Review

The Potential Role of Soundscape and Music Interventions in post-Intensive Care Rehabilitation: A Narrative Review

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ABSTRACT

Post Intensive Care Unit (ICU) survivors face physical, psychological, and cognitive impairments during their recovery phase, adversely affecting their quality of life. Given the worldwide scarcity and barriers to access to post-ICU care, patient-centered adjuncts are worth exploring. Although music interventions have gained recognition as non-pharmacological approaches in the acute phase of critical illness, exploration of their potential benefits in the post-ICU is scarce. This paper examines the potential of soundscape and music interventions to improve the well-being of adult patients' post-ICU through a narrative overview of research evidence regarding post-ICU recovery and other relevant post-acute conditions, such as post-traumatic stress disorder and anxiety. The effectiveness of sound/ music interventions on several key outcomes, including reduced anxiety, stress, pain, and PTSD, improved sleep, and enhanced mood and emotional well-being, have been explored. Research indicates that music-based approaches to physical and psychological well-being reduce emotional distress, foster connectedness, and improve overall well-being. The potential benefits of soundscape and music interventions, both in terms of physiological and psychological well-being, encourage further investigation into their potential application and implementation into post-ICU care and rehabilitation.

Keywords: Music, post-ICU, recovery, rehabilitation, soundscape, survivors

INTRODUCTION

Post-intensive care unit (ICU) recovery and rehabilitation are challenging clinical issues as patients may experience persistent pain and physical, psychological, and cognitive impairments. These may

be either worsened or new impairments, adversely affecting an individual's quality of life, and may persist for months or years post-ICU discharge (Brown et al., 2019). The numbers and complexity of the condition of former ICU patients are increasing, along with global increases in ICU admissions, ranging from 1 to 54% per hospital stay (Abate et al., 2021; Sjording et al., 2016). In Canada, more than 1 in 5 (21%) hospital stays are intensive care unit admissions. Among these patients, 60% receive mechanical ventilation (CIHI, 2022), accounting for more complex needs post-ICU.

Promoting physical and psychological well-being for former ICU patients is resource-and cost-intensive, as it requires the availability of large multidisciplinary teams of physicians, nurses, physical and occupational therapists, nutritionists, psychologists, and psychiatrists (Liang et al., 2020). Worldwide, access to post-ICU care is very limited, either due to the unavailability of programs or patient-load and care coordination barriers (Rousseau et al., 2021). Evidence on the effectiveness of post-ICU clinics is scarce (Schofield-Robinson et al., 2018), which further hinders the implementation of post-ICU programs. As former ICU patients' needs remain unmet, there is an urgency to explore easily implemented, low-cost, and approachable solutions.

Clinical practice guidelines recommend exploration of complementary and non-pharmacological measures, such as music interventions, to manage symptoms and to promote recovery in the ICU and post-ICU (Ames et al., 2017; Barr et al., 2013). Evidence from populations with mental health challenges and functional deficits shows that music interventions can improve psychological well-being and rehabilitation (Golden et al., 2021). However, the exploration of music and soundscape interventions to promote psycho-physical well-being in ICU survivors is very limited. These interventions could provide a low-cost, non-pharmacological, and easy-to-implement adjunct to improve post-ICU impairments.

Soundscapes are acoustic environments experienced by an individual or group of people in the environment (ISO, 2014). A soundscape is a sound or combination of sounds that may consist of natural sounds, human sounds, life sounds, earth sounds or some combination. Evidence indicates that positively perceived sounds, for example, natural sounds, are tied with a high quality of life and enhanced physical and psychological health (Aletta et al., 2018). Music, on the other hand, is both an art and science of arranging sounds through melody,

harmony, tone, rhythm, and timbre. It combines vocal or instrumental arrangements (Merriam-Webster's Collegiate Dictionary, 1994). Music not only evokes emotions or feelings, but it is a medium of nonverbal communication (Bruscia, 1998).

In this paper, we examine the potential of soundscape/ music interventions as an adjunct therapeutic modality to improve the well-being of adult post-ICU patients, through a narrative overview of published evidence regarding post-ICU recovery and other relevant post-acute conditions, such as post-traumatic disorder and anxiety. To highlight patients' needs that could be addressed through soundscape/ music approaches, we summarize evidence on post-ICU impairments in ICU survivors, as well as the current ICU care. We then provide an overview of applications of music/sound interventions in post-acute conditions, and we discuss evidence on the attributes of music/sound interventions.

METHODS

We conducted a narrative review in the last quarter of 2023. We used systematic literature searches in Medline, PubMed, EBSCO, Scopus, targeting original research papers published in English. We used keyword searches including combinations of the terms: (critical care, intensive care OR ICU, CCU), AND (post-ICU OR post-ICU OR post-intensive care unit, PICS OR post-intensive care syndrome, OR ICU survivor OR intensive care survivor), AND (rehab or recovery or long-term care, follow up), AND (music or sound). Articles published between 1990 and 2023 were included for further analysis. The questions guiding the review were: a) what are the healthcare needs of ICU survivors, and (b) what are the potential effects of soundscape and music interventions in improving the well-being of ICU survivors?

