Arguably, modern-day society lives in a perpetual state of distraction and technological isolation. Illuminating this societal inattention has created the need for a new body of evidence to consider the ramifications of this behavioral pattern brought forth in current research. For example, it has been determined that talking on a cellular phone while driving increases the risk of an accident by 4 times, which is equivalent to the risk of driving while intoxicated.1

Since 1960, hospital noise levels have risen around the world.2 In 1972 Shapiro and Baland described noise in the operating room (OR) as “the third pollution” and found that OR noise equaled traffic noise coming from a freeway, as cited by Hasfeldt et al.2 In 2003, Borchgrevink3 reported that 12.5% of US children aged 6 to 19 years show a noise “notch” in 1 or both ears, indicating an elevation in baseline noise threshold shifts. These threshold shifts were seen in children who had no occupational noise exposure, leading to the conclusion that Western citizens are at risk of noise induced-hearing loss (NIHL) from general noise exposure.3

Current research demonstrates that OR decibel levels of constant or intermittent noise exceed the National Institute of Occupational Safety and Health (NIOSH) limits for damaging noise at baseline without the additive noise of music.4 Furthermore, a 2013 study noted that OR performance outcomes have been previously linked to changes in mental loading such as task complexity and workload at baseline noise levels without additive noise effects such as music.5 This behavioral pattern has been compared with “normalization of deviance.”6 People engage in deviant behavior, that is, playing background music too loud; as a result, equipment alarms must be increased to compensate, and thus, out of deviance, a new “normal” emerges.6

Today, ORs are equipped with surround sound and iPod docking stations despite evidence that OR environments affect surgical efficiencies. A single-facility, blind study determined that peak noise levels during neurologic and orthopedic surgeries exceeded 100 dB more than 40% of the time, with the highest levels routinely greater than 120 dB.7 Contextually, to understand noise exposure levels as it relates to everyday events, the noise generated from a lawnmower is 90 dB, an ambulance siren is 120 dB, a jet engine during takeoff is 140 dB8, and a shotgun discharge is 130 dB, which is equaled in the OR when high-pressure hoses are disconnected or a mallet strike occurs.4 Moreover, as a result of hard materials and relatively small rooms, there are longer reverberation times, causing noise to dissipate over a longer period.9

Technology contributes to noise. Noise is a health hazard, is a source of stress, and impairs concentration and communication. The genetic makeup of humans does not evolve at the rate of technology. Noise exposure, sensory overload, and the capacity to adapt to this stimulus without physical and psychological consequences are absent from the human condition. The World Health Organization (WHO) has recognized environmental noise as harmful pollution that causes adverse effects on health. Although noise in the OR is unavoidable, music is a choice. The purpose of this literature review is to provide further insight into the ramifications of the presence of music in the OR, evaluate its appropriateness in relation to care and safety for the patient and staff, and provide information for future research.

Keywords: Music in the operating room, noise-induced hearing loss, noise in the operating room, safety hazards in the operating room.
further insight into the ramifications of the presence of music in the OR, to evaluate its appropriateness in relation to care and safety, and to provide information for future research. This research could serve as a safety guideline for critical timeframes when music should not be present in the OR and could help establish general decibel guidelines for the operative course.

**Review of the Literature**

This literature search was conducted between October 2012 and October 2013. It was limited to English-language articles published in the last 6 years at the start of the search to include current relevant data. Standard procedures were undertaken to search for literature reviews, primary research, and expert opinion articles via electronic databases on PubMed/Medline/Ovid, Cumulative Index to Nursing & Allied Health Literature (CINAHL), The Cochrane Library, Google Scholar, *Journal of the American Medical Association*, ProQuest (CINAHL), The Cochrane Library, ProQuest (CINAHL), and InfoTrac Health Reference Center Academia. The following search terms were used: *noise in the OR, music in the OR, impact of noise; and safety hazards in the OR*.

