AbstrAcT

• **Objective:** To review the effects of hospital noise on staff.
• **Methods:** Review of the literature.
• **Results:** The authors searched for studies that relate the hospital acoustic environment and staff response. Forty-one papers were selected that focus on hospital staff stress, satisfaction, psychosocial environment, job performance, and health, although not all specifically discuss noise. Although the effects of hospital noise on staff are generally negative, results are sometimes inconclusive. Further, some staff outcomes (eg, psychosocial environment, health) were studied in a very limited number of articles or via small subject sample sizes.
• **Conclusion:** Although the effects of hospital noise on staff are generally negative, interpretations must be made with caution.

High levels of noise are often found in the hospital environment, and the potential negative impacts of noise on patients have been demonstrated [1]. Hospital noise has been associated with patient risk for sleep disturbance, cardiovascular response, increased length of stay, increased incidence of re-hospitalization, and other problems [1]. Fewer studies have been conducted examining the effect of noise on staff.

We conducted a literature search to find articles relating the hospital acoustic environment and staff response. We examined the reference lists of known articles in the field as well as utilized the search engines PubMed, JSTOR, and JASA as well as common internet search engines using the keywords hospital noise, hospital staff stress, nurse and noise, staff error, and others. Only peer-reviewed articles published in English were included. Editorials and letters were generally excluded. We reviewed 41 papers that focus on hospital staff stress, satisfaction, psychosocial environment, job performance, and health, although not all specifically discuss noise.

NOISE OVERVIEW

Kryter defines noise as “an audible acoustic energy that adversely affects the physiological or psychological well-being of people” [2]. Noise is also commonly referred to as “unwanted sound.” A variety of methods are used to quantify sound but the most common unit of measurement is the decibel (dB). A decibel measures the energy contained in sound relative to the very minimum most humans can detect. The A-weighted filter (dBA) is commonly applied to better simulate human response to sound and noise across frequency and is used for a wide range of typical sound levels. Likewise, another human-response weighting is sometimes applied to very loud sounds (C-weighting, dBC). Sound is measured across frequency, which is related to human perception of pitch and measured in Hertz (Hz). The range of frequencies included in a particular sound is referred to as bandwidth. For example, the sound of air-conditioning is an example of a broadband sound (wide bandwidth), whereas a single tone is a narrow-band sound.

Approximate sound levels for various sources can be described, for example, quiet residence (40 dBA), private office (50 dBA), conversational speech (60 dBA), vacuum cleaner (70 dBA), heavy traffic (80 dBA), pneumatic hammer (100 dBA), and jet aircraft (120 dBA) [3,4]; however, perception of sound is complex and these approximations are given only for reference. Guidelines have been developed that specify acceptable sound levels...
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for various types of indoor spaces, including hospitals. The World Health Organization (WHO) recommends that averaged sound pressure levels measured over time not exceed 30 dBA in patient ward rooms or 35 dBA in patient treatment and observation rooms [5]. However, the appropriateness of these guidelines has been questioned as no hospital noise results published since 1960 have shown compliance [6]; new guidelines are under development [7].

The noise normally occurring inside rooms is often referred to as “background noise.” In hospitals, background noise can result from sources such as air-conditioning systems, medical devices, and occupant sounds such as conversation. Impulsive noises, or very loud, short-duration events, are also commonly found in hospitals (eg, doors slamming, metal-to-metal contact, alarms). Two other types of noise sometimes used in acoustics experiments are white noise and pink noise. White noise has a constant amount of energy across frequency, whereas the energy in pink noise changes with frequency. Both types of noises sound similar to TV or radio static (ie, turned on but not tuned to a station).