Health Care Needs After ICU Discharge

Post ICU Syndrome (PICS)

The transition from ICU to home is a complex process. Post-ICU impairments may persist for months or years. The combination of impairments and sequelae experienced by ICU survivors is termed 'Post ICU syndrome' (PICS). Post-ICU syndrome encompasses a combination of physical, neurological, social, and psychological decline (Jaffri & Jaffri, 2020), and is viewed as an 'umbrella term' (Rousseau et al., 2021). Physical complications post ICU include bone loss, joint stiffness, increased risk of fractures, swallowing disorders, endocrine and metabolic disorders, sleep

disorders, fatigue, persistent pain (nociceptive or neuropathic), nerve injuries, and alteration in cortisol and pituitary hormone levels (Rousseau et al., 2021), experienced by nearly one-third of the patients (Huang et al., 2021). Intensive care unit-acquired weakness and muscle weakness are the most common physical impairments observed in ICU survivors (Morgan, 2021). Physiological and somatic symptoms following critical illness are very common, but often under-recognized. ICU survivors are likely to suffer from chronic pain and sleep disorders. Managing pain in ICU patients is complex and challenging. Persistent and reoccurring pain for 3 months is common among post-ICU patients. Despite analgesia, the incidence of chronic pain after ICU discharge is high, ranging from 33-73% (Stamenkovic et al., 2019). Most ICU patients are treated with opioids for acute and chronic pain, however, its use for symptom control may not always represent an ideal approach. These opioids can be associated with long-term consequences which can lead to opioid dependence, tolerance, addiction, and various psycho-physiological effects (Stamenkovic et al., 2019). Sleep disturbances are also significant after ICU discharge. Reduced and fragmented sleep predispose patients to adverse outcomes (Altman et al., 2018). The prevalence of self-reported sleep disturbance in post-ICU survivors can 50–66.7% in the first month, and as high as 61% more than 6 months after ICU discharge (Altman et al., 2017; Schwitzer et al., 2023). Sleep abnormalities increase the risk of cardiovascular disease, depression, cognitive impairment, seizures, and overall mortality (Altman et al., 2017).

Cognitive impairment is also a serious and common deficit in ICU survivors. It may be even more severe if ICU patients have a prior cognitive impairment. More than 70% of critically ill patients experience cognitive impairment at 12 months post-ICU discharge (Rivosecchi et al., 2016). Clinical manifestations include decreased attention and concentration, a decline in memory, and decreased mental processing and comprehension. These prohibit patients from engaging in daily living activities and returning to their premorbid functional status (Schwitzer et al., 2023). ICU survivors are also at risk for suicide and self-harm (Schwitzer et al., 2023). Problems with mental health can lead to disability and reduced health-related quality of life for both patients and their families (Schwitzer et al., 2023).

High stress, anxiety, sleep deprivation, depression, and post-traumatic stress disorder (PTSD) symptoms are very common in post-ICU patients and may compromise recovery and survival (Schwitzer et al., 2023), as described below. PICS also contributes to social impairment in

post-ICU patients, especially in relation to decreased social interaction due to prolonged functional disability. It increases the burden of financial costs due to unemployment after ICU discharge. This may lead to low or no income, loss of savings, loss of health coverage, and increased medical bills (Schwitzer et al., 2023).

Post ICU Syndrome- Family (PICS-F)

PICS not only impacts patients' overall health and well-being but can affect their family members and loved ones. Family members or caregivers of critically ill patients, particularly spouses, may suffer from emotional and psychological distress associated with the critical illness of their loved one (Fumis et al., 2015; Serrano et al., 2019). Between 25% and 50% of ICU survivors require long-term family caregiving support (Schwitzer et al., 2023). Post-intensive care syndrome– family (PICS-F) describes the post-ICU syndrome in family members, who face significant challenges and experience psychological distress in response to their loved one's illness (Serrano et al., 2019). They experience anxiety, depression, somatic symptoms, acute stress disorder, PTSD, complicated grief, and worsening symptoms following the death or discharge from the ICU of their loved ones (Rawal et al., 2017). In a single-center, prospective, longitudinal descriptive study conducted, Petrinec and Martin (2018) reported that 60% of family members experience these psychological symptoms during the first 6 months following their relative's hospitalization in the ICU. They may also experience a decrease in the quality of life that may persist for 2 years or more (Beesley et al., 2018). In a mixed-methods study, PICS-F was observed in 48% of family members, approximately 90 days after ICU stay, with 13% reporting depression, 29% anxiety, and 39% PTSD (Inoue et al 2022).