These studies were assessed according to the quality of the evidence and the strength of the study by applying the American Society of PeriAnesthesia Nurses' evidence-based practice (EBP) model by Stetler. The attributes of the studies were evaluated based on the design of the study and the quality of the ensuing research. A distinction was created between descriptive and analytic designs. The analytic designs were differentiated between experimental and observational as denoted by the design tree from the Centre for Evidence-Based Medicine.12

The quality of each study was assessed according to the Methodological Index for Non-Randomized Studies (MINORS),13 which assesses for the following quality indicators:

- **Aim**: the precision of the research question and relevance related to the available literature
- **Inclusion criteria**: inclusion in the study of all study subjects who satisfy criteria for inclusion
- **Data collection**: occurred according to study protocol as outlined at the onset of the study
- **Endpoints**: evaluated as to their appropriateness to the study, and a clear explanation of the criteria used for evaluation as addressed by the research question
- **Assessment of endpoints**: evaluation of blind and double-blind subjective endpoints and reasons for not blinding

None of the studies included was a follow-up study. Therefore, the quality indicators outlined in MINORS relating to follow-up assessment were excluded from the evaluation process (Table 1).

A search of the literature yielded 27 relevant articles that were evaluated and categorized using the criteria and guidelines as outlined earlier for the validity and quality of each publication and study (Table 2).

- **Baseline Noise Exposure in the Operating Room.** Nineteen articles, questionnaires, and editorials discussed the impact of baseline OR noise exposure (see references 2, 4, 6-9, 14-17, 19, 20, 22, 24, 25, 27, 30, 32, and 33). Hospital noise levels were delineated by 2 editorial articles.17,21 The impact of noise specifically as it relates to music was addressed by 5 studies, references 4, 8, 14, 18, 23 5 editorials, references 6, 16, 27, 30, 34 2 questionnaires, references 15, 32 A study and 1 questionnaire.15 Surgical instrument noise was denoted by 8 studies, references 4, 7, 9, 18, 20, 22, 24, 25 2 editorial articles, references 6, 30

The impact of noise on the patient and staff was outlined in 2 studies, references 25, 33 1 questionnaire.21 One prospective pilot study considered 35 patients undergoing abdominal procedures and determined that the subjective perception of increased noise in the OR correlated with surgical site infection.24 In cardiac surgery, 21% of medical errors occurred in the OR, whereas surgical time represented only 4% of the patient's length of hospital stay, with the authors citing high OR noise levels and poor communication as possible causative factors.33 The impact of noise on staff was delineated in a study that indicated that intermittent noise throughout the surgical case causes startle responses and interference with complex tasks.25 The disruptive effects of noise on communication and attention were noted in 1 literature review, 28 studies, references 4, 5, 7, 9, 14, 22, 25, 33 5 editorial articles, references 6, 16, 23, 30, 32 2 questionnaires, references 15, 29 A study and an editorial article discussed distractions in the OR, stating that distractions and interruptions are common,

### Table 1. Rating of Study Design and Quality of Outcomes

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Reflects a well-designed study with no more than 1 unaddressed design flaw</td>
</tr>
<tr>
<td>B</td>
<td>Well-designed study with 2 unaddressed design flaws</td>
</tr>
<tr>
<td>C</td>
<td>A study with 3 unaddressed flaws</td>
</tr>
<tr>
<td>D</td>
<td>Study has major flaws with ≥ 4 unaddressed design flaws</td>
</tr>
</tbody>
</table>

### Rating study design

- **Level I**: Meta-analysis/multicontrolled study
- **Level II**: Experimental study
- **Level III**: Quasi-experimental study
- **Level IV**: Nonexperimental, correlational, descriptive qualitative, or case study
- **Level V**: Case report
- **Level VI**: Expert opinion

- **Endpoints**: All studies were observational studies with a controlled follow-up period of 30 days or less.

- **Data collection**: All studies were conducted in the OR at various hospitals, and all studies were observational in nature.

- **Endpoints**: All studies were observational studies with a controlled follow-up period of 30 days or less.