Two other important measures of sound in rooms are reverberation time (RT) and speech intelligibility (SI). RT is a measure of energy decay, which is related to spatial volume and absorptive characteristics of surface materials; generally, larger spaces with less absorption (harder, reflective surfaces) have longer RTs. SI is the ease of communicating orally in an environment. A variety of different acoustic metrics are used to characterize SI. One of the more common metrics used in hospitals is the speech intelligibility index, which considers speech importance (eg, speech recognition) and audibility (eg, comparison of speech to background noise). Generally, speech is most difficult to understand in loud, reverberant environments where multiple noise sources are present.

Noise and Stress

Hospitals are inherently stressful work environments, even absent from noise [8]. Several methods exist for measuring human stress response, including self-report, heart rate, and salivary amylase measurements. Satisfaction is a measure of how content people are with their jobs and measured through various self-report surveys. Factors influencing stress and satisfaction also affect the psychosocial environment, described by Shortell as the “caregiver interaction comprising the culture, leadership, coordination, communication, and conflict management abilities of the unit” [9,10]. Like satisfaction, psychosocial environment is usually evaluated via self-report surveys. Research shows that stress, satisfaction, and the psychosocial environment can be influenced by the sensory overload imposed by environmental factors such as high noise levels. According to Levi, “stress is caused by a multitude of demands (stressors), such as an inadequate fit between what we need and what we are capable of, and what our environment offers and what it demands of us” [11]. Occupational stress is derived from workplace conditions—environmental loads such as noise, work hours and shift times, level of responsibility, and pace of work are just a few examples of occupational stressors that also relate to satisfaction and psychosocial environment.

In recent years, environmental health researchers have linked occupational noise exposure to a variety of negative stress, satisfaction, and psychosocial effects among non-hospital workers. For example, Sundstrom et al surveyed 2391 office employees and found a significant relationship between increased noise and declining job satisfaction [12]. Others show that noise might both directly impact outcomes and also interact with either psychosocial or work elements. For example, Leather et al studied 128 office workers and found no direct effects of noise on staff-perceived satisfaction, well-being, or organizational commitment [13]. However, quieter sound environments did buffer the negative impact of psychosocial job stress on all 3 outcomes. Stated otherwise, high noise amplified the impacts of stressful jobs. This led the authors to conclude that psychosocial job stress was important in understanding the context of sound events at work.

Although there is abundant literature on job stress, satisfaction, and psychosocial environment among hospital staff, only a handful of studies also consider noise. Nurses generally perceive that increased noise levels cause stress [14,15]. Ryherd et al surveyed 47 nurses in a neurologic intensive care unit and found that 91% felt that noise negatively affected them in their daily work environment [15]. Many nurses reported experiencing noise-induced stress symptoms such as irritation (66%), fatigue (66%), and tension headaches (40%). The noise in the unit averaged between 53 and 58 dBA.

There is also evidence that the broader work context is important for health. For example, a study by Topf related personal hardiness (eg, commitment, control,
mental load, and time pressure. The authors concluded that stress, and self-reported job performance [21]. Worker analyses [20]. For example, a large-scale Dutch study including sustained attention to multiple cues or complex analyses showed that higher noise levels were associated with increased heart rate. Higher caffeine intake, less nursing experience, and work shift were also significant predictors of elevated heart rate.

Topf revealed that noise-induced stress and individual sensitivity to noise was related to self-reported health outcomes [18]. Subjects were 100 critical care nurses. Results showed that more noise-induced stress was related to more headaches on the job, particularly for noise-sensitive individuals. The author suggested additional studies should be conducted to evaluate the implications of immediate health outcomes such as headaches on long-term effects such as hypertension and other cardiovascular outcomes.

**Noise and Job Performance**

The non-hospital literature contains abundant evidence suggesting that environmental sensory overload can disrupt processing of stimuli and information. Sundstrom et al describes the overload hypothesis, which suggests that humans have a finite capacity for processing stimuli and cope with overload by utilizing selective attention and ignoring low-priority inputs [19]. Indeed, numerous studies have shown that noise can degrade mental activities, including sustained attention to multiple cues or complex analyses [20]. For example, a large-scale Dutch study examined 539 male plant workers and related noise, stress, and self-reported job performance [21]. Worker noise exposure was estimated either via actual measurements or perceived estimates. Findings showed that stress responses increased in conditions of noise exposure, high mental load, and time pressure. The authors concluded that the combination of noise and stressful mental activities can result in disturbed concentration, irritation, and annoyance.

