

*Full-Length Article***Medicine's Melodies: On the Costs & Benefits of Music, Soundscapes, & Noise in Healthcare Settings**Charles Spence¹, Steve Keller²¹*Crossmodal Research Laboratory, Department of Experimental Psychology, Oxford University, Oxford, United Kingdom.*²*Pandora, Oakland, California.***Abstract**

A large and growing body of empirical research now demonstrates the positive impact that music and other auditory stimuli, such as nature soundscapes, can have across the entire spectrum of the healthcare ecosystem: From the point of entry and onward to the operating room, in the perioperative environment, patient wards, and medical waiting rooms, music affects those who hear it: Patients, their families, surgeons, caregivers, and hospital staff alike. In the age of the “experience economy,” where patients are considered as both guests and consumers, private healthcare is increasingly starting to focus on customer satisfaction, and its impact on both financial performance and (not unrelated) health outcomes. In this review, we summarize the latest evidence concerning the impact of music, soundscapes, and noise, on medical outcomes and healthcare provision. We highlight the importance of the auditory (and, ultimately, the multisensory) environment on health and well-being. We also look at the role that music plays in improving patient satisfaction and potentially reducing the costs associated with healthcare provision

Keywords: *Music, Medicine, Atmospheric, Soundscapes*multilingual abstract | mmd.iamonline.com**Introduction: Music, sound, noise, and health**

The connection between music and medicine is an ancient one. According to Merriam [1], music and sound have been used in the healing practices of civilizations for centuries. Indeed, for the aboriginal cultures of Australia, the world was sounded into existence with the call of the didgeridoo, and chants, drums, bells, and shakers have been used by shamans and healers in every major civilization [2]. It may be no coincidence, then, that Apollo was embraced by the Greeks as the god of both music and medicine [3].

It seems as though the ancients were on to something: With the advent of new technologies and robust empirical investigation, a growing body of rigorous scientific research now demonstrates the profound ways in which music affects us whenever and wherever we hear it [4]. Music can help us to relax when we are stressed [5-7] and lift our spirits when we are depressed [8]. When we are incapacitated, such as when lying in a hospital bed, listening to music can distract us when we are bored, and change our perception of the passage of time [9]. There is even evidence to suggest that painful

procedures can be made a little less unpleasant/painful by having the patient focus their attention on a pleasing tune or two [10-13].

It has been shown that some of our behaviors can be entrained to a musical beat [14-15]. Music and ambient soundscapes can also be used to help provide a blanket of privacy and/or to mask other sounds, such as the unpleasant noises associated with the operation of medical apparatus – think here only of the whining of the dentist's drill [16] or the cacophony of alarms in the intensive care unit [17-19]. While music is normally used in commercial settings and/or public spaces to attract people [20], there have also been occasions when it has been used deliberately to repel the gathering of certain groups of individuals [21]. For example, classical music acts as an effective deterrent to youths who might otherwise be tempted to congregate in public spaces [22-23].

Recognizing music's impact on our perception, behavior, and neurophysiology across a wide range of everyday situations, it stands to reason that it might play an especially important role in the world of healthcare and wellness. So can music, in any meaningful sense, be said to help in the healing of those who hear it? There has been a surprisingly large amount of research in this area, spread across a variety of contexts: Music in the operating room (for the surgeon and so-called ‘support’ staff); music in peri-operational care; music, and the problem of noise, in patient wards; music to help people who are grieving. In the sections that follow, we take a closer look at each of these in turn, before finally broadening out the discussion to a consideration of music as but one component of multisensory atmospheric – Atmospheric, being an area of marketing concerned with the

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International Association for Music & Medicine (IAMM).

creation of commercial spaces that elicit a particular atmosphere or mood, especially through the use of music.

The 'experience economy' reaches healthcare

Kotler [24], in his classic paper on store atmospherics, not only discusses the importance of getting the multisensory attributes of the atmosphere right in prototypical commercial spaces, such as shops, restaurants, and travel agencies, but briefly discusses the notion of atmospherics in the psychiatrist's office as well. At the time, this foray into the healthcare ecosystem, broadly defined, perhaps seemed like something of an odd addition to a marketing paper. More recently, however, there has been a growing trend to think of patients as 'consumers' or 'guests', whose multisensory experience of healthcare (the consumer journey, in other words) needs to be carefully curated in order to meet (or possibly even to exceed) their expectations [25]. This emphasis on experience constitutes a potential point of differentiation, and is becoming ever more important in competitive healthcare environments, where hospitals with better patient-reported experience perform better financially [26] and produce more favorable clinical outcomes [27]. In a sense, one can think of this as a natural extension of the 'experience economy' mindset [28-29] applied to healthcare [30].