- **Assessment of endpoints**: All studies were observational studies with a controlled follow-up period of 30 days or less.

- **Assessment of endpoints**: All studies were observational studies with a controlled follow-up period of 30 days or less.
<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects and sample</th>
<th>Study design</th>
<th>Study purpose</th>
<th>Level of evidencea</th>
<th>Quality ratinga</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hasefeldt et al,2 2010</td>
<td>Review of noise in the OR; 18 articles assessed</td>
<td>Literature review</td>
<td>Identified current knowledge and provided a source for new research</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>Way et al,14 2013</td>
<td>15 subjects with operative experience ranging from 1 to 30 years</td>
<td>Experimental</td>
<td>Assessed impact of noise on OR communication and surgical skill</td>
<td>II</td>
<td>B</td>
</tr>
<tr>
<td>Stevenson et al,5 2013</td>
<td>33 anesthesiology residents (19 male; mean age, 30 ± 3 years old); paid participants</td>
<td>Experimental</td>
<td>Assessed OR environment regarding amount of competing information and effects of divided attention on monitoring</td>
<td>II</td>
<td>B</td>
</tr>
<tr>
<td>Feuerbacher et al,19 2012</td>
<td>18 second-year, third-year, and research-year surgical residents</td>
<td>Experimental</td>
<td>Ascertained risks of OR disruptions and distractions-induced errors in a simulated surgical procedure by novice surgeons</td>
<td>II</td>
<td>C</td>
</tr>
<tr>
<td>Chen et al,8 2012</td>
<td>9 employees (4 surgical technologists, 4 RNs, and 1 surgeon) for 1 full shift x 2 days</td>
<td>Experimental</td>
<td>Evaluation of health hazard request in OR of West Virginia University Hospital, Morgantown</td>
<td>II</td>
<td>C</td>
</tr>
<tr>
<td>Fritsch et al,4 2010</td>
<td>Sound levels assessed for 20 medical instruments in 5 surgical specialties</td>
<td>Experimental</td>
<td>Examined effects of long-term hearing loss from OR sound exposure for patients and staff</td>
<td>II</td>
<td>B</td>
</tr>
<tr>
<td>Plyuter et al,28 2010</td>
<td>12 medical interns</td>
<td>Experimental</td>
<td>Examined role of distraction and noise in performance of surgical tasks</td>
<td>II</td>
<td>C</td>
</tr>
<tr>
<td>Siu et al,26 2010</td>
<td>10 medical students (age, 26.6 ± 4.1 years)</td>
<td>Experimental</td>
<td>Examined impact of music during practice with da Vinci robotic surgical system</td>
<td>II</td>
<td>C</td>
</tr>
</tbody>
</table>
| Smith et al,31 2010         | 1st study: 36 adult office workers  
2nd study: 24 undergraduate students                                                  | Experimental          | 1st study: Compared noise with quiet on performance of math skills             | II                 | B               |
| Conrad et al,18 2010        | 8 internationally recognized laparoscopic surgical experts                            | Experimental          | Measured music and noise auditory effects on performance of laparoscopic surgery experts | II                 | B               |
| Pearlman and Sandidge,21 2009 | One individual wearing surgical space suit                                      | Experimental          | Evaluated noise generated by performing orthopedic surgery and assessed potential for hearing loss associated with years of practice | II                 | B               |
| Kurmann et al,24 2011       | 35 elective open abdominal procedures                                               | Descriptive and observational analytical | Evaluated noise level in OR to correlation of subsequent surgical site infection | IV                 | A               |
| Wong et al,25 2010          | NA                                                                                   | Descriptive and observational analytical | Evaluation of OR environment and impact on patient care and working conditions | IV                 | B               |
| Siverdeen et al,20 2008     | 25 orthopedic procedures                                                            | Descriptive and observational analytical | Detected noise generated by orthopedic instruments at varying distances from operative site; evaluation of effects on staff and patient | IV                 | B               |
| Kumar et al,15 2013         | 110 surveys distributed, 68 (61.8%) collected                                        | Descriptive           | Anesthesiologists surveyed regarding perception of communication, stress, music, need for training, and language barriers in OR | IV                 | C               |
| Elks and Riley,29 2009      | 222 anesthetists                                                                    | Descriptive           | Anesthesiologists surveyed regarding impact of communication on performance in OR | IV                 | C               |
| Tsiou et al,22 2008         | 9 Greek hospitals: 43 surgical procedures, 684 staff members                         | Observational analytical | Determined impact of noise pollution on staff and patients in OR               | IV                 | A               |