Only a few hospital studies have directly related noise to job performance. Murthy et al exposed 20 anesthesia residents to recorded operating room (OR) noise and measured their performance [22]. The noise was played at a level of 77 dBA, a typical level of exposure based on measurements they conducted in actual ORs. The Trail Making Test and Digit Symbol Test were used to assess mental efficiency, and the Benton Visual Retention Test measured short-term memory. Performance was evaluated in audiometric testing rooms during both the noise exposure and a quiet condition. Results showed a significant deterioration on all tests with exposure to noise.

Another study found that general interruptions and distractions were associated with dispensing errors in an ambulatory care pharmacy [23]. However, as the noise in the same pharmacy increased, errors increased to a point, then decreased [24]. In this study, pharmacists were video-taped over 23 days. Any deviation from the physician’s written order was considered as an error, including wrong drug, wrong dosage strength, wrong quantity, or wrong prescription label information. Typically 1 to 2 pharmacists and 1 to 2 technician assistants were on staff at any given time. The volume of prescriptions filled per day was 221, on average. Although increased noise levels tended to produce more errors, some pharmacists were able to maintain a stable error rate regardless of noise.

Conversely, several other studies found no correlation between hospital noise or music and performance [25–27]. In one study, 12 surgeons completed laparoscopic suturing under 3 conditions: quiet, noise at 80 to 85 dBA, and music [25]. Suturing performance was assessed by blind observers based on accuracy, knot quality, and number of nonpurposeful movements. The authors hypothesized that there were no observed effects because the surgeons could “block out” the noise and music via high levels of concentration on the complex suturing task. However, sustained attention during noise is often followed by increased tiredness after work and is in fact a more consistent measure of noise effects than poor performance during work [28]. The failure to record any such effect and the small sample size may have factored into the lack of nonsignificant results.

In another study, no difference in task performance was found for anesthetic trainees under self-chosen music, classical music, white noise, and no noise signals,
all played at self-adjusted volumes [26]. The PsychE psychomotor evaluation program was used to assess vigilance, reaction time, and percentage of time on target. Twelve subjects listened to the 4 signals via headphones and performed the computer-based tasks in a quiet room. Authors conceded that the subjects did not represent a typical cross sample of anesthetists, and their scores may have been improved due to their high computer literacy. They suggested following up with more realistic tasks, eg, via anesthetic simulators.

In a third study, the ability of subjects to hear key patient physiological sounds was evaluated in an emergency department (ED) [27]. Over 100 physicians, nursing personnel, and medical students listened for heart and lung sounds in a healthy individual. Pink noise was played at 90 dB during the tasks. Around half of subjects reported hearing diminished lung (50%) and heart (53%) sounds, and a much smaller percentage were totally unable to hear lung (3.8%) and heart (8.7%) sounds. However, although this study evaluated whether subjects could hear the sounds, it failed to determine if they could detect clinically significant subtle findings. Further, the pink noise type and loudness (90 dB) used in the study was somewhat unrealistic. The authors also note that there was a subject bias in that most listeners were relatively young and thus their hearing acuity may have been better than average.

Individual noise sensitivity or attitude may factor into results. For example, Park et al found differences in x-ray reading performance among subjects who stated a preference for quieter versus louder conditions but not among subjects with no preference [29]. Performance on rib fracture detection for 8 radiology residents was assessed under 2 noise exposures: a quiet room (43–45 dBA) and the same room with noise added (81–84 dBA). The noisy condition was comprised of 3 overlaid recordings made in a busy administration room, a fluoroscopic room, and a large waiting room that all included loud talking.