In this context, there is a growing recognition that music (and soundscapes) can functionally enhance the experience of patients, and thus improve patient outcomes [31-32]. One finds early mention of the effects of atmospherics on patient satisfaction in the work of Andrus [33], specifically in the context of dental surgery offices [34]. Some hospitals have gone further, even introducing live music in an attempt to improve the quality of life for both the patients and the staff employed to look after them. Consider the case of the patients and staff at The Adelaide and Meath Hospital in Dublin, Ireland (associated with the National Children's Hospital). They reported feeling more relaxed, happier and more positive after having listened to live music in the hospital setting. The patients' perception of the hospital itself was also positively affected by the sound of live music in the waiting areas [35]. Likewise, Mogos et al. [36] reported that patients gave higher ratings for care when live music was provided bedside, in contrast to those for whom music was not provided. That being said, one also needs to be aware of demand characteristics (not the least of which being scalability and cost for the provision of live music) and the fact that subjective feelings of well-being do not always correlate with more objective measures in healthcare situations [37].

More recently, at Sloan Kettering Hospital's Brooklyn Infusion Center in New York, some of the treatment pods have been equipped with custom chemotherapy chairs allowing the patients the opportunity to check their e-mail, shop online, listen to Pandora internet radio (note that

Pandora is a large North American music streaming service; see www.pandora.com), and even control the lighting (in the pod). Consider too, the findings of Zhou et al. [38], where post-mastectomy women had significantly lower depression scores (and shorter hospital stays) if they were part of a music listening group that was given access to a music library that had been specifically curated for the study. Indeed, a number of interesting interventions have been executed in this space over the last decade or so [39-41]. At the same time, however, it is important to remember that there is likely going to be some cost implication associated with offering live or pre-recorded music to those in healthcare settings. Crucially, in order for a successful sonic strategy to remain in place in the long-term, any costs associated with the playing of music will need to be well-justified. For unless a sound business case (if you'll excuse the pun) can be made in terms of the benefits of introducing music and/or soundscapes into healthcare, such an approach is unlikely to stick in the long-term due to the all too frequent cost-cutting by accountants [42].

At the same time, however, one also finds a growing awareness of the negative consequences produced by seemingly ever-increasing levels of background noise, not only in the intensive care unit (ICU) but also in the public wards and neonatal units [43-53]. It certainly feels like we are a long way from the time, a little over half a century ago, when the sound levels in hospitals were recorded at no more than 50-68 dB [54].

The professional's perspective

Music in the operating room

Much like chefs slaving away in the kitchen [55-56], surgeons often like to have music playing in the background while operating on their patients [57-58]. Intriguingly, when Pennsylvanian surgeon Evan Kane first wrote a brief note to the *JAMA*, as cited by Bosanquet et al. [59], in which he declared himself a keen supporter of the "benefic [sic] effects of the phonograph within the operating room," his concern was primarily with "calming and distracting the patient from the horror of their situation," rather than distracting/relaxing the surgeon and or his/her team in the operating room [59]. Granted, improvements in anesthesia presumably mean that patients today often have less awareness of what is going on than would have been the case over a century ago when Kane wrote his letter. However, it is important to stress that while the focus amongst researchers has typically been on the desires of the surgeon in this regard, they are certainly not the only ones who want music to be played in the operating room. Indeed, according to a 2014 study [60], music, most often of the classical variety [61], is played in the operating room somewhere between 62-72% of the time [62]. Given the literature suggesting that people walk, shop, eat, drink, and

even drive faster while listening to loud music with a fast beat [63-64], one might legitimately want to know what listening to music does to a surgeon's operating performance. A number of simulation studies have demonstrated that music aids task completion while, at the same time, lowering stress and muscle fatigue. The good (reassuring, one might say) news here is that the presence of background music in the operating room has been shown to improve both the speed and quality of surgical closures, at least in the context of plastic surgery, thus suggesting that it might indeed improve the surgeon's efficiency, hence potentially translating into healthcare cost savings [65] (for reference, consider that 14 years ago, hospital operation room fees averaged out at \$62 per minute [66] – thus time saved could be considered cost saved). Furthermore, in an often-cited early study, Allen and Blascovich [67] reported that autonomic (specifically cardiovascular) reactivity was reduced while mental task performance was enhanced in surgeons listening to music of their own choice as compared to no music, or a generic stress reduction music condition. While these studies are promising, it should be noted that in the previously cited surgical closers study, the music played was the preferred music of the individual doing the stitching, and the simple wound closure was actually carried out on pigs' feet rather than a human patient, and in the case related to cardiovascular reactivity, all of the participants were music enthusiasts, the study was conducted in a soundproof laboratory, and the task was an arithmetic exercise. Future research in more ecologically valid settings is needed to truly understand the cost benefit.