Family members do not only suffer from psycho-physiological problems, but they also experience socio-economic burdens. The first years of ICU discharge are usually costly for ICU survivors and their families (Brown et al., 2019). They carry the burden of emotional distress, financial pressures, loss of employment, work overload, disruption of family dynamics, and re-engagement with everyday life (Ågård et al., 2019; Rawal et al., 2017). Of families of former ICU patients, 48.5% experience financial burden 3 months after ICU discharge (Khandelwal et al., 2018). The consequences of PICS can have financial implications on patients and their families, and on society as a whole, in terms of increased healthcare utilization (Rousseau et al., 2021).

Mental Health in the Aftermath of Critical Illness

Treatments and care experiences in the Intensive Care Unit (ICU) are often traumatic and stressful and can have a long-term psychological impact (Rawal et al., 2017). PTSD symptoms such as anxiety, depression, sleep disturbances, neurocognitive impairments, and intrusive memories are common concerns in ICU survivors (Brown et al., 2019; Davydow et al., 2013). These symptoms have profound and long-lasting effects on individuals' functional outcomes and quality of life. Prevalence estimates of PTSD among ICU survivors have ranged widely from 4 to 62% (Parker et al., 2015; Righy et al., 2019). Annually, approximately 1 million former ICU patients develop PTSD (Righy et al., 2019). An estimated one-fifth of ICU patients fulfill the diagnostic criteria for PTSD, while larger numbers experience some PTSD symptoms (Parker et al., 2015). Moreover, one-third suffer from depression, stress, and anxiety symptoms during the first year of recovery (Bienvenu et al., 2018; Kim et al., 2023). Anxiety affects approximately 70% to 80% of all ICU patients, especially those receiving mechanical ventilation (Chahraoui et al., 2015; Golino et al., 2019).

No specific management recommendation exists to date for these conditions (Gayat et al., 2018). Although sedatives and analgesic medications (Chlan et al., 2013) can help in reducing stress, anxiety, and symptoms of PTSD, these drugs have serious adverse effects including bradycardia, hypotension, dysmotility, immobility, neuromuscular weakness, delirium, agitation, and respiratory depression (Lee et al., 2017; Witusik & Pietras, 2019). Evidence indicates that early intervention and rehabilitation incorporating non-pharmacological approaches and early follow-up are fundamental to prevent psychological distress and to improve functional outcomes among ICU survivors (Karnatovskaia et al., 2019).

Frailty and post-ICU Outcomes

Frailty is an additional factor in poor outcomes and is very common in ICU survivors, particularly older adults. Frailty is a state of increased vulnerability resulting from physical, psychological, cognitive, and functional decline that leads to mortality (Geense et al., 2019). Recent evidence shows that people living with frailty are distinctly vulnerable, independently of age (De Biasio et al., 2020). Frailty compromises the ability of ICU survivors to cope with everyday stressors. It is associated with weight loss, undernutrition, muscle wasting, and weakness. Overall, 30 to 40% of older individuals requiring hospitalization and treatment in the ICU are frail at 3- and 12 months post-discharge (Muscedere et al.,

2022). They are more functionally dependent and have more disabilities which lower their quality of life and worsen their psychosocial and physical recovery (Geense et al., 2019). Frailty significantly impacts healthcare utilization, due to unplanned readmissions, and increased ICU length of stay (Muscedere et al., 2017).

Post-ICU Care

Standards and Gaps of post-ICU Care

The early post-discharge period is the most crucial phase for the prevention and management of PICS, but it remains the least explored in the recovery from critical illness. The most likely reason for this is the delivery of fragmented, disintegrated, and inadequate care post discharge which may lead to poor outcomes (Brown et al., 2019). Patients, families, and clinicians are often not well informed about survivorship issues post-ICU discharge, which may result in unmet needs after ICU. ICU survivors' unmet needs can range from durable medical equipment to medication management, rehabilitation, and follow-ups (Brown et al., 2019; Haines et al., 2021). Other challenges may adverse events, psychosocial issues, financial constraints, lack of access to continuing of care, and loss of rehabilitative gains. (Haines et al., 2021).

A comprehensive rehabilitation plan and post-ICU follow-up clinics are the key factors in ensuring an optimal continuum of care for survivors of critical illness (Haines et al., 2021). In the United Kingdom (UK) national guidelines recommend long term care and follow ups, but many jurisdictions have not yet implemented them, partially due to gaps in our understanding of PICS and approaches to management (Colbenson et al., 2019). In Canada, a lack of formal post-ICU care has been noted, with only six post-ICU clinics across the country. Lack of healthcare personnel, time, access to specialized care, increased ICU readmission, and loss of follow-up are the barriers reported to establishing more post-ICU follow-up clinics (Stapleton et al., 2020).

