control nights and 46.92 dBA for intervention nights (p. 102). • Polysomnography indicated that patient sleep was poor both in the control and implementation group throughout this trial.
The purpose of this review was to identify difficulties in quantifying ICU patient sleep, to discuss melatonin as it relates to the circadian process, and to identify the role of "sleep disturbing factors" and "critical illness" in ICU patient sleep (Boyko, Jennum, & Toft, 2017, p. 277).	Level I, Secondary Study	• This study summarized the literature as it relates to sleep and sleep monitoring, ICU environment, mechanical ventilation, critical illness, and medication/melatonin.	• This study determined that "sleep and circadian rhythm are severely abnormal in critically ill patients due to a number of factors such as intensive care environment, including noise and procedures, mechanical ventilation, and medication" (p. 282). • This study determined that the measurement of circadian rhythm was difficult to quantify since several studies failed to use the gold standard measurement: polysomnography.
The purpose of this study was to	Level VI, Primary Source	• This descriptive study was comprised of 100 patients who	• This study concluded that though sleep quality was decreased in the ICU, the results

identify patient described quality of sleep and factors that interfered with this sleep (Cicek, 2014).		each answered a 9-question survey regarding their sleep in the hospital setting. • Participants answered questions in a face-to-face consultation with an interviewer. Sleep quality was ranked on a numeric 1-10 scale. • Participants were admitted to the hospital with a cardiac issue such as MI or CHF exacerbation. • The study took place in a coronary ICU in Turkey.	were not statistically significant and sleep quality improved when the patient moved out of the ICU. • Sleep disrupting activities and noises included lighting, nursing intervention, blood collection, medication administration, vital signs, diagnostic testing, alarms, telephone, television, talking, and other factors. • This study recommended environmental modification and further study such as polysomnography be conducted.
The purpose of this study was to determine if light and noise cycles in the medical ICU could lead to circadian sleep disruption and to describe patient, family, and nursing perspective about these factors (Danielson et al., 2018).	Level VI, Primary Source	• This was a prospective, observational study took place in a medical ICU. • Light measurements occurred between 0900-1100 on multiple days during the months of February, March, August, September, and October. The goal was to identify the amount of light present when the room was undisturbed, then to measure maximum brightness when all lights were on and window curtains open. • Sound measurements were obtained via a handheld sound meter and were obtained from January 31-March 4. Noise samples were obtained from occupied patient rooms,	• Light levels were obtained on fourteen different days. The initial room light level was determined to be very dim with a median of 50.9 lux. Max brightness light level median was 206.1 lux. • Noise samples were obtained on twenty-one days from seven different rooms. The average decibel level was 52.8 during the day and 47.9 at night (p. 59). • The survey indicated that nurses were more likely than patients to indicate that light and noise levels were a problem. • This study demonstrated that “ICU environment alone is sufficient to engender circadian phase delays in critically ill patients” (p. 60). • The discussion reveals that “LD cycles in our ICU are extremely weak, and when present are phase delayed relative to the solar cycle” (p. 60). It also revealed that

		unoccupied patient rooms, and the nurse's station. • Patients, patient families, and nurses were surveyed regarding "sound, lighting, and sleep environment in the MICU [Medical Intensive Care Unit] from November 2013 through May 2014" (p. 59).	"patients are exposed continuously to excessive noise levels generated mostly within their own room" (p. 60). Lastly, the study demonstrated that "patients and families are largely uncritical of the ICU light and sound environment, even in the face of severe environmental disturbances that would be expected to produce phase delays in healthy individuals" (p. 60).
The purpose of this study was to determine if patient sleep could be improved with the usage of eye masks and earplugs (Dave et al., 2015).	Level II, Primary Study.	• 50 patients from an ICU were included in this study. They were placed into one of two groups by computer generation. • Both groups received earplugs and eye masks on alternate days. • Patients took the Richard Campbell Sleep Questionnaire each morning to describe their sleep.	• The results were statistically significant indicating that when patients received earplugs and eye masks, they slept better.
The purpose of this study was to "determine nocturnal noise levels and their variability and the related sources of noise" (Delaney et al., 2017, p. 1).	Level VI, Primary Source	• This observational cross-sectional study took place in a 24-bed ICU in Australia. • Six decibel level readers were used to obtain noise measurements for three nights in 18 different clinical spaces. • "Noise levels were monitored for 9 h (2200-0700 h) over three weekday nights" (p. 2).	• The average decibel level in the ICU was 52.85 dB. The peak decibel level in the ICU was 98.3 dB(A). Nosie levels greater than 70 dB(A) occurred >10 times/hr (p. 1). • "The primary sources of environmental noise were staff conversation and monitor alarms, which accounted from 35.4 and 34.1% of noises per hour" (p. 3). • This study indicated that measures to decrease decibel levels were warranted.
The purpose of this study was to determine if the use of eye masks	Level II, Primary Source	• Sixty-four ICU patients were included in this study. • Inclusion criteria included "no sedation >24 h," "sedation level	• The results indicated that "earplugs and eye mask reduce long awakenings and increase N3 duration when they are well tolerated" (p. 1).