It can further be imagined how the opportunity to listen to background music likely becomes all the more important as the duration of the operation increases. In fact, over the years, a number of studies have considered the role/influence of music in the operating room, along with potential tensions that might be triggered in this unique environment – e.g., between the different healthcare individuals working in the same space who might, it can all too easily be imagined, have somewhat different musical preferences [68]. In one light-hearted yet nevertheless interesting study, rock music was shown to impair the performance of men (but not women) when attempting multi-organ resection in the board game "Operation" [69].

Classical music has been shown to improve the performance of expert surgeons performing a laparoscopic task [70]. By contrast, in another study, the task performance of novice surgeons undertaking virtual laparoscopic interventions was found to be impaired by particularly aggressive or upbeat background music, as compared to soothing music or silence [71]. Meanwhile, Siu et al. [72] reported that trainee surgeons (N = 10) with limited experience performed various robot-assisted laparoscopic surgical tasks significantly faster when highly rhythmic music (e.g., Jamaican music or hip-hop) was playing in the background rather than jazz, classical, or else when the tasks

were performed without any music. It should, however, be noted that no patients were operated on in this particular study. Notice too that when quizzed, anesthesiologists in another study rated reggae and pop music as the two most disturbing types of music that might be played in the operating room [73], though it is unclear what role expertise plays in the different results reported here.

In spite of the potential benefits, the impact of music on the so-called 'noise floor' (the measure of the signal created from the sum of all the noise sources and unwanted signals within a system) is a concern. It has been estimated that music can add 87 dBA or more to these already noisy conditions in the operating room [74]. According to Kracht et al. [75], peak noise levels in operating rooms during orthopaedic and neurosurgical procedures exceed 100 dB for extended periods of time (i.e., > 40% of the time), a fact that is particularly troubling when one considers that the negative impact of loud noise is related to the duration for which people are exposed to it. Alarms, 'suckers', 'intercoms', etc. [76] all contribute to noise levels in this space [77-80]. Across a range of surgeries, average equivalent sound levels (also known as the time average sound level or LAT) of 62-66 dB (A) are common. Somewhat worryingly, the highest peak levels routinely documented during surgery exceed 120 dB [61]. Indeed, the peak noise levels in orthopaedic surgery are such that there is very real concern about long-term consequences (i.e., hearing loss) amongst orthopaedic staff [81-82]. Note here that the anaesthetized patients may also be at risk of hearing damage due to the fact that anaesthesia paralyses the stapedius muscle that normally protects the ears by attenuating the response to loud noise [83-84]. According to Liu et al. [85], many patients have reported finding the noise levels around surgery too loud.

MacDonald and Schlesinger [86] attempted to address music-related noise floor issues by creating a device that functions as a semi-automated music volume controller. The idea here is that the device would control music in the operating room and integrate it with vital sign data from the anesthesia monitor. A slowing heart rate, diminishing blood pressure, or declining oxygen saturation might then all be deemed salient events that necessitate a quieter operating environment in which the surgical team can communicate and concentrate on the patient in hand. Hence the idea is that the device would automatically lower the volume of the music at the relevant point(s). Note that a similar solution has also been considered for use in the interior of cars, where natural music levels of 130 dB have been reported [87].

The choice of music to play in the operating room is not an insignificant consideration. The head surgeon is typically given the choice, but his/her selection must then be listened to by the rest of the operating staff, and perhaps even by the unlucky patients themselves [88]. While music might help those working in the operating room to maintain their focus and avoid boredom when performing more intricate

operations, some researchers/commentators have highlighted a number of possible problems with the use of music during operations [89]. Here, it is perhaps also worth considering whether levels of boredom might not be higher in routine operations, rather than more intricate ones. That said, we are not aware of any information on this particular issue. Hawsworth et al. [73] surveyed 200 consultant anesthetists (senior doctors) in the UK to determine the prevalence of music playing in the operating room and anesthetists' attitudes toward it. Of the 72% of those who responded, an equivalent percentage (N = 104) worked in an operating room where the playing of music was a regular feature. Roughly one quarter of the sample thought that music reduced their vigilance and impaired their communication with other staff with a little over 10% being concerned that music might distract their attention from alarms. A little over half felt that music was distracting when a problem was encountered during the operation. That said, a subsequent study by the same research group failed to identify any adverse effects of self-selected or classical music on psychomotor task performance (testing numeric vigilance, tracking, and RT) by residents (i.e., trainee doctors) in anesthesiology [90].