Another paper conducted noise measurements in an OR and interpreted potential for task interference based on a literature review [30]. Unpredictable noise from sources such as alarms (measured as greater than 75–85 dBA) were hypothesized to negatively affect performance and concentration during complex OR tasks. The study also pointed out that the high average level of noise measured (51 dBA) could potentially reduce the reliability of oral communication. However, this study did not directly measure performance or communication and thus the hypotheses were not confirmed.

Several hospital studies linking noise and job performance relied on self-reports instead of direct error measures or literature analyses. Bayo et al surveyed 295 staff across a range of units in a major university hospital [14]. Between 15% to 20% of staff believed that noise negatively affected their professional performance and quality of work. The average noise levels in the hospital ranged between 52 and 75 dBA. In the Ryherd et al study described earlier, 43% of neurologic ICU nurses felt that noise in their unit caused concentration problems [15]. Another study of 51 medical-surgical ICU nurses showed that noise annoyance was significantly related to self-reported mental fatigue (ie, tiredness, headaches, concentration difficulties, irritation) and auditory fatigue (ie, sound sensitivity, hearing fatigue, ringing in the ears) [31]. Hawksworth et al surveyed 200 anesthetists to determine the potential influences of music played in ORs [32]. Most of respondents worked in operating rooms where music was played regularly (72%). A large number felt that the music negatively affected their job performance—26% reported reduced vigilance and impaired communication, 11.5% reported that music distracted their attention from alarms, and 51% found music distracting when there were anesthetic problems.

Medical Alarms

Auditory warnings and alarms are used throughout the medical environment, and numerous articles describing the potentially negative impacts of the alarm environment have been published [32–43]. One study of a 15-bed medical progressive care unit measured a staggering 16,953 alarms over an 18-day period [33]. The authors pointed out this equates to an average of 942 alarms per day, or 1 critical alarm every 92 seconds. Three areas of concern are (1) masking of alarms by the overall background noise environment, (2) decreased detection because of staff hearing acuity, and (3) “alarm fatigue,” where staff tune out, silence, or disable alarms because they are desensitized or exhausted by them.

Wallace et al studied both alarm masking and staff hearing acuity [35]. The intensity and frequency of 26 OR alarms were measured along with the overall background noise from anesthesia equipment and room ventilation systems. The hearing acuity of 188 anesthesiologists was evaluated via audiograms, which measure hearing thresholds across frequency from 250 to 8000 Hz. Sixty-six percent of subjects had abnormal audiograms. Alarms were measured to contain frequencies
ranging from 250 to 8000 Hz and noise levels from 54 to 84 dBA. They then compared the measured alarm levels to subject hearing acuity, with the assumption that 15 dB above each individual's hearing acuity would be needed to detect the alarm in the presence of background noise. Consequently, they determined that several high-frequency alarms (4000 Hz and above) could go undetected and that alarm design should consider both hearing acuity and room background noise.

Alarm fatigue is described as “limited capacity to identify and prioritize alarm signals, which has led to delayed or failed alarm responses and deliberate alarm deactivations” [36]. Indeed, several studies show that ignoring, silencing, or disabling alarms is common among staff. Ryherd et al found that almost half (49%) of 47 neurologic ICU nurses surveyed said they sometimes adjusted alarm levels so that they would not hear them, and 43% thought the alarm noise negatively influenced their task performance [15]. In another study, over half (56%) of the 58 neurologic and medical-surgical ICU nurses surveyed said that they sometimes tune out alarms [37]. The same study showed that nurses perceived alarms as nearly as disruptive as overall background noise with regards to effects on work performance, health, anxiety, and annoyance. Similarly, a larger survey of 789 anesthetists found that 58% admitted to deactivating alarms. Respondents gave reasons such as the need for peace and quiet, the occurrence of too many false alarms, and the sheer unacceptability of the alarm itself [38,39]. Another study highlighted the waste of valuable staff time and delayed response times related to difficulties identifying alarms [39].