Non-pharmacological Approaches for ICU Survivors

Pharmacologic approaches are the usual mode of treatment for managing physical and psychological conditions post ICU, but can potentially cause harmful effects such as insomnia, drug dependency, high-stress levels, anxiety, agitation, and delirium (Oh et al., 2015). Multiple pharmacological interventions have failed to demonstrate improvements in the quality of life of ICU survivors (Chlan & Tracy, 1999). However, non-pharmacological interventions for reducing physiological and psychological distress among post-ICU survivors suggest promising

directions (Tingey et al., 2020). A number of studies have investigated non-pharmacological interventions in heterogeneous groups of critical care survivors in reducing psychological distress and improving functional outcomes in ICU patients (Brown et al., 2019). These interventions are classified into four domains: physical, psychological, social, cognitive, and care coordination. Examples include physical therapy and early mobilization, nutritional treatment, cognitive restructuring, cognitive behavioral therapy, keeping ICU debrief diaries, establishing social and family support systems, self-management, home-based exercises, mind, and body relaxation, guided imaginary, bright light exposure, noise reduction, interventions for simulated family presence using pre-recorded audio/video messages, music listening, rehabilitation and follow up clinics (Brown et al, 2019; Lee et al., 2021).

Most non-pharmacological interventions require professional support and are also associated with increased costs. Three complementary interventions are frequently used in critically ill patients such as music, aromatherapy, and guided imagery (Meghani et al., 2017). These interventions do not necessarily require professional support, although they can be initiated by healthcare professionals.

Potential Role of Soundscape/ Music Interventions in post-ICU Care

Historical Overview: Therapeutic Use of Soundscape/Music

Music and sound were used for healing in ancient Greece before and after the Hippocratic era, and in traditional Chinese medicine, as well as in other cultures (Meymandi, 2009). Hippocrates proposed mental care and art therapy interventions, in which music and drama were used in treating illness (Kleisiaris et al., 2014). Greek physicians used flute, lyres, and zitters to heal their patients. Vibration was used to aid in digestion, treat mental disturbances, and induce sleep (Meymandi, 2009).

The history and evidence of usage of music in China goes back thousands of years (Wu, 2019). A very ancient Five-Element Music Therapy (FEMT) approach has a history of more than 2000 years in China. FEMT originated from the Yellow Emperor's (Huangdi Neijing) Classic of Internal Medicine (Liao et al., 2023). FEMT is a part of traditional Chinese music and has five tunes connected to the five organs of a human being: Jue (liver), Zhi (heart), Gong (spleen), Shang (lung), and Yu (kidney) (Liao et al., 2023). In ancient India, music as a therapy especially having Sanskrit text was used for the treatment of physiological and psychological distress (Gangopadhyay & Prasad, 2022). The textual references in *Bṛhattrayī* and *vihāra* have much in common with the active and receptive method of

modern music therapy in daily life (Gangopadhyay & Prasad, 2022). Table 1 contains a brief overview of the historical sources and therapeutic uses of music in antiquity.

Investigators began to systematically study the use of music in medicine and healing near the end of the 19th century (Meymandi, 2009). In the early 1800s, Florence Nightingale described the importance of music and its healing effect on patients (Bulechek & McCloskey, 1985). In the last 20 years, investigation into the therapeutic effects of music has proliferated (Li et al., 2021). Several contemporary systematic reviews and meta-analyses support the benefits of music in various populations including mental health, critical care, cancer, and cardiac care (Cao and Zhang, 2023; Li et al., 2020; Li et al., 2022; Rodwin et al., 2023).

Table 1:

Historical Sources & Therapeutic Applications of Music in Antiquity (circa 2500 BCE- 525 CE)*

Era	**Historical Sources & Therapeutic Applications of Music**
ca. 2500 BCE	**China:** The Ancient Five-Element Mus Therapy (FEMT) approach, originate from The Yellow Emperor's Class Internal Medicine. FMET has five tune connected to the five organs of a huma being: Jue (liver), Zhi (heart), Gon (spleen), Shang (lung), and Yu (kidney).
ca. 1550 BCE	**Egypt:** In Ebers Papyrus, Egyptia medical priests-physicians considered th music "physic for the soul". In th Babylonian civilizations, music was use to appease the wrath of the gods.
ca. 800 BCE	**India:** Music therapy having Sanskrit text, is used for the treatment of physiological and psychological distress. The textual references in *Bṛhattrayī* and *vihāra* have active and receptive methods of modern music therapy in daily life.