and earplugs would improve patient sleep (Demoule et al., 2017).		<3 on the Ramsay Sedation Scale," "expected remaining ICU stay >48 h," and "morphine <0.01 mg/kg/minute and norepinephrine <0.3 μg/kg/minute" (p. 2). • Patients were randomly (via computer generation) assigned to the control and intervention group. • Those in the intervention group received eye masks and earplugs between the hours of 2200-0800. • Sleep was measured via the use of polysomnography.	• The earplugs and eye mask were not found to "increase the N3 proportion of sleep" (p. 7). • This study suggests that patients can sleep for longer periods of time if they wear eye masks and earplugs.
The focus of this article was to determine "the perceptions and beliefs of staff, patients, and surrogates regarding the environmental and nonenvironmental factors… that affect patients' sleep" (Ding et al., 2017, p. 278). The study also sought to determine if opinions differed between staff and	Level VI, Primary Source	• This exploratory qualitative study was comprised of thirty-eight interviews: "eight patients, 6 surrogates, and 24 clinical staff participated" (p. 280). • The study took place from June 2013-February 2014 in a 38-bed MICU in England • Inclusion criterion were English-speaking patients older than 21 years, at least one night spent in the MICU, no neurological difficulties, agitation, or violence. • If the patient did not meet the inclusion criterion, a surrogate was welcome to stand in his place.	• Perception of staff was that the environment was noisy for many reasons, but mostly due to in-room interruptions and light exposure. • Patients and surrogates perceived that sleep was interrupted due to psychological factors such as acute illness and chronic sleep loss. • Patient report of sleep was mixed. Some perceived nurse interruption as normal in the hospital setting and reassuring that the nurse was present. • "High levels of emotional and psychological distress are most likely contributing to disturbed sleep patterns" (p. 284). • This study recommends evaluating the role of nonenvironmental factors on patient sleep.

patients regarding reasons patients do not sleep well and if practical suggestions could be given to improve patient sleep (Ding et al., 2017).			• This study also recommends implementing "sleep-related training among ICU staff" (p. 285).
The goal of this study was to understand the decibel levels experienced in one ICU and to identify the associated noise-making factors (Elbaz et al., 2017).	Level VI, Primary	• This observational study included eleven ventilated patients. • Sleep analysis was performed via three ActiWave devices ("a miniaturized polysomnography device") (p. 2) over a 24-hour period. • Decibel (C) levels were obtained via a monitor that was placed near the patient's head.	• "The most clearly identifiable sounds were classified into three main categories: monitor alarms, mechanical ventilator and conversations" (p. 3). • Though the sleep cycles did not vary much between day and night, patient awakening occurred at a much higher frequency at nighttime (p. 4). • Patients were most frequently aroused due to ventilator alarms (p. 6). • "Our study shows that sound levels above 77 dBC are associated with awakenings 60% of the time during the night" (p. 7).
The goal of this study was to create and implement a protocol for sleep improvement in the ICU setting at night (Elliott & McKinley, 2014).	Level IV, Primary Study	• This multi-step process took place in a hospital in Sydney, Australia. • An integrative review was completed and documented separately from this paper prior to the development of the new protocol. • This article indicates that a thorough literature review was essential to the compilation of a	• A protocol containing three headings ("optimize the environment," "rest and sleep interventions," and "consider sleep promoting medication") was developed (p. 252-253). • Audits regarding the uptake of this protocol were performed. The study indicated that the new protocol was not yet fully integrated into practice. • The article recommends continued audits to determine the protocol's efficacy.

		new sleep protocol since several recommendations in the literature were not high-level evidence. • Audits regarding the effectiveness of the newly developed guideline were obtained from 264 patients.	
The goal of this study was to determine if patient total sleep time could be improved through environmental modification and melatonin administration (Foreman, 2015).	Level II, Primary Study	• This study was conducted in a neuro ICU in the United States. Twelve patients were included in the study (six in the intervention group and six in the control group). • Melatonin and sleep promotion interventions of eye masks and ear plugs were offered nightly x 3 nights upon EEG placement. • Sleep was measured via EEG monitoring. • Of the six patients in the intervention group, only four received all melatonin dosages. The other two did not complete the study. Another patient refused EEG monitoring on day three and would not wear the eye mask or ear plugs.	• The results in this study are not generalizable. The participant number started out low then decreased as some patients failed to complete the study. • The results were not statistically different between the control or intervention group. • "During sleep, both groups demonstrated an average of 14 awakenings per hour" (p. 70).
The purpose of this study was to determine if noise cancelling headphones would	Level II, Primary Study	• This study took place in a ten-bed cardiac ICU in the United Kingdom. • Three polystyrene heads were placed on a shelf at the head of	• The decibel level recording in the polystyrene head without the headphones (control) was found to be louder than the decibel level recorder that was not placed in a model head. The decibel level difference