False alarms are one of the many contributors to alarm fatigue. Also called false-positive or nuisance alarms, a false alarm is one that occurs in absence of a valid patient or alarm system trigger [40]. Some studies have documented extremely high occurrence rates of false alarms (86%–99%), with as few as 1% of alarms actually necessitating a change in patient management [33,40–42]. The abundance of false alarms can lead to a “cry wolf” environment where nurses ignore or disable alarms [41]. A survey of 1327 hospital staff revealed that most agreed that false alarms are problematic (81%), disrupt patient care (77%), and can reduce trust in alarms and cause caregivers to disable them (78%) [43].

Speech Communication
Oral communication is paramount to patient safety in hospitals. Miscommunication in hospitals could potentially lead to medical errors such as incorrect medication administration, although this topic has not been adequately investigated [5,6]. Research has shown that both orthographic (spelling) and phonological (sound) similarities increase the probability of medication errors, regardless of level of experience [44]. Noise in other types of occupational environments, such as offices, can hinder oral communication [45]. We found no published studies on speech errors in the context of hospital noise.

Noise and Hearing Loss
Very few studies have evaluated the impacts of hospital noise on staff health. The few studies that do exist focus on stress responses, as described earlier, or on hearing loss. High noise levels in ORs are of particular concern because of the noisy surgical equipment used. Kracht et al measured noise during 76 surgeries in 38 ORs [46]. Operations spanned many branches of medicine. Orthopedic surgeries were the loudest at 66 dBA, followed closely by neurosurgery, urology, cardiology, and gastrointestinal surgeries, which ranged from 62 to 65 dBA. Peak levels were of particular concern; for example, peak noise exceeded 100 dB over 40% of the time during neurosurgery and orthopedic surgery.

Several hearing loss studies have focused on orthopedic surgeons due to their frequent use of noisy power instruments. A summary of several articles shows recorded noise levels for instruments such as drills, reciprocating and plaster saws, mini and maxi drivers, air hoses, and air tools can range from 45 to 105 dB [47]. A few studies conducted noise measurements in ORs and interpreted the potential for staff hearing loss based on a literature review [50]. One study measured noise exposure for 3 surgeons during 5 surgeries—3 total hip replacements and 2 total knee replacements [47]. All surgeries were conducted in the same OR. Noise exposures were evaluated based on the allowable daily dose of noise according to occupational guidelines. Although overall total noise exposure (dose) during the surgeries was generally acceptable, there were brief periods of noise exposure in excess of guideline levels. For example, transient peak sound levels exceeded 140 dB multiple times during surgery and maximum levels approached 108 dBA. The authors concluded that results point to serious health hazards for surgeons that require further investigation.

Three other studies directly measured noise-induced hearing loss among orthopedic staff using audiometry.
to perform tasks, and communicate.

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reduction of re-hospitalization; and improvements
pointing toward beneficial effects of acoustic interven-
strategies on occupants, but the results are promising,
Few studies exist that evaluate the effects of these various
zones, reducing alarm volume settings) or design strate-
as administrative (eg, behavioral modifications, quiet
user.
masking (from room background noise), no disturbance
of patients/staff, and no reliance on hearing acuity of the
user.

Acoustic interventions can be generally categorized as administrative (eg, behavioral modifications, quiet zones, reducing alarm volume settings) or design strategies (eg, sound absorbing materials, architectural layout). Few studies exist that evaluate the effects of these various strategies on occupants, but the results are promising, pointing toward beneficial effects of acoustic interventions, including patient sleep improvements [51–53] and reduction of re-hospitalization [54]; and improvements in staff perceived psychosocial environment [20], ability to perform tasks, and communicate [55].