ca. 500 BCE	**Greece:** Asclepius healing temples use music. The god Apollo, father of Asclepius, was considered the protector of both medicine and music. In Greek philosophy, the effects of music on the psyche considered music a medicine for both the soul and the body, with relaxing or invigorating effects.
ca. 400 BCE	**Plato:** Treated the music in two of his dialogues, Republic and Laws. He claimed that the whole life of humanity is dominated by harmony and rhythm.
ca. 4th Century BCE	**Aristotle:** Musical arts improve morals and have a liberating, purifying, and cathartic power. The function of music is to evoke emotional catharsis.
ca. 480–524 CE	**De Institutione Musica, written by Boethius:** Reworked the Pythagorean elements and subdivided the music into three hierarchical levels: mundana (derived from Pythagoras, considers music a mathematical concept of harmony in proportions and numbers), humana (music as an effect of harmony of the human body and spiritual harmony), and instrumentalis (audible music and is executed by instrumentalists and singers)

*Gangopadhyay & Prasad, 2022; Liao et al., 2023; Montinari et al., 2018

Modes of Delivery of Soundscape/Music Interventions

Soundscape and music interventions are usually offered by a music therapist, by other healthcare professionals, and/or without any professional support. These interventions are delivered through different approaches, such as listening to pre-recorded sounds or music administered by a researcher or healthcare professional, self-administered by patients without the involvement of a music therapist, and/or live music sessions (American Music Therapy Association, 2019). Music intervention

as a part of music therapy is conducted by trained music therapists and involves a therapeutic process and the use of personal music experiences (De Witte et al., 2020). Music interventions can be delivered remotely, which may be beneficial in improving access to this mode of therapy (Harney et al., 2022). There are several evidence-based music therapy techniques that are used in different patient populations including passive music listening, active music participation, music and counseling, music and development or educational objectives, music and stimulation, music and biofeedback, music and group activity (Schneider et al., 2022). These techniques involve activities such as singing, songwriting, therapeutic instrument play, guided relaxation, music and imagery, drumming, dancing, rhythmical training, and memory recall (Schneider et al., 2022; Yinger, 2018).

The duration of interventions (time period of treatment), length of sessions ("dosage" of music), and frequency (times repeated) vary across studies. "Dosage" can vary from 15 minutes to more than one hour, the frequency from a few times a day to a few times per month, and the duration from single session to repeated sessions over months. Overall, regardless of the variance in the intensity of the intervention, studies tend to report positive results. For example, a systematic review of RCT involving older adults reported that active music therapy >60mins/week without the presence of a music therapist helps in reducing depression (Dhippayom et al., 2022). Another review conducted by Zang et al. (2022) includes RCT studies reporting reduced anxiety levels in cancer patients after listening to 15 to 60 minutes of recorded music. Concerning the dosage of music listening, for single-session interventions, both <30 mins and >30 mins produced similar effect sizes (Umbrello et al., 2019; Harney et al., 2022). Sessions of 20-30 mins are most common across studies (Chen et al., 2021; Harney et al., 2022). In critically ill patients, an intervention duration of >45 mins to <60 mins improved psycho-physiological outcome and sleep quality (Chen et al., 2023). A review of RCT studies including critically ill patients with a single session of 30 mins, reported a significant reduction in anxiety and stress, as well as changes in physiological parameters such as reduction in pain level, heart rate, respiratory rate, and blood pressure (Umbrello et al., 2019). A study conducted by Chlan et al. (2013) reports the results of multicenter RCT among ICU patients receiving mechanical ventilation using patient-preferred music type. By the fifth day of the study, anxiety was reduced by 36%, and sedative exposure during mechanical ventilation in patients directed music group. Overall, studies

across diverse acute and sub-acute patient populations report positive results irrespective of the specifics of the music intervention, as reported in recent umbrella reviews (Chen et al., 2021; Lipe & Edmonston, 2019; Martin-Saavedra et al., 2018).

Attributes of Music and Genre

Specific attributes of music may have an impact on the stress-reducing and other effects of music interventions. Sonic qualities (rhythm, tempo, melody, pitch, harmony, frequency, volume, duration, genre) are important for relaxation (Chang et al., 2012; Chi, & Young, 2011; Batista, 2022). These are essential therapeutic attributes of music intervention which are interdependent and non-hierarchical (Murrock, 2016). They help to stimulate neurophysiological responses that influence mood and emotions, and physiological responses (Clark & Tamplin, 2016). These attributes seem to mediate the regulation of vital signs, emotional response, and neural activity. Especially music tempo and rhythm capture an individual's attention. They influence the rhythmicity of the internal organs through the synchronization of physical movements, heart and respiratory rate, and neural activity (Clark & Tamplin, 2016; Batista, 2022; Hilz et al., 2014). A slow music tempo of 60-80 bpm results in reducing heart rate and promoting relaxation (Hilz et al, 2014). Melody, the combination of pitch and rhythm, is characterized by its length and intensity that expresses a mood or emotion from one extreme response (happy, calm) to another (sad, anxious). Pitch is a perceptual sound property related to vibrations per second. If the sound has a faster vibration, it causes high-pitched tones which may be associated with happy reactions. Low-pitched sound is due to slower vibrations that may be associated with sadness or depression (Murrock, 2016). Harmony enhances the beauty of the melody. It blends with the pitches to form a combination of sounds producing musical chords. Frequency is the number of beats per second at which the wave vibrates. A human ear can listen to sound with a frequency of 20 to 20,000 Hz. The 40 Hz is the basic frequency in the thalamus which can be captured by a human ear and can trigger cognitive effects on music therapy (Joseph & Ulrich, 2007). A volume of 40 to 60 dB through a headset is generally comfortable for music listeners to produce a therapeutic effect (Laksmidewi & Dewi, 2021).