* continues on page 46
 occurring as often as every 3 minutes.

A literature review noted that noise in the OR is perceived differently by the clinical staff, with anesthesia providers placing the most importance on this issue. Salient to this point was that research indicated that the noisiest period in the OR is anesthesia induction. Two studies addressed the impact of noise on anesthesia providers, discussing the amount of competing information and the effects of divided attention; the authors noted that competing attention demands were found to have a potential detrimental impact on anesthesia providers’ performance.

- **Surgical Performance Impact.** Eight studies and 2 editorial articles addressed the impact of noise on surgical performance communication during the operative course. Four of these studies were conducted in a laboratory and were designed to assess surgical skills on surgical simulator equipment in the presence of certain noise, music, and distraction scenarios. Four studies and 2 editorials focused on various areas that affect surgical performance such as interruptions, distractions, effective communication, and speech recognition under operative conditions. Four studies noted that surgeons demonstrated a significant decrease in auditory performance when music was played compared with a quiet OR environment or in the presence of baseline OR noise. Three studies determined that surgical errors occurred in cases where there were distractions and interruptions.

- **Communication and Safety Impact.** The impairment of communication relating to operative noise was outlined in 1 literature review, 7 studies, and 2 questionnaires, and 5 editorial articles. One literature review, 4 studies, and 1 questionnaire concurred that noise levels in the OR were in excess of WHO standards, the International Noise Council, NIOSH, and the US Environmental Protection Agency.

  - **Patient and Staff Health Impact.** The impact on patient and staff health and safety was outlined in 1 literature review, 13 studies, 6 editorial articles, and 1 questionnaire. A review of the literature reported that 16% of patients experienced noise and felt stressed by the noise. Six studies noted that repeated exposure to excessively loud noises could cause NIHL. Two studies stated that NIHL contributes to 50% of hearing loss in orthopedic surgeons and staff. Four studies discussed the negative health impacts related to noise exposure for patients and staff, including hypertension, tachycardia, increases in cortisol response, and psychological effects from increased stress.

### Table 2. Summary and Assessment of Reviewed Studies

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Design</th>
<th>Setting</th>
<th>Study Type</th>
<th>Data Collection</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kracht et al, 2007</td>
<td>38 ORs at several sites at The John Hopkins Hospital</td>
<td>Observational analytical</td>
<td>Ascertained data on sound levels present in OR environment</td>
<td>IV B</td>
<td></td>
</tr>
<tr>
<td>Stringer et al, 2008</td>
<td>365 procedures in 57 ORs in 9 hospitals in 3 cities</td>
<td>Observational analytical</td>
<td>Calculated average and peak noise in OR and identify nurses’ perception of communication</td>
<td>IV B</td>
<td></td>
</tr>
<tr>
<td>Bush, 2013 Editorial follow-up to recent surgical simulation laboratory study</td>
<td>NA</td>
<td>Expert opinion</td>
<td>Considered potential sources of noise in hospital and examined its impact on staff and patients</td>
<td>VI B</td>
<td></td>
</tr>
<tr>
<td>Mazer, 2012</td>
<td>NA</td>
<td>Expert opinion</td>
<td>Examined various methods used and impact on noise reduction in hospital</td>
<td>VI C</td>
<td></td>
</tr>
<tr>
<td>Saver, 2011</td>
<td>NA</td>
<td>Expert opinion</td>
<td>Identified noise throughout hospital and strategized for potential noise reductions</td>
<td>VI A</td>
<td></td>
</tr>
<tr>
<td>Eggertson, 2012</td>
<td>NA</td>
<td>Expert opinion</td>
<td>Presented 2 editorial opinions on opposing sides of music’s presence and impact in OR</td>
<td>VI C</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: NA, not available; OR, operating room; RN, registered nurse.
and 2008, the US Food and Drug Administration received reports of 566 alarm-related deaths, substantiating that some of those adverse events occurred after the staff did not hear the alarm.9