Ultimately, the effect/impact of music (either positive or negative) may differ depending on an individual's role in the operating room [91], and given that the choice typically resides with the lead surgeon [62], whether or not the music is liked [73]. The loudness level is presumably also a relevant issue that is worthy of further consideration. Nevertheless, the evidence does support the suggestion that music can be a helpful adjunct, assuming its use is carefully managed.

Music for the staff

A number of studies have shown that music and ambient soundscapes can have a positive effect on employees in a working environment, including its role in helping to reduce fatigue [92], improve visual recognition [93], and increase productivity [94]. The implications of this research might be especially important when applied to healthcare providers, as any drop-in staff well-being and associated burnout has been shown to significantly impact patient safety [95-96]. Unfortunately, beyond a number of studies looking at the negative effects of noise on healthcare workers [46, 97-99], research into the specific effects of music and sound on healthcare practitioners, while promising, is currently quite limited [100-101]. Due to the critical nature of the work performed by many healthcare professionals, it's imperative that we understand how sonic interventions that have been designed to improve the patient experience might also affect professionals, as they will likely be living with the consequences for longer.

The patient's perspective

Detrimental effect of noise: Too much noise in wards

Florence Nightingale was right when, back in 1859, she wrote that "Unnecessary noise is the most cruel absence of care which can be inflicted either on sick or on well," as cited by Katz [79]. As anyone who has been in a hospital ward or ICU knows only too well, hospitals tend to be exceptionally noisy places [43, 47-48]. While the World Health Organization (WHO) recommends that noise levels inside hospital wards should not exceed 30 dBA at night [102], recent measurements show that the peak noise levels in some hospitals can rival that of a chainsaw, reaching more than 80 dBA [103]. Such loud noise on the wards undoubtedly affect the patient's ability to sleep, and hence must presumably deleteriously affect their recovery. Besides proving detrimental to rest, loud background noise also results in a number of other negative effects, including the suppression of the immune response to infection, increased pituitary and adrenal gland stimulation, and increased cardiovascular stimulation [104-106]. Poor sound absorption (due to the need for hard, cleanable, floors and surfaces), coupled with the plethora of warning signals, alerts, and bleeps, can all too easily create a cacophony of sound that is further complicated by noise from carts, intercoms, staff conversations and visitors. We have already touched on the problematic design of most effective alerts and warning signals for use in the operating room, or elsewhere [107]. "Effective" here being something of a euphemism for attention-capturing, which often translates into "disturbing" for anyone who is not interested in noticing it. Notice here how oftentimes those who are not interested in the alert are nevertheless aware of its presence.

A number of researchers and practitioners have been attempting to address the problem of alarm noise and fatigue [108-109]. Tactile alerts (e.g., warning signals or notifications that are delivered with the skin surface) offer another potential solution and much more personalized (and less distracting to those who are not interested in them) [110], but their uptake has unfortunately been (s)low in this sector, particularly when compared to other sectors, like automotive [63]. At the same time, it is worth noting that alternative solutions to the problem of noise in hospitals may come from outside the medical sector, with musicians occasionally leading the way. One such example is Yoko K. Sen, a Washington, D.C., based composer and performance artist. Sen has collaborated with medical and design professionals at Sibley Innovation Hum, Stanford Medicine X, IDEO, and Medtronics to develop alarm sounds and hospital soundscapes designed to sonically improve the patient experience, while still adhering to standard alarm protocol [111]. The use of tactile alerts and enhanced sound alert design just two of the ways in which people are trying to limit the problem of noise in hospitals.

Music in perioperative care

Certainly, the use of music is not limited to the operating room. There is also a rich literature base on the impact of music and music therapy instituted for a broad range of medical populations, from neonates through the elderly in painful procedures and perioperative care [112-117]. Perioperative care is defined as the *care* that is given before and after surgery; Note that it commonly includes ward admission, anesthesia, surgery, and recovery. Feelings of anxiety and apprehension are understandably common amongst patients during the various phases of their surgical procedure or healthcare encounter. While there are undoubtedly a growing number of pharmacological agents that are available to ease their anxiety and pain, music can be seen as providing an alternative that is both cheap and effective [42, 118]. What is more, it can be used in combination with, or even on occasion, to replace anxiety-reducing medications [119-121]. For example, Bringman et al. [120] reported on a randomized trial of 372 patients undergoing elective surgery, in which relaxing melodies (60-80 bpm, coincidentally mimicking the resting heart rate) were found to be significantly more effective than midazolam as a pre-anesthetic anxiolytic. Music has also been shown to improve patient comfort and satisfaction during local anesthesia [12, 122-123]. Music may play an important role in keeping patients relaxed and “sonically isolated” from noise and conversations during the administration of general anesthesia.