Music genres can have a significant impact on an individual's mental health in many ways. They are related to the content of music and the structure of their rhythm and instrumentation. Studies have reported the usage of different genres such as classical, jazz, country, pop, rock,

blues, metal, instrumental, nature sound composition, meditative, and so on. Some genres can make people more relaxed, and some make people more energized (Markos, 2022). A meta-analysis conducted by Leubner and Hinterberger (2017) reported three genres that researchers used frequently for their music intervention groups to reduce the symptoms of depression: classical, percussion, and jazz. Classical and jazz music usually relieves stress, promotes relaxation, increases brain function, improves physical well-being, and lowers cortisol levels (Markos, 2022). Malakoutikhah et al. (2020) showed that most studies only used a single genre of music, and their focus was only on the music intervention rather than exploring the effects of different genres. Classical, Turkish, nature sounds and Western music all seem to reduce anxiety and promote relaxation in healthy individuals and patients (Malakoutikhah et al., 2020).

Understanding individual sound and music preferences is also important to gain insight into a person's cultural background and societal context. Knowing what genre and attributes of soundscape and music resonate with an individual can reflect their personality, values, unconscious motives, and desires (Rentfrow et al., 2011). Evidence suggests that various psychological and social factors exist underlying preferences for music (Rentfrow et al., 2011). The selection of soundscape and music depends on the individual's personal traits, emotional state, social and psychological processes, and situational goals (Rentfrow et al., 2011). Individual differences in preferences also vary with different age groups. One may prefer a particular type of soundscape or music in a particular context but may not want to hear it in another context. Understanding these differences in music preferences can help therapists, caregivers, and healthcare providers use sound/music as a therapeutic tool more effectively in patients.

Evidence from Soundscape/ Music Interventions in ICU Patients

Extrapolating the benefits of interventions from the acute ICU phase to post-ICU care has many limitations; however, it is reasonable to anticipate that individuals who benefited from soundscape/music during the acute phase of their illness may continue to do so during their recovery. In ICU patients, listening to tranquilizing sounds and music has been reported to improve psychological outcomes, such as decreased stress, anxiety, PTSD, delirium, agitation, increased relaxation, and diverted attention from unpleasant thoughts to positive perceptual experience (Chlan et al., 2013; de Witte, 2020; Landis-Shack et al., 2017). A literature review indicated that relaxing music such as nature-based sounds, classical, and easy listening

can help manage pain, agitation, delirium, stress, anxiety, PTSD, and depression in ICU patients (Hetland et al., 2015). It reduces the need for sedatives during mechanical ventilation, length of stay, and decreases physiologic signs of anxiety and biomarkers of the stress response (Hetland et al., 2015). Patients involved in sound and music interventions identified many positive changes and experiences such as positive mood, improved well-being, increased family and social communication, and increased hope and inner strength (Burns, 2012). A randomized controlled trial conducted by Gullick and Kwan (2015) examined that patient-directed music intervention lowers anxiety scores, sedation frequency and intensity in mechanically ventilated patients than usual care. A study by Chlan et al. (2018) demonstrated that patient-directed music interventions can save about $2,000/patient and better manage stress and anxiety with less sedative medication than usual care. A study conducted by Khan et al., (2018) reported an association between music and sound intervention and decreased serum cortisol levels, positive effects on state anxiety, reduction in respiratory rate, blood pressure, and heart rate, and decrease in sedative and analgesic requirement in mechanically ventilated patients.

The available analyses show that the use of sound/music interventions reduces anxiety, stabilizes physiological parameters, and improves well-being. However, there is still not enough knowledge about the physiological mechanisms at play and potential outcome-measuring tools that reflect the effects of music intervention on the well-being of ICU patients.

Evidence on the effects of Soundscape/ Music Interventions on Mental Health

Group music therapy and therapist-guided music interventions were reported to result in a significant reduction in PTSD symptoms and depression that did not respond to cognitive behavioral therapy (Beck et al., 2021; Carr et al., 2012). A systematic review conducted by Baker et al (2018) reported the potential of relaxing music therapy help to cope and to recover from PTSD. A systematic review involving 104 RCTs in adult populations, showed an overall significant effect on physiological stress-related arousal (blood pressure, heart rate, hormone levels) and psychological stress-related experiences (state anxiety, restlessness, or nervousness). The tranquilizing effects of music are very significant for the prevention and treatment of stress-related problems, considering their low cost and lack of side effects of music interventions (De Witte et al., 2020).