limit the amount of sound to which patients were exposed in the ICU (Gallacher et al., 2017).		the patient's bed. Each model head had a sound monitor. One only had the sound monitor. One had a sound monitor and earphones, but the noise cancelling feature was not turned on. One had a sound monitor and earphones with the noise cancelling feature turned on. • An additional sound meter was placed in the room. • Noise levels were measured in 24-hour increments for 10 days. • Recording samples were obtained from the three decibel meters at the same time. A total of 86,400 noise samples were collected per decibel reader in a 24-hour period.	was not identified, nor was this value compared to the decibel levels recorded from the sound monitors in the polystyrene heads. • The mean noise difference between the control (polystyrene head without headphones) and polystyrene head with noise canceling headphone function in the on position was 6.80 decibels (p. 5). • The results indicated that using headphones to cancel noise was a significant means of reducing noise.
The goal of this study was to decrease peak noise in the neurological ICU by 10 decibels in 6 months (Goeren et al., 2018).	Level III, Primary Study	• This non-randomized, controlled trial took place in a 16-bed neurosurgical ICU. There was a 1:2 nurse-patient-ratio. • Noise samples were obtained using a decibel meter from four locations "every 30 minutes during the chosen time for 8 days" (p. 38). • Nurse education was given and a quiet time was implemented between the hours of 3am-5am and 3pm-5pm.	• There was a reduction of noise at the nurse's station, but only half of the nurse's station was considered to be statistically significant ("2 of the 4 locations" [p. 44]). • "Noise levels during quiet time decreased to an average of 10 to 15 decibels lower than baseline data" (p. 38). • Reductions in peak noise persisted even six months after the changes were enacted. It is pertinent to note that staff knew they were being recorded.

		• A quiet time checklist was implemented during prescribed times. • Peak noise events identified were "floor buffing, central monitor alarms, human conversation, and automatic door opening" (p. 43).	
The goal of this literature review was to identify/propose guidelines for preventing sleep deprivation in the ICU environment (Grimm, 2020).	Level V, Secondary Study	• This literature review included 54 articles between the years of 2000-2018. "Articles before 2000 were considered if they were historically relevant" (p. e18). • The review covered environmental and nonenvironmental items that impact sleep. • The review covered modifiable and nonmodifiable factors that impact patient sleep.	• This article maintains that sleep in the ICU is a multifactorial issue. For sleep to improve, both modifiable and nonmodifiable factors need to be understood. • The study proposes a "sleep deprivation clinical resource" tool (p. e17). • This literature review indicates that though several tools have been proposed to improve patient sleep, none can be generalizable to all ICU settings. None of these tools have adequate reliability or validity. • Sleep should be approached from several different angles including sleep deprivation protocols, nonpharmacological interventions (ex. music, sleep hygiene practices, noise reduction endeavors, dimmed lights, etcetera), and pharmacological prescriptions.
The purpose of this study was to "describe noise levels in a pediatric cardiac intensive care unit, and to determine	Level IV, Primary Study	• This prospective cohort study took place in a pediatric ICU in Canada. • Sound levels were measured via a SoundEarPro meter.	• Peak decibel levels reached >90 decibels. • "The average (SD) sound level in the open area was 59.4 (2.5) dB(A)" (p. 318). The difference between this and in room sound was not statistically significant. • The environment was the noisiest during morning patient rounds.

the relationship between sound levels and patient sedation requirements" (Guerra et al., 2018, p. 318). The study also sought to identify if there were any large contributors to elevated sound levels (Guerra et al., 2018).		• 39 pediatric patients were hospitalized in this unit during this study. • Recordings took place over a one-month period in a 10-bed unit. Two decibel monitors were used to collect noise samples. One was placed in an open area and another was placed in the patient room 60 cm from the head of the patient's bed	• "Sound levels were above the recommended values with no difference between day/night or open area/single room" (p. 318). • There was a correlation between elevated decibel levels and subsequent sedative administration. Causation could not be determined with this study.
The purpose of this literature review was to explore the association between quiet time and decreased decibel levels in the ICU (Halm, 2016).	Level V, Secondary Study	• Four articles were reviewed for this study. Articles were located through CINAHL and MEDLINE searches for key words of "quiet time/hours, noise reduction, and critical care" (p. 552).	• The review indicated that quiet time periods did decrease noise level. • Evidence also indicated that patients were more satisfied when the hospital was quiet.
The purpose of this systematic review was to identify successful non-pharmacological interventions to be used in promoting	Level I, Secondary Study.	• Thirty randomized-controlled trials or quasi-randomized-controlled trials were used in this review. • These studies included 1,569 participants. • Multiple interventions were reviewed including ventilator	• This study revealed that non-pharmacologic interventions do not consistently improve patient sleep. • The review indicated that "findings across studies of the same intervention were often inconsistent" (p. 22).