The postoperative use of music has also been shown to be effective in reducing anxiety, distress, pain, and medication consumption, while at the same time also improving patient satisfaction [124-130]. In one frequently cited study, Conrad et al. [131] found that the presence of music resulted in a significant decrease in the dosage of sedative needed to achieve a desired level (of sedation). Other studies have also alluded to the potential power of music as a sedative [132-135]. Here, allowing the patient to choose the music (i.e., rather than the surgeon in the case of the music playing in the operating room) may lead to the best results [124].

In summary, then, the widely-held belief is that music plays an important role in helping to relax/calm those individuals who may be about to undergo an operation and/or any other stressful healthcare encounter [136-139]. At the same time, a positive role for music has also been reported in those undergoing mechanical ventilation [140-142]. In conclusion, therefore, from intake to anesthesia, surgery, and recovery, it is clear that music can play a valuable role in perioperative practice for a variety of patients. Indeed, perioperative care may be one of the most important places where music can be used to enhance the healthcare encounter from the patient's perspective.

Music to aid recovery

While noise can have a negative impact on patients, some sonic interventions can be beneficial to patients and treatment outcomes. It is not enough simply to reduce noise; Adding soundscapes to healthcare settings is the other part of the equation. Indeed, it has been suggested that the introduction of intentionally-designed soundscapes can enhance the patient experience [143]. Positive soundscapes (operationally defined as those soundscapes that were rated positively by listeners) have been associated with faster cardiovascular stress-recovery in laboratory research [144], as well as with better self-reported health conditions in large-scale surveys (e.g., how often survey participants reported experiencing/feeling irritated, headaches, stomach discomfort, depression, etc.). Aletta et al. [145] have provided a systemic review of the associations between positive health-related effects and soundscapes. Additionally, the use of music has been shown to help reduce the postoperative pain suffered by children [146-147]. Särkämö et al. [148-149] found that the verbal memory and focused attention of recovering stroke patients improved when listening to music for a couple hours a day. The researchers suggested that listening to music may help recovery via three distinct neural mechanisms: 1) Stimulation of the damaged brain areas; 2) stimulation of general mechanisms related to brain plasticity (i.e., the ability of the brain to repair/renew neural networks); and 3) stimulation of the dopaminergic mesocorticolimbic system (i.e., the part of the nervous system associated with memory, motivation, reward and arousal).

When considering music as part of the “recovery soundscape”, it should be noted that the type of music used makes a difference to the outcomes that are observed. Trappe [150] reported that vocal and orchestral music had a significant impact on correlations between cardiovascular and respiratory signals, whereas classical and meditative music were reported to produce the most beneficial effects on health for intensive care patients. By contrast, it has been suggested that heavy metal music or techno may not only be ineffective, but could actually lead to stress and life-threatening arrhythmias, giving a rather macabre twist to the genre known as ‘death metal’ (see also Bosanquet et al. [59] for a playful take on good and bad playlists during surgery).

Finally, the use of music and soundscapes away from the healthcare setting can also prove effective as a component of treatment. Salivary cortisol is often used as a biomarker for stress [151]. Khalfa et al. [152] have reported that relaxing music has a beneficial effect after the induction of psychological stress, while Thoma et al. [153] found that listening to music had a positive impact on the psychobiological stress system.

Music interventions in the face of death and dying

While composers have been writing music especially for those who are grieving for millennia [154], research into the use of music as it relates to the experience of death and dying has been limited. However, in the instances where research is available, the results are promising. One example is found in “music vigils” offered to terminally ill and/or actively-dying patients and their families, where it was found to improve patients’ breathing, relaxation, comfort, and ability to sleep [155]. Relevant here, Bernardi et al. [156] assessed cardiovascular and respiratory variables while their participants (both musicians and non-musicians, N = 12 in each group) listened to different kinds of music with differing rhythmic, harmonic, and melodic structures. As one might have predicted, fast tempo music was found to be arousing [157], whereas slow or meditative music was reported to be more relaxing instead. It may be worth noting that, though there has been little discussion to date regarding cross-cultural differences in music, there may well be a cultural component to the music that people deem appropriate to listen to in healthcare settings [158].