Evidence suggest that sound/music appears to have positive effects on measures of mental health and stress. However, there is wide variation in individual preferences, the characteristics of the music interventions, and the method of implementing the intervention.

Evidence on the Effects of Soundscape/ Music Interventions on Cognitive Outcomes

Cognitive functions are associated with the activities of daily living and the quality of life of critically ill patients. Post-ICU survivors suffer from neurocognitive sequelae which are often under-recognized and require a cognitive rehabilitation pathway (Muradov et al., 2021). Sound and music-based interventions in rehabilitation have been gaining research and clinical attention in improving cognitive function in chronic illnesses that often require long-term rehabilitation. However, evidence regarding the effect of sound and music interventions on general cognitive function in this population is scarce. We identified only one trial incorporating music in cognitive rehabilitation post-ICU. Zhao et al. (2017) conducted a trial with 167 medical and neurological ICU survivors who received cognitive training through learning to play a musical keyboard, along with learning and memorization tasks performed post-ICU and over 3 months (4 days/ week; two 30-minute sessions/ day). The authors found significant improvement in cognitive function, memory, attention, and language. Despite the scarcity of music intervention for cognitive recovery post-ICU, a large body of evidence supports the effectiveness of such interventions in individuals with cognitive disorders. A meta-analysis conducted by Ito et al. (2022) on people with mild cognitive impairment and dementia identified that music intervention improves attention, executive function, and episodic memory. Furthermore, the type of music such as active intervention (playing musical instruments, singing, listening to a favorite song, moving with music) promotes socialization, engagement, verbal processing, and motor planning (Ito et al., 2022). Another systematic review of RCTs involving dementia patients reported that rhythmical and enjoyable music interventions combined with movement (using props, such as a balloon, ribbon, balls, rhythmical tapping of the feet, and mirroring movement) and physical exercise improves cognitive function (Sharew, 2022). Similarly, music interventions, including instrument-based, listening-based, rhythm-based, and multicomponent-based music interventions, have improved cognitive functions, fine and gross motor dexterity, and gait in stroke survivors, Parkinson's disease, and multiple sclerosis patients (Moumdjian et al., 2017).

Despite overall robust controlled designs, the evidence in ICU and post-ICU patients is not sufficient and more exploration is needed. Moreover, investigators need to consider the combination of sound/music with movement for the improvement of both psychological and functional outcomes.

Rehabilitating ICU Survivors with Soundscape and Music Intervention

There are very few studies addressing post-ICU rehabilitation, with only two studies involving adult former ICU patients. Overall, the studies show the feasibility and acceptability of these approaches and the beneficial effects of music, mostly on psychological responses. A pilot study conducted by Liang et al. (2020) on ICU survivors demonstrated that music-guided exercise is feasible and highly desirable by ICU survivors and participants also noted improvement in their ability to move and mood. These patients were given an individualized playlist, considering of patient's music preference and their pace, and taught to coordinate exercise to music for 15 to 20 minutes. A randomized controlled trial by Hwang and Lim (2021) identified a significant decrease in the PTSD scores of post-discharged Korean burn patients after evaluating the effect of the Special Program for Acute Burn Patients (SPA) which included a 60-minute music intervention component. Few studies recommend sound and music interventions in combination with comfort measures in the recovery of post-ICU patients in the pediatric and neonatal populations. These studies reported that music intervention promoted psychological well-being, improved sleep, had a calming effect among critically ill children, and reduced parents' anxiety post-discharge (Bieleninik et al., 2020; Ghetti et al., 2021; Rennick et al., 2018).

Despite the perceived benefits of soundscape/music, there are very few studies validating its use in ICU survivors. These interventions can be opioid-sparing, low-cost, less invasive, safe, and easy to implement. Moreover, due to the less complex nature of these interventions, there is an opportunity to both engage family members and caregivers and also to expand such interventions to address the well-being of families of former ICU patients.