ICU patient sleep (Hu et al., 2018).		changes, earplugs, eye masks, relaxation techniques, music, massage, aromatherapy, baths, etcetera (p. 3).	
The purpose of this study was to determine if music would improve patient sleep, melatonin, and cortisol levels (Hu et al., 2015).	Level II, Primary Study.	• 45 patients from a cardiac ICU in China were included in this study. • This study included two different groups to which patients were randomly assigned. • The study took place the night after surgery. The control group received normal medical care. The intervention group received ear plugs and eye masks to wear for sleep and listened to music for 30 minutes. They incorporated these activities one night pre-op and two nights post-op. • 12-hour urine was collected for 6-SMT testing and cortisol levels one-night pre-op and two days post-op. • Patients reported their sleep using the Chinese version of the Richards-Campbell sleep questionnaire.	• 12-hour urine was collected for 6-SMT testing and cortisol levels one-night pre-op and two days post-op. • Statistical significance was unable to be demonstrated for urine 6-SMT testing and cortisol levels between the control and intervention group. The results revealed that 6-SMT decreased in both groups on the post op nights and cortisol increased in both groups on the post op nights. • A sound meter was used to evaluate nighttime noise from 2000-0800. Nighttime decibel levels remained steady ranging between 69.8 ± 2 in the intervention group and 69.6 ± 2.2 in the control group (p. 4). Mean light levels were not statistically different either. • Patients in the intervention group identified less noise interruption than those in the control group. • The study results state that the interventions proposed led to improved patient sleep in the cardiac ICU. While subjective patient report may indicate that sleep was better, objective measurement of 6-SMT and cortisol levels appear to be backward on the postoperative days.
The purpose of this study was “to	Level II, Primary Study	• This was a two-part study that involved forty participants.	• Melatonin was found to be the most effective in improving sleep quality levels in

determine the effect of simulated ICU noise and light on nocturnal sleep quality, and compare the effectiveness of melatonin and earplugs and eye masks on sleep quality in these conditions in healthy subjects" (Huang et al., 2015, p. 1).		• Inclusion criteria: >18 years old, no history of sleep disturbance, went to bed between 2100-0000, routinely slept between 6-9 hours, and Pittsburg sleep quality index score less than or equal to 7 • "In part one, 40 healthy subjects slept under baseline night and simulated ICU noise and light (NL) by a cross-over design" (p. 1). • "In part two, 40 subjects were randomly assigned to four groups: NL, NL plus placebo (NLP), NL plus use of earplugs and eye masks (NLEE) and NL plus melatonin (NLM)" (p. 1). • Sleep quality was measured by polysomnography and melatonin levels were measured through hourly blood tests. Subjective sleep assessment via a 1-10 numeric sale was also obtained.	"healthy subjects exposed to simulated ICU noise and light" (p. 1). • Those who used earplugs and eye masks had "less awakenings and shorter sleep onset latency" (p. 1). • Those who were in the melatonin group or the earplug/eye mask group reported "improved perceived sleep quality and anxiety levels" (p. 1). • "Nocturnal sleep and body production of melatonin are both disturbed in healthy subjects with exposure to simulated ICU noise and light" (p. 7).
This study sought to identify staff perception of noise in the ICU (Johansson et al., 2016).	Level VI, Primary Study	• This study's design was two-part: descriptive questionnaire & qualitative interviews. • The sample size included 1047 staff members in nine intensive care units in western Sweden. • Questionnaires were emailed to potential participants. Only 305 answered the questionnaire.	• The average correct answer on the questionnaires was 4 questions. This indicates that nurses can use education regarding their knowledge of noise in the ICU. • Age and work experience did not influence these numbers. • Those who were interviewed proposed suggestions to decrease noise in the ICU.

		• A convenience sampling of twenty staff members were interviewed. Unit managers gathered a select few they believed would be interested. • Topics on the questionnaire included "major contributor of noise in the ICU," "noise and its effects on patients' sensory perception," "noise and its effects on nursing staff," and what "70 decibels sounds like" (p. 5). • The questionnaires included 10 questions regarding provider knowledge.	These suggestions are "improving staff's own care actions and behavior; improving strategies requiring staff interaction; and improving physical space and technical design" (p. 1).
The focus of this project was to identify factors that hinder patient sleep in the PICU setting. This study specifically evaluated the nursing and patient perspective (Kaur et al., 2016).	Level VI, Primary Study	• This study took place in a 16-bed PICU in Minnesota. • A 28-question survey was developed and delivered to all staff (including physicians, nurses, and ancillary staff in the PICU) and patients with stays of greater than 24 hours. • One hundred fifteen individuals participated. Of those, 65 were staff members and 50 were completed by patient families.	• Noise was measured by a dosimeter; levels "averaged between 49 and 59 dB" (p. 79). "The loudest time of day was 01:30pm-03:00pm" (p. 79). • The highest contributors to noise in the PICU were identified to be medical alarms, medical equipment (such as IV pumps), and staff conversation. • Staff specifically identified "intra-staff communication [to be] a considerable cause of the noise pollution in the PICU" (p. 80). • Interventions identified to mitigate this noise include shutting the patient's door, maintaining 'quiet time,' "silencing inappropriate alarms," reducing telephone ring volume, etcetera.