Meanwhile, Holm et al. [159] conducted a focus group study examining the impact of music during care for family members and the deceased (i.e., after-death care). The study, which consisted of a series of interviews with ICU nurses, concluded that there were positive outcomes when music was part of the caregiving process. In addition to positive feedback shared with the caregivers by the bereaved (e.g., creating a more peaceful atmosphere, helping distract from other disturbing sounds in the environment, adding a sense of reverence), there was also a noticeable increase in the amount of time the grieving would spend with the deceased when music was playing. While the researched did not indicate if this increase in time spent was a positive or negative result, it is assumed that the caregivers saw this as a benefit to those grieving. What was also notable in this study was the self-reported impact of music on the caregivers themselves: There were, for instance, reports of music providing more dignity during the preparation of the body of the deceased, leading to feelings of peacefulness and increased focus and mindfulness on the part of the nurses to the task at hand. Caring for those grieving after the loss of a loved one is understandably stressful. The suggestion here is that music may be used strategically in after-death care in order to help reduce anxiety, stress, and fear for both caregivers and those needing the care [160-161].

By extension, one might also think about the important role that music often play at funerals or memorial services. Here it is worth noting that different types of music (e.g., classical, heavy metal, and personally curated playlists) have been shown to have differential effects on people’s ability to deal with stress [153, 162]. At the same time, it should be recognized that the extended period over which grieving

normally takes place means that it is obviously not an easy subject for empirical research on the impact of music. It is also worth noting that music may help temper other kinds of loss-related grief, including end-of-life care [163-165].

Finally, when it comes to practical applications in this space, once again we find artists and composers willing to lend their talents. In 2013, composer/musician Brian Eno made a foray into creating music especially for the hospital setting [166], creating an ambient soundscape specifically for the “meditation room” at Montefiore Hospital in Sussex. We are not aware of any empirical research specifically designed to assess the effect of this particular soundscape on people’s response to grief, but the question arises as to whether music/soundscapes specially developed for healthcare situations would be more beneficial than music that may have been created for a variety of other purposes, including entertainment [167-169].

Music at mealtimes

Long-term exposure to noise has been shown to have a detrimental effect on people’s health no matter where they happen to be – either hospital or home [170]. As has been noted earlier, public hospital wards tend to be exceptionally noisy places [171]. The research demonstrates that loud background noise also adversely affects people’s ability to taste food and drink [172-173]. All that noise is likely to impair the patients’ ability, if not to enjoy, at least to experience the food as acceptable, resulting in potentially adverse effects on maintaining a nutritionally-balanced diet. Indeed, it has often been commented on that continuing care patients experience particular problems at mealtimes [174]. It is great to see that some hospitals have been focusing on the provision of food [175, 176]. But can sound really be used to improve the patient experience and outcomes as they relate to food enjoyment and nutrition? As it happens, there is an extensive literature on the effects of music while dining [177]. As such, one might want to ask about similar applications in the hospital setting [178].

Certainly, music and soundscapes can be used to help calm agitated patients [179]. Courtright et al. [180] studied the effects of relaxing music on disruptive and violent aggressive behaviors during dinner amongst more than 100 psychiatric inpatients. The idea here was that music would buffer the general noise level that is typically found in dining rooms, so exerting a calming influence, and thus perhaps reducing the incidence of disruptive behaviors. In fact, according to the authors, playing the sound of sea gulls led to a drastic reduction in the incidence of aggressive behaviors. This is particularly interesting in the context of the use of sea gull sounds in a dish called the ‘Sound of the Sea’ [180-182], served in world-leading The Fat Duck three Michelin-starred restaurant.

Noise-cancelling headphones might provide another solution to the extremely loud noise in wards. In fact, the noise in wards is, in many cases, louder than the intolerable levels one increasingly finds in restaurants [172]. The key point to note here is that all that noise is likely to impair the patients' ability to, if not enjoy, at least to experience the food as acceptable and hence to achieve a nutritionally-balanced diet. In addition, noise-cancelling headphones might help not only with the reduction of ambient noise, but also provide for the addition of music and/or soundscapes to the dining experience [56, 173]. While the use of headphones in some instances might be beneficial, it should be noted that their use obviously reduces the opportunity for socialization at mealtimes, when socialization is something that many older patients desperately want/need [183].