Three studies6,11,24 noted that repeated exposure to excessively loud noises could cause NIHL, an irreversible sensorineural condition caused by damage to nerve cells of the inner ear.11 Two studies6,24 found NIHL in 50% of orthopedic surgeons, with a greater incidence associated with years of practice. Pearlman and Sandidge23 noted that the greatest risk of NIHL might be to the anesthesia provider who is assigned to several orthopedic surgeries in a single day and is positioned close to the patient. Furthermore, a study concluded that proficiency in surgery does not protect against stressful auditory influences or mental preoccupation.19

It has also been determined that anesthetized patients are at increased risk of NIHL because the stapedius muscle reflex, which attenuates loud sounds, is likely to be paralyzed as a result of the anesthetic agents.20 Furthermore, patients receive greater noise exposure than do OR personnel during bone-conduction cranium work.4 It is known that if the drill touches the ossicular chain, noise levels sufficient to cause hearing loss can be produced.4

A study stated that anesthesia providers were found to experience mental deficiency at ambient OR noise levels, suggesting that any additive noise could compound this condition.4 A review of the literature reported that 16% of patients experienced noise in the OR and felt stressed by the noise.2 Noise has been determined to slow healing, increase pain, and heighten anxiety and stress,23 and has been linked to hypertension and ischemic heart disease.17 A Greek study reported that sudden high-level noises can have an impact on the reflex system of the autonomous nervous system.22 These types of noise are believed to have an impact on human behavior and make cooperation within the surgical team more difficult.22 A study found that optimizing the OR environment may have greater impact on surgical outcome than improving surgical skills, suggesting that the effects of music may be related to the experience of the surgeon.25

Conclusion
Noise in the OR is a baseline condition of fact. This fact notwithstanding, the ramifications are multifocal and threaten the health and safety of both patients and staff. The successful administration of patient care in a multidisciplinary team environment is predicated on effective, accurate, and timely dissemination of information. In a complex, multispecialty healthcare environment with division of roles, responsibilities, and skill sets, this element of effective patient care is compounded by situational factors and patient care considerations, making each operative event a unique experience. The unpredictability of these encounters demands a constant stream of data and transference of information to take place. As a condition of the OR environment, there are barriers to this component of care. This is illuminated by the literature that substantiates the need for noise containment in the operative setting.

All members of the multidisciplinary team, patient care requirements, personal preferences, and environmental comfort, combined with the ability to carry out each unique professional role must be considered. The ability to hear monitors, respond to alarms, communicate effectively, and coexist in this environment mandates consideration of all team members as equal stakeholders in patient care and staff health and safety. Surgical and anesthetic implications mandate that staff members maintain a state of heightened vigilance to deliver proactive care.

What role, if any, should music have in the OR after a patient is under general anesthesia? A review of the literature demonstrates it contributes to the overall stress of the environment, interferes with communication, inhibits the ability to accomplish tasks safely, and poses a threat to patient and staff health and safety. As an ethical matter, the appropriateness of creating a different patient care environment because the patient is anesthetized must be considered. There is no place in the healthcare setting where a patient is more vulnerable and dependent than when anesthetized and undergoing surgery. If music is played in the OR, it must be done so judiciously and with the consent and safety of all stakeholders. Future research may establish safety decibel parameters and link critical care events in the operative setting that mandate heightened vigilance and intraoperative quiet. It is hopeful that this information will guide the appropriate use of intraoperative music.

REFERENCES


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