			• This article stresses the responsibility of individual staff members to modify behaviors in such a way as to decrease the noise level.
The purpose of this study was to identify peak decibel levels on A-weighted and C-weighted scales in a medical ICU (Knauert et al., 2016).	Level VI, Primary Study	• This observational study took place in an ICU in Connecticut, United States. • The 28-bed MICU is in a rectangular shape. Rooms that were deemed to be in a noisy or quiet part of the unit were excluded from the study. • Multiple patient criteria were set to determine which rooms would be monitored. Inclusion criteria included patients older than 18 years, English speaking patients, patients not expected to transfer, etcetera. Exclusion criteria included those expected to die, those expected to transfer, those on comfort care, etcetera. • 59 patients meeting this criterion were included in the study. • Sound was collected in 10-second intervals using both the A-weighted and C-weighted decibel level monitors.	• The average A-weighted decibel reading from 2000-0800 was 53.5 decibels. The average C-weighted decibel reading from 2000-0800 was 63.1 decibels. The average peaks were 80.0 dB(A) and 84.9 dB(C). The average "sound minutia were 46.5 dB(A) and 57.5 dB(C)" (p. 3). • The sound minutia results were statistically significant indicating that dB(C) monitoring is better able to pick up on low frequency sounds than dB(A) monitoring. • This study is also pertinent because it reveals that there is low frequency noise in the ICU that is not being identified through dB(A) monitoring.
The purpose of this study was to introduce a sleep promotion protocol and	Level III, Primary Study	• The total sample size was 56 patients. 30 patients were assigned to the control group and 26 patients were assigned to the sleep protocol group.	• The sleep protocol increased patient rest from the normal 20 minutes at a time to >45 minutes at a time. • Patients had fewer interruptions to their sleep.

evaluate if this would improve factors that generally cause sleep disruption (Knauert et al., 2019).		• In room activity, noise, and light levels were measured. • In room activity was measured based on how frequently staff entered the patient room, noise was measured in decibels in the patient rooms, and light was measured according to brightness.	• Though the noise was decreased, the results did not reveal much difference between the control group and protocol group in regards to light levels.
The purpose of this study was to implement a sleep promotion protocol thereby reducing environmental noise and activity in the patient's room at night (Knauert et al., 2018).	Level III, Primary Study	• This study affected twenty-six patients. It took place in a MICU between August 2013 - June 2014. • Bedside nurses were individually coached regarding the bundle. They were instructed to complete certain activities prior to naptime. • A naptime was initiated between the hours of 0000-0400. The desired goal was that patients have an uninterrupted stretch of 4 hours to sleep. • The naptime protocol included components involving the "institution level," "unit level," "bedside," "direct care," and "challenging cases" (p. 184).	• At times the following factors precluded this four-hour rest period: new admissions / transfers, changes in stability, and imperative care activities. • This study allowed the staff to identify sources of sleep disturbance. It was unsuccessful in eliminating many of these disturbances.
The purpose of this study was to identify and circadian disruption factors	Level V, Secondary Study	• At least 37 articles were used for this literature review. The method section indicates that an additional 51 articles were identified, but does not state if	• This study addressed multiple "factors that contribute to circadian disruption" (pp. 2-5). • The review particularly states that noise levels are not being maintained within WHO recommendations.

in ICU patients (Korompeli et al. 2017).		any of them were included in the study.	• This study recommends environmental modification to improve patient circadian rhythms.
The purpose of this study was to identify the noise level in the pediatric ICU and to evaluate both patient family and staff perception of this noise (Kramer et al., 2016).	Level VI, Primary Study	• This study took place in a 20-bed PICU located in Omaha, Nebraska. • Decibel levels were recorded by using the NoisePro DLX. This was placed in the patient's room at the head of the bed. • One-hundred patients older than 7 years were included in this study. • Both parents and nurses answered a questionnaire regarding their perception of noise on the PICU.	• "The average noise in an individual room ranged from 56.1 to 79.5 dB" (p. 112). • Peak levels exceeded 100 decibels. • Both nurses and patient family members identified sources of noise. • The greatest contributing factors to the noise level was "monitors and their associated alarms" (p. 113). Other sources of noise included ventilators, adjacent bedsides, human noise, TV, etcetera.
The purpose of this literature review was to identify if the implementation of quiet time would improve patient sleep and provide other benefits in the ICU environment (Lim, 2018).	Level V, Secondary Study	• Seven qualitative and quantitative articles were reviewed in this literature review. • The study sought to evaluate patient sleep, nurse work environment, and the impact of visitation with quiet time.	• These studies did not yield sufficient information to indicate that quiet time improved patient sleep. • The study did indicate that a quiet time can improve the work environment for nurses. • This review did not indicate that family visitation interfered with quite time.
The purpose of this study was to determine the efficacy of	Level II, Primary Study	• This study was conducted in Perth, Western Australia and included 40 cardiac surgery patients.	• Noise was measured in decibel levels. "The mean maximum sound level was 69dB" for 37 of the 40 patients (p. 130).