Most administrative interventions rely on occupant behavior modifications. Biley provides a set of relatively easy-to-implement administrative suggestions on how nurses might reduce noise [56]. These include changing telephone ringers to quiet settings, speaking softly, closing doors whenever possible, encouraging patients to use headphones for TV and music, moving noisy equipment away from patient beds when possible, minimizing number of caregivers at the bedside, advising patients to bring ear plugs, and wearing soft-soled shoes. Although these suggestions are all likely to reduce noise, sustained implementation of some interventions may be difficult in an already stressful, fast-paced working environment. Regularly scheduled staff noise education and training sessions could help sustain efforts. Cmiel et al also provides a detailed list of potential administrative interventions that may have better long-term impact, such as eliminating overhead paging systems at night and changing ancillary staff stocking and cleaning schedules [57]. One study evaluated the impact of implementing personal paging instead of overhead paging in a pediatric ICU [6]. Before the intervention, overhead pages occurred at least once every 5 minutes, for typically less than 30 seconds. After implementing a personal, hands-free telecommunication system, overhead pages were reduced to 1 to 2 per hour.

Changing alarm settings (eg, volume) or their inherent design are other intervention possibilities. The norm is to design alarms to sound dangerous, frightening, unpleasant, loud, and tense so that they are easily distinguishable and alerting [34]. However, a promising study by Stanford et al engineered new alarms with characteristics of the human voice and evaluated their detection in the presence of masking noise [58]. Four broadband noises, from a suction device, skull drill, grinder-reamer, and plaster saw, were recorded in an OR. Eight alarm signals were synthesized to have acoustic characteristics that the authors believed might improve detectibility; specifically, the alarms were constructed to mimic human vowel sounds. Alarm detectibility in the presence of the masking sounds was evaluated for 43 subjects. Results showed that the alarms could be detected with at least 93% accuracy, even when the alarms were played at up to 24 dB below the masking sounds. Another study utilized administrative controls to reduce the number of physiologic monitor alarms in a medical progressive care unit by 43% without compromising patient safety [33]. Solet and Barach provide a detailed discussion of potential avenues for clinicians and managers to improve the overall alarm environment [36].
Several studies have evaluated the impacts of acoustic design changes on staff. A study by Blomkvist et al examined the impact of acoustic interventions on perceived psychosocial environment [20]. The unit under study was an 8-bed coronary care unit. A pre/post analysis consisted of examining the unit in an original condition with a sound reflective ceiling versus a renovated condition with sound absorbing ceiling tiles. The addition of ceiling tiles in patient rooms reduced reverberation time from 0.9 to 0.4 seconds and decreased overall noise levels from 57 to 56 dBA. Thirty-six nurses were surveyed in both the base and renovated conditions. Results showed that the change in acoustics positively impacted the psychosocial environment; specifically, afternoon shift nurses reported lower work demands, less pressure, and less job strain in the renovated condition.

In another renovation study, sound absorbing panels were added to the upper walls and ceiling of the corridors and nurse stations in a hematological cancer unit [55]. Significant reductions in noise (5 dBA) and reverberation time (decreased by a factor of 2) were seen. Additionally, a survey of 12 nurses in both the original and renovated conditions revealed several perceived improvements. Specifically, staff perceived that their abilities to sign off chemotherapy with another nurse, communicate with other health care providers, hear clinical conversations during rounds, and concentrate on the work at hand (calculating medical dose, documenting, talking to a patient or family) all improved in the renovated condition. Statistical analysis was not conducted.

Another study investigated the use of noise cancelling headphones [59]. Eighty-one caregivers participated, including parents, nurses, respiratory therapists, and nursing assistants in an adult medical ICU and a pediatric ICU. Subjects wore either functioning or non-functioning noise cancelling headphones for at least 30 minutes in a randomized, double-blind scenario. Results indicated that although caregivers felt that the headphones reduced noise, they reported that they preferred not to wear them.