Looking to the future, there may also be the potential to use 'sonic seasoning' – defined as the use of specific pieces of music or soundscapes in order to season the food [184] - to help address poor nutrition, and possibly also taste disorders amongst various patient groups. One relevant example here comes from the Xin café in Beijing [185], where 'sweet' music (that is, high-pitched sounds, etc.; see Knöferle et al. [186] for a summary of the sonic parameters associated with 'sweet' music) is played so that less sugar can be added to a customer's drink, while not having to compromise on taste (as the "sweet" music creates a perception of sweetness that might otherwise be missing). While this particular intervention smacks more of a marketing-led story than a genuine attempt by those concerned to nudge the populace towards better health, the idea is still definitely one worth exploring. It is striking how little thought is often given to the provision of healthy food options elsewhere within the hospital, particularly when one considers the foods available from vending machines and outlets which, typically, tend to be of very low nutritional content [171].

One could potentially also use music to enhance the perceived authenticity of food amongst patients [187-189]. In fact, the results of several studies have shown that the perceived authenticity of a dish can be enhanced simply by matching the music to the region where foods are thought to come from in order to [190]. Similarly, playing classical music has been shown to enhance perceived quality of food and drink [188]. To the extent that the food in the hospital is perceived as better, either because it is rated as more authentic, or because it appears to be of higher quality, this may improve health outcomes by enhancing the likelihood of the patients receiving somewhat better nutrition. There could also be an important role for music and food in triggering nostalgia, especially for those older patients who may be suffering from memory loss [191]. Consider the French palliative care hospital where proper meals are served by staff dressed as waitresses rather than as nurses [192], or the effect of nostalgia triggered by sound on flavor perception/meal experience [193]. One might, for example, think of playing the

music of Vera Lynn for those octogenarians wasting away in the UK healthcare system. As yet, though, we have not seen anyone taking a systematic approach to applying this research in the hospital setting. The key point remains that in order to deliver meaningful food provision in the care sector, one needs to go beyond the current focus on the food itself, and think about the total experience – sonic elements play a key role here.

The multisensory perspective

Music and soundscapes (i.e., a sound or combination of sounds that are part of an immersive auditory environment) undoubtedly have an important role to play for both patients and the staff who look after/treat them. However, it is important to remember that the auditory environment (or atmosphere) constitutes but one element of the total multisensory experience [194-195]. Consider the research on the impact of olfactory cues both in helping to mask unpleasant, and/or stress-inducing odors, while at the same time potentially aiding relaxation [196-201]. What is more, the tactile elements of design, including the feel of materials and surfaces [202] as well as the interpersonal tactile elements of interaction in the hospital setting [203], are coming to be recognized as increasingly important, especially given the growing awareness of the so-called "touch hunger" facing so many in society today [204]. "Touch hunger" can be defined operationally as the need for tactile stimulation that most people have, and which is evidenced by the typically positive health outcomes associated with increased tactile stimulation. Petting dogs and weighted blankets [37, 205] are both popular interventions in this space, not to mention the therapeutic use that massage therapy might play. The visual aspects too, can impact healthcare experiences and outcomes [206-207]. Everything from providing a view of nature through the patient's bedroom window [208] to the restorative effects of viewing art [209-212]. There has been some consideration of the role of lighting and use of color as well [213-214].

Given these considerations, an informed approach to music/soundscape provision in the various stages of the healthcare encounter must recognize that, no matter the situation, we never just listen to sound in isolation (i.e., as a unisensory experience). Rather, we must consider the auditory environment in the context of the total multisensory experience [195].

There are a number of uses of often relatively unstructured multisensory stimulation designed for its therapeutic value, as in psychiatric care [215-217]. Those working with the 'Snoezelen' concept try to develop multisensory environments that encourage both relaxation and sensory exploration (the term itself is derived from the Dutch verbs 'to explore' and 'to relax'). The Snoezelen company has been supplying multisensory environments for

various healthcare applications for a number of years now [218-219]. While such environments often involve visual and olfactory stimulation, the auditory component (often consisting of relatively unstructured sound, i.e., without any vocal or explicitly musical components) is also important. Indeed, according to one anthropologist, hearing becomes more pronounced in the hospital environment from the patient's perspective, precisely because the visual environment is typically dull/boring [220]. This kind of controlled multisensory stimulation (e.g., in the Snoezelen) has been shown to have beneficial effects in the control of chronic pain [221], as well as helping those with dementia [222-224] or severe brain damage [225].

Ultimately, though, a considered multisensory approach is likely going to deliver the biggest benefits for all of the interested parties. Indeed, if the impact of the various sensory manipulations are not coordinated, one may be in danger of delivering sensory incongruity [196, 226-227], or else perhaps even sensory overload [228]. Sensory incongruity is bad not only because it lacks processing fluency, but also because the end result might be confusion, with the various components actually counteracting one another [229]. Unpacking these terms, 'sensory incongruity' refers to when the senses do not match, while 'processing fluency' refers to the subjective ease of information processing. Incongruity is typically not processed fluently. Especially relevant here is research by Fenko and Loock [196] demonstrating that while music or ambient (i.e., environmental) scent (both chosen to be pleasant and minimally arousing) could be used to reduce stress in a plastic surgeon's waiting room in Germany (N = 117 patients), combining these two sensory interventions did not actually result in a significant reduction in patients' self-reported anxiety over the no sensory intervention baseline condition. However, it may be worthwhile to consider whether the study had sufficient power to detect an effect had there been one.