earplugs in ICU patient delirium reduction and sleep improvement (Litton et al., 2017).		• Patients were divided into a control group and intervention group. Twenty participants were placed into each group. • Patients completed the Richards-Campbell Sleep Questionnaire “after their first full night during which they were not undergoing” mechanical ventilation (p. 129).	• This study concluded that ear plugs is a feasible intervention to implement in this patient population. • The study did not delve into patient answers on the Richard Campbell Sleep Questionnaire. • Twenty percent of pre-operative patients found the earplugs to be uncomfortable. Only 12% of patients found the earplugs to be intolerable or uncomfortable once in the ICU. • The study indicates that “perceived sound levels were reduced by about half with the use of earplugs” (p. 131).
The purpose of this literature review was to identify factors influencing patient sleep in the ICU (Medrzycka-Dabrowska et al., 2018).	Level V, Secondary Study.	• This literature review pulled articles from three separate sources. • Articles between the years of 2000-2017 were selected; studies had to be performed in the ICU environment. • Studies had to include validated tools to evaluate sleep, objective or patient subjective sleep evaluation, and factors that interrupt patient sleep in the ICU.	• This literature review revealed that noise was a common factor in patient’s lack of sleep. • The review indicated that white noise did not reduce noise levels that were already present. • Patient sleep was interrupted by nursing care. • This study recommends that “main measures should aim at increasing the comfort of patients, reducing light and noise intensity at night, and the good organization and aggregation of nursing care interventions to prevent sleep interruptions” (p. 392).
The purpose of this study was to “assess the quantity and	Level VI, Primary Study	• This study was conducted in a medical ICU in India. • Actigraphy was used on patients to determine their sleeping	• Both actigraphy and the Richards-Campbell Sleep Questionnaire indicated that patient sleep in the ICU was poor.

quality of sleep in patients admitted to the ICU using actigraphy and Richards-Campbell Sleep Questionnaire" (Naik et al., 2018, p. 23).		pattern. It measured sleep between the time patients pushed a button stating they were going to sleep and when they pushed it stating they were waking up. • Patients were asked about their sleep quality (good vs. poor) and to complete the Richards-Campbell Sleep Questionnaire (5 questions). • A total of 32 patients completed both portions of this study (18 males and 14 females). A total of seventy patients completed the questionnaire.	• Actigraphy indicated sleep was worse than the questionnaire. More patients filled out the questionnaire.
The goal of this literature review was to reveal the nurse's perspective of patient sleep and steps nurses take to promote that sleep (Nesbitt & Goode, 2014).	Level V, Secondary Study	• This literature review included 25 different studies from 2003-2013.	• This study concluded that patients are not sleeping well in the ICU environment and nurses are not making this a priority to their care. • This study recommended that nurses be educated better regarding the importance of patient sleep.
The purpose of this study was to determine if music and massage therapy could decrease stress and improve patient sleep (Nicola et al., 2019).	Level III, Primary Study.	• 74 ICU patients in Italy participated in this non-controlled study. • Patients received normal medical care the first night. • On the second night, they were exposed to the intervention: patient's musical preference or nature sounds (headphones	• Patient stress factors were broken up into four categories: "environment", "feeling", "emotions", and "physical state" (p. 75). • The second day patients identified that stressful factors included their perception that staff was "very busy, stressed and in a hurry," "hearing unusual sounds and noises," staff loud conversation, feeling

		playing this music were left on all night), and massage using lavender/lemon-scented almond oil (via 20-minute leg and foot massage). • Patients filled out the Stress Factors in Intensive Care Unit Questionnaire and the Modified Richards-Campbell Sleep Questionnaire on day two and day three.	"worried/afraid," and feeling "thirsty" (p. 75). • The third day patients identified a decrease in their perception of "unusual sounds and noises," a decrease in "hearing other patients suffering, crying or complaining," and a decrease in staff speaking volume (p. 76). • On the second day, 43.2% of patients described their sleep as "light" (p. 76). >50% of these patients experienced trouble falling asleep, and >70% of these patients experienced trouble staying asleep. • On the third day, the findings indicated a positive correlation between "awakenings" and "healthcare professionals talking, joking and arguing in loud voices" as well "unusual sounds" (p. 76). The study also revealed that "difficulty in falling asleep" was positively correlated to "being worried/afraid" (p. 76). • "Quality of sleep" and "difficulty in falling asleep were negatively correlated as were "quality of sleep" and "hearing unusual sounds" (p. 79). • Overall, patients indicated that their ability to sleep improved with the complementary activities.
The goal of this study was to determine if environmental modification in the	Level III, Primary Study	• This study took place in a cardiovascular surgery ICU in Turkey. One-hundred patients were evenly randomized to a control and intervention group.	• Patients in the intervention group slept longer and rated their sleep as better than those in the control group.

ICU would improve patients sleep (Ozlu & Ozer, 2017).		• Patient data was collected in the evening after their cardiac operation, the patients were divided into the control and intervention group, the study was performed, and the patients were asked to evaluate their sleep via the Richards-Campbell Sleep Questionnaire the following morning. • Those in the intervention group experienced environmental modification to "light, temperature, bad smell discomfort caused by the bed or pillows" (p. 90).	
The purpose of this study was to determine if a bundle of non-pharmacologic interventions could improve patient sleep and decrease delirium (Patel et al., 2014).	Level III, Primary Study	• One hundred-sixty-seven medical and surgical ICU patients were involved in the pre-survey. One-hundred-seventy-one were involved in the post survey. • Among the methods included were "closing doors," "decreasing the alarm noise levels on bedside monitors and the volume of the telephones," decreasing light at bedsides during certain hours, and offering eye masks and earplugs to patients with RASS >-4. • There was >90% compliance with the changes.	• Changes were found to reduce environmental noise. Pre-intervention decibel levels were 68.8 decibels, post levels were 61.8 decibels. • Patient report of sleep was improved with the implementation of these components.