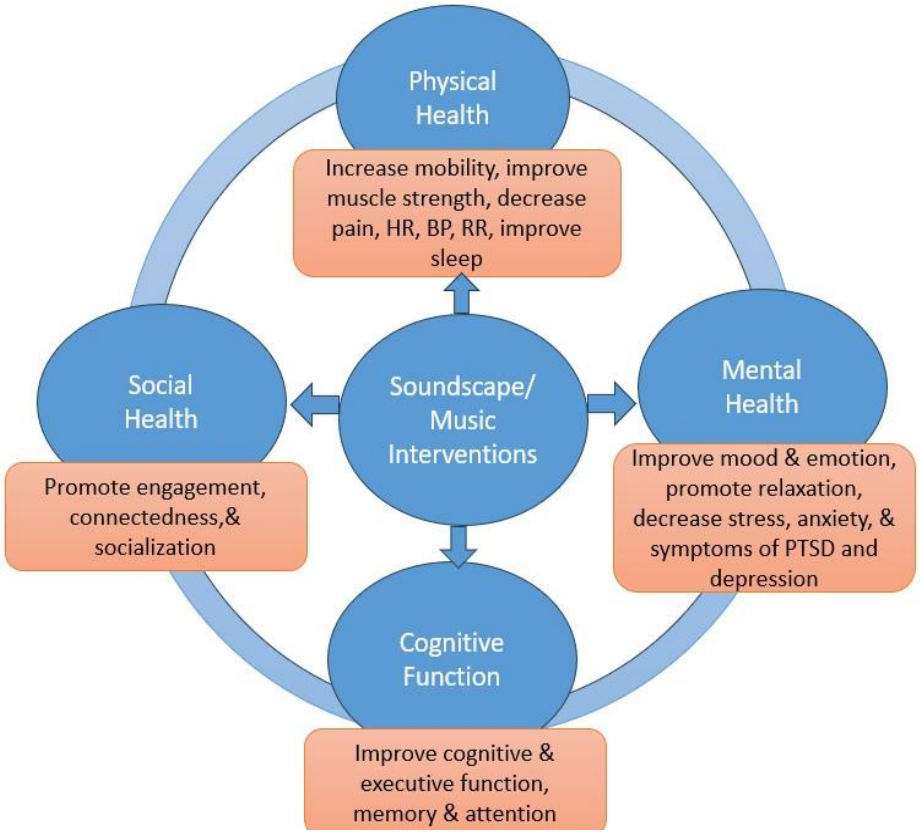
Limitations

The review shed light on the therapeutic effects of sound/music interventions in ICU survivors. In examining the effects of sound and music interventions on ICU survivors, it is crucial to acknowledge several limitations. Firstly, the heterogeneity of ICU populations and their medical conditions poses a challenge in standardizing intervention protocols and

assessing their outcomes uniformly. Additionally, the subjective nature of music preferences and individual responses to auditory stimuli may introduce variability in the perceived effectiveness of interventions. Furthermore, the long-term effects of sound and music interventions on physiological and psychological well-being and functional outcomes among ICU survivors warrant further investigation through rigorous longitudinal studies. In designing and conducting sound/music-based intervention studies, researchers must ensure that the intervention is meaningful to the patients and makes significant changes in their quality of life.

Figure 1

Evidence-based summary of potential effects of sound/ music interventions on the manifestations of post-ICU syndrome.



Legend: HR: Heart Rate, BP: Blood pressure, RR: Respiratory Rate, PTSD: Post-traumatic stress disorder

CONCLUSION

Soundscape/ music interventions are emerging therapeutic tools that are examined in diverse populations and in different clinical settings with positive outcomes established through systematic reviews, meta-analyses, and umbrella reviews. Exploration of such interventions in adult post-ICU patients is very scarce, although music has received more attention in the recovery of neonates after NICU hospitalization. Our overview of research evidence from studies involving post-ICU patients or other similar post-acute patient populations supports the notion that music/ soundscape interventions can improve several post-ICU impairments, commonly regraded as manifestations of post-ICU syndrome. These potential effects are summarized in Figure 1. Evidence from post-ICU patients to date supports that soundscape/ music approaches are cost-effective and safe and reduce anxiety, stress, pain, depression, and PTSD, relieve negative emotions, and improve recovery from illness post-ICU. However, whether such interventions can improve physical health and quality of life in post-ICU patients remains to be established. Further research involving adult ICU patients needs to establish the effectiveness of such interventions and to clarify the components and intensity of interventions, implementation approaches, and appropriate outcome measures.

Implications for Clinical Practice and Research

1. Our overview of research evidence from studies involving post-ICU patients and other similar post-acute patient populations supports the notion that music and sound interventions can improve several impairments commonly associated with post-ICU syndrome. These interventions have been shown to be cost-effective and safe, with evidence indicating that they can reduce anxiety, stress, pain, depression, and PTSD, alleviate negative emotions, and enhance recovery from illness.
2. Therapeutic sound and music listening should be integrated into nursing interventions as part of non-pharmacological treatment strategies. Clinical practice guidelines recommend exploring such complementary measures to manage symptoms and promote recovery in post-ICU patients, who often face persistent pain, physical, psychological, and cognitive impairments.
3. Despite the perceived benefits and preliminary evidence supporting the use of soundscape and music interventions, there remains a

significant gap in research. There are very few studies specifically validating their effectiveness in ICU survivors. Future research should focus on establishing the effectiveness of these interventions, as well as clarifying the optimal components, intensity, implementation approaches, and appropriate outcome measures. This will enhance the evidence base and guide their integration into clinical practice.

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