An important approach in establishing a good hospital sound environment is to utilize the services of a building acoustical consultant. Basic design strategies and information about how to facilitate collaborations with acoustical consultants have been described [7,60,61]. Although most design interventions require an acoustical consultant’s expertise, there are a few interventions which staff can begin to implement themselves. Examples include adding padding to the bottom and sides of pneumatic tube systems and patient chart holders, or replacing noisy paper-towel and antibacterial dispensers with quieter versions [57].

**SUMMARY**

This literature review highlights a number of potentially negative effects of hospital noise on staff. Although there is abundant literature on job stress, satisfaction, and psychosocial environment among hospital staff, only a handful of studies also consider noise. Nurses generally perceive that increased noise levels cause stress, with some reports of stress symptoms such as irritation, fatigue, and tension headaches. Personal hardness and noise sensitivity have been related to perceived noise-induced stress. Additionally, noise-induced stress and individual sensitivity to noise have been linked to self-reported health outcomes. Only one study was found that directly related staff physiologic stress and hospital noise [16]. Although results of that study showed no significant relationship between noise and salivary amylase, self-reported stress and annoyance did increase with higher noise levels. The study also found that higher noise levels were associated with increased heart rate, with caffeine intake, nursing experience, and work shift acting as significant predictors of tachycardia. Additional studies that directly relate staff stress to noise and its impact on potential performance, satisfaction, and health outcomes are needed.

Although the non-hospital literature suggests that environmental sensory overload can disrupt task performance, the hospital literature is sparse and conflicting in this area. Some studies have shown negative effects of noise on staff mental efficiency, short-term memory, pharmaceutical dispensing, and x-ray reading performance. However, others showed little to no effects on suturing, psychomotor skills, and ability to hear heart and lung sounds. Interestingly, staff often perceive noise as negatively impacting their job performance, including quality of work, concentration, vigilance, and communication. Although speech communication is paramount to patient safety in hospitals, we found no published information on speech errors in the context of hospital noise.

The alarm environment has been the topic of numerous articles. Three areas of concern are masking of alarms by the overall background noise environment, decreased detection because of staff hearing acuity, and alarm fatigue. Several studies showed that ignoring, silencing, or disabling alarms is common among staff. False alarms have also been studied fairly extensively, and are thought to be a major contributor to alarm fatigue.
Very few studies have evaluated the impacts of noise on staff health. Hearing loss has been studied with a focus on operating rooms. A few studies directly measured hearing loss among orthopedic staff using audiometry with conflicting results. Although average noise levels do not always exceed occupational noise exposure limits, the extremely high peak noise levels measured during many surgeries are concerning. Research on other health effects among staff is extremely limited. A couple of articles highlight the prevalence of noise-induced, stress-related health symptoms such as headaches or increased heart rate as described above. However, the non-hospital literature reveals many potential negative impacts of occupational noise exposure that are dependent upon the broader work context. One survey of 133 critical care unit nurses showed that evening shift nurses were more distressed by noise and rotating shift nurses had more emotional exhaustion [62]. Some limited non-hospital studies have linked pregnancy complications and cardiovascular arousal with noise in the context of other work-related stress factors (eg, work shift, lack of social support, unsatisfactory work tasks), although more research is needed [63,64]. It is possible that more relationships between noise and hospital staff outcomes would be revealed if the broader work context was considered in more studies.

CONCLUSION

The conclusions drawn in this article are limited due to the small number of publications specific to hospital staff and noise. Additional concerns include limited sample sizes (as few as 8 subjects), lack of detail about acoustic methodologies, and the presence of conflicting results. Nonetheless, we conclude that hospital noise can potentially have serious negative effects on staff stress, satisfaction, psychosocial environment, job performance, and health.

The need for more research in this area is acute, particularly given that many of the results that do exist raise serious concerns. In the meantime, nurses, staff, and administrators can take steps to advocate for good hospital sound environments. By pursuing a combination of administrative and design interventions, hospitals can begin to ensure that hospital soundscapes satisfy the principle precept of medicine: primum non nocere.

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