The purpose of this study was to obtain decibel readings in a cardiac care unit. The goal was to determine if noise levels were a problem in this environment (Ryan et al., 2016).	Level VI, Primary Study	• Sound in decibel levels was recorded in three different locations in the coronary care unit over the course of one month. • Decibel levels were monitored at the nurse's station desk and in two patient rooms. • The Extech Sound Logger SDL-600 Sound level meters were used for decibel monitoring.	• "The central nurses' station experienced, on average, 522.24 medium alarms per day and 40.02 high priority alarms per day" (p. 434). • 4 am decibel levels of 49.98 dB were an average low at the nurse's station desk. At 2pm the unit saw its average high of 65 decibels. • Patient room decibel level average low was 43.03 decibels at 3am. This however, was not consistent to all patient rooms. Another room was louder with an average low of 49.73 at 4 am. • Cardiac monitors and oxygen saturation monitors accounted for the largest proportion of alarms. • Note: two weeks data (of the one-month data collection) were lost due to a power outage. • The decibel levels in this study were greater than the WHO's recommendations. Thus, the decibel levels were indicated to be a problem.
The purpose of this systematic review was to determine the "feasibility, validity, and reliability as a measure of sleep in critically ill patients" (Schwab et al., 2018, p. 1).	Level V, Secondary Study	• This systematic review included 13 studies. Three of these studies were RCTs and ten of them were observational studies. • These studies measured nighttime sleep (14-hour time block) over an average span of 4.4-7.8 hours. The average was 7.1-12.1 hours over a 24-hour time block.	• This study revealed that actigraphy showed improved patient sleep when compared to other sleep measuring techniques. The authors questioned the validity of actigraphy results. • The study recommended further study be performed to better understand actigraphy results in ICU patients. It stated that there is a "lack of ICU-specific actigraphy data-processing algorithms" (p. 7).

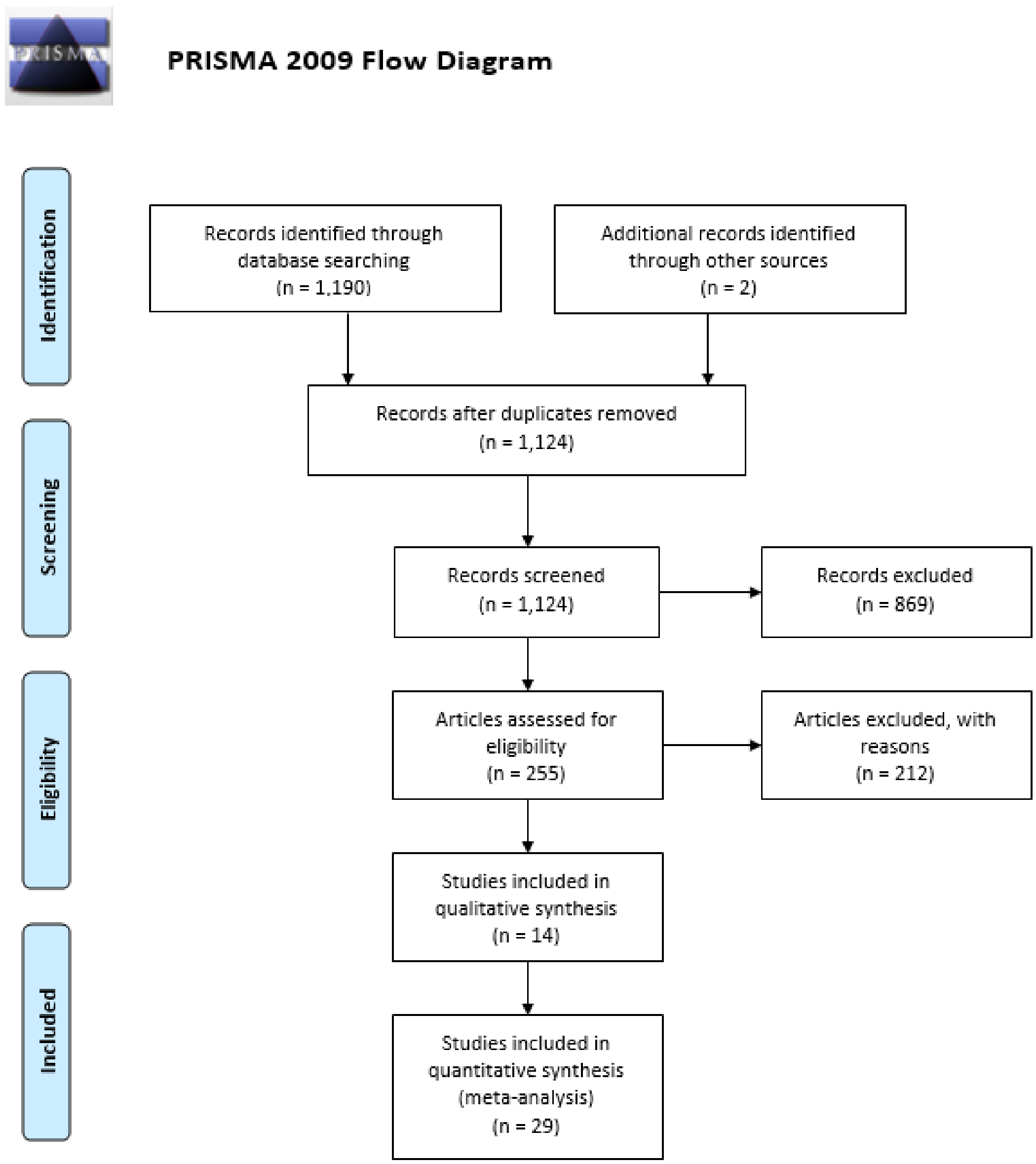
The purpose of this study was "to analyze the contribution of ear protectors and eye masks to promote sleep of the patient admitted to intensive care" (Vieira et al., 2018, p. 2784).	Level I, Secondary Study	• A multi-database literature review was performed. • Controls were set to filter for articles between the years of 2014-2018. • Four RCTs were selected for review.	• Of the four articles selected, all of them "point to the benefits of using these devices to promote quality of sleep of the patient in intensive care" (p. 2784). • This integrative review points supports the usage of ear and eye protectors in the ICU environment.
The purpose of this study was to determine if sound and light could continuously be monitored in an ICU patient room and to determine light and sound differences in the ICU between night and day (Voigt et al., 2017).	Level VI, Primary Study	• This pilot study included four 1-hour long time sessions. • Two empty rooms were evaluated; one during day shift and one during night shift • Two occupied patient's rooms were evaluated during day shift. One patient was stable, one was unstable	• The results indicated that it is feasible to monitor light and sound in the ICU. • Further results indicate that there is not much noise/light difference in an empty room between day and night shift: decibel levels were 45 & 46 dBA. • The study indicates that sound level "reached toxic levels in both the stable and unstable patient" rooms: decibel levels were 61 & 81 dBA (p. 37). • Lux levels were able to be modified according to the investigator's preference. Maximum dimness was 1-3 lux. Maximum brightness was 1306-1812 lux (night to day variation).
The purpose of this study was to determine if eye masks and ear plugs would help to improve patient perception of sleep	Level III, Primary Study	• This cross-over clinical trial was conducted in Iran and included 50 ICU patients. • The patients were randomly divided into two groups. These groups alternated being the	• This study was somewhat inconclusive. While patient scores on the sleep scales improved indicating that sleep was improved, the positive effect of this intervention on "sleep effectiveness and sleep disturbance was not confirmed" (p. 677).