Beyond Fenko and Loock's study [196], the multisensory design of the waiting room environment is undoubtedly important, given that people may end-up spending a lot of time here, experiencing elevated levels of anxiety and/or stress [206, 230]. While the environment might well be designed to reduce stress/anxiety, another role for sensory design here could, of course, be used to help reduce the perceived duration of the wait too [231], though Fenko and Loock [196] found no influence of their environmental manipulations on this particular aspect of their participants' ratings.

Given that these various sensory interventions have been shown to interact it is important to consider noise/music as but one albeit important element of the sensory milieu [232]. Ultimately, as desirable as music may be in many different healthcare settings, it needs to be cost-effective, financially-speaking, in order to confirm its legitimacy. And, beyond the technical delivery of calming multisensory environments there is, of course, also the long tradition of the healing garden

in healthcare facilities in many countries, from The United States and Canada to Europe and the UK [233-235]. As yet, it is unclear what aspect of the salutogenic nature inputs are key here. The term 'salutogenic', coined by Aaron Antonovsky [236], refers to an approach to medical practice that focuses on those factors that support human health and well-being, rather than on the factors that are responsible for causing disease (pathogenesis). However, it is likely to be that the sound of nature is not unimportant, especially if, as has been shown repeatedly, the sight and sound of nature can be offset, say, by distracting traffic noise [237-239]. The key point here, then, being one of how the beneficial effects of nature's influence us – is seeing nature sufficient, or being in it, hearing nature, or perhaps feeling it [240-242].

Conclusions

As this review of the literature makes clear, there is more to the topic of music and medicine than meets the eye (or more literally, "the ear"). There is a growing body of robust empirical research demonstrating the therapeutic role that music can play in a variety of contexts and for a variety of players [243], though as we have seen, there are undoubtedly also tensions [244]. It would seem that damping noise, aiding distraction, and delivering a bit of nature sonically might be most beneficial [245]. Key questions in this area include who gets to choose what music is listened to (and by whom), what type of music will be played, and at what volume. Looking to the future, we can imagine how better outcomes might be achieved by the use of music or soundscapes that have been especially composed for the various stages of healthcare provision, rather than simply picking music that was composed for some other primary purpose (and hence presumably not ideally suited to the constraints of the healthcare situation). The beneficial effects in this case being backed-up by a number of Randomised Control Trials (RCTs; in many ways, the gold standard), along with multiple Cochrane Systematic reviews assessing the impact of music at various stages of the consumer's/patient's healthcare journey [246-248].

Music's ability to distract our attention can be good for the patient who is undergoing a painful medical procedure (e.g., wound dressing), while at the same time being bad for those who need to monitor safety critical machinery [249]. It is important to consider that multiple mechanisms may be in play simultaneously when trying to help explain the impact of music, soundscapes, and noise on the various players in the healthcare scenario. One important question for future research is the extent to which people need to attend to/be aware of the sensory cues, be they auditory or olfactory, in order for them to influence people's cognitive, affective, or physiological state [196].

Although the auditory aspects of the healthcare environment are undoubtedly important, it is imperative that we consider them within the broader context of the salutogenic properties of the built environment as a whole [32, 41, 250-255]. As we have seen time-and-again throughout this review, music's influence is likely moderated by not only the type of music (and possibly the volume at which it is played) but also by the hedonic response to the music of those who hear it.

The weight of the evidence summarized here makes it difficult to argue against the integration of sonic interventions into the regular practice and delivery of healthcare provision/services. The positive impact on patient health and wellness, not to mention on healthcare providers themselves, should be reason enough to explore a more intentional approach to the use of music and soundscapes in healthcare settings. Perhaps a further motivation can be found in taking a cue from retail and service marketing, where customer satisfaction and care can make all the difference between business success or failure [30]. Indeed, positive patient experiences have been associated with increased profitability, while a negative patient experience can lead to the opposite outcome [256]. The use of music and sound may be good not only for the health and wellbeing of patients and staff, but for the health and wellbeing of the healthcare business, too. Taking such a view may offer greater justification for management to devote more time and resources to "medicine's melodies." It's certainly worth a look – and a listen.

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