in the ICU environment (Yazdannik et al., 2014).		control and intervention group on two subsequent nights. • The intervention group received an eye mask and ear plugs. • "Verran and Snyder-Halpern Sleep Scales were used to measure the patients' sleep quality" (p. 673).	
The purpose of this study was to confirm or deny that "patients' demographic characteristics affect their perceived quality of sleep" and to determine the correlation between "ICU environmental factors and the patients' perceived quality of sleep" (Younis et al., 2020, p. 298).	Level IV, Primary Study	• This cross-sectional, correlational study involved a three-part patient questionnaire. • The study took place in two multidisciplinary ICUs in Jordan. • One-hundred three individuals participated by responding to a demographic survey, Freedman Quality of Sleep Scale, and Richards-Campbell Sleep Scale.	• "This study found no significant correlations between any of the patients' demographic data with their perceived quality of sleep" (p. 300). Therefore, the first hypothesis was not substantiated. • This study concluded that "light and talking have the greatest impact on the quality of patients' sleep" (p. 300). Other contributing factors include noise, "nursing intervention, vital sign measurement, administration of medications, [and] talking and phones ringing" (p. 302). • This study indicates that there is a correlation between environmental factors and patients' ability to sleep.

Appendix

Appendix A

PRISMA Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Appendix B

CITI Training

CITI PROGRAM

Completion Date 11-Oct-2017
Expiration Date 10-Oct-2020
Record ID 24914561

This is to certify that:

Heather Smith

Has completed the following CITI Program course:

Biomedical Research - Basic/Refresher (Curriculum Group)
Biomedical & Health Science Researchers (Course Learner Group)
1 - Basic Course (Stage)

Under requirements set by:

Liberty University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?wd3fe0818-5261-4959-952d-df8cb035dce3-24914561

Appendix C

Liberty University Institutional Review Board

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

July 2, 2020

Heather Smith
Tonia Kennedy

Re: IRB Application - IRB-FY19-20-269 Nighttime Quiet In The Intensive Care Unit: An Integrative Review

Dear Heather Smith, Tonia Kennedy:

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your research with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study does not classify as human subjects research because:

(1) it will not involve the collection of identifiable, private information.
(2) evidence-based practice projects are considered quality improvement activities, which are not considered "research" according to 45 CFR 46.102(d).

Please note that this decision only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office