Music-Based Smart Digital Interventions for Health: *A Scoping Review*

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Abstract

This scoping review systematically maps and synthesizes empirical research on smart, digital technology-delivered music interventions for health. Following Joanna Briggs Institute (JBI) methodology and PRISMA-ScR reporting guidelines, a comprehensive search of six electronic databases yielded 30 included studies spanning four clinical domains: psychological and mental health, neurological and motor rehabilitation, aging and cognitive care, and acute care and symptom management. Studies employed four primary technology categories: mobile applications, artificial intelligence and machine learning systems, wearable biosensors, and alternative interface platforms. Findings demonstrate that smart digital music interventions are broadly feasible and acceptable, with preliminary efficacy across diverse populations. The field is adapting and expanding to include adaptive, closed-loop systems that modulate musical parameters in response to real-time physiological data, moving beyond traditional music interventions. Key gaps include standardized outcome frameworks, longitudinal data including adherence, and clinical validation of AI algorithms and machine learning systems.

Keywords: *Music-Based Intervention, Music in mHealth, Digital Therapeutics, Smart Applications, Scoping Review*

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Introduction

Background: The Therapeutic Role of Music in Health

Music therapy is a validated, therapist-delivered intervention used across diverse health domains, including emotional regulation, neurological rehabilitation, and pain management (Bruscia, 2014; Park et al., 2024; Yu et al., 2025). Music medicine (MM) refers to the clinical use of music-based interventions – typically involving pre-recorded music – administered by healthcare professionals (e.g., physicians or nurses). The primary aim of music medicine is to achieve specific physiological or psychological outcomes, such as reducing anxiety, lowering heart rate, or managing pain, often as an adjunct to conventional medical care (Dileo, 1999). Despite a large evidence base to support music therapy, traditional face-to-face delivery models are limited in their capacity to meet growing service demands. Global access is further constrained by a shortage of trained professionals and by transportation and scheduling barriers (Thompson et al., 2023; Zajac et al., 2023). In contrast, traditional music medicine typically involves pre-programmed playlists designed to manage symptoms, which lack the flexibility to adapt to individual needs or changing conditions (Bruscia, 2014; Bradt, Dileo, and Magill, 2016). In response, music-based digital applications have emerged as complementary tools that extend care and support continuity between clinical encounters (Bai, 2026).

Defining Digital Therapeutics and "Smart" Applications

Within this context, digital therapeutics (DTx) and mobile health (mHealth) technologies have emerged as widely accessible alternatives that extend care beyond traditional clinical settings. (Afra et al., 2018; Fleszar-Pavlovic et al., 2025; Wall et al., 2026). In this review, "smart" applications refer specifically to systems that incorporate adaptive, data-driven, or automated decision-making capabilities, often powered by artificial intelligence, biosensing, and real-time feedback mechanisms (Jiao, 2025; Salirrosas et al., 2026). Unlike static playlists, these systems monitor the user's real-time physiological or behavioral state and dynamically adjust musical parameters such as tempo, rhythm, or song selection, without continuous clinician input (Hutchinson et al., 2020; Ma et al., 2026). The rapid expansion of digital healthcare following COVID-19 has accelerated this shift toward remote, hybrid, and autonomous care models. Together, these developments broaden music-based care to include adaptive, data-driven models alongside therapist-delivered approaches.

Breadth of Populations and Clinical Applications

The clinical applications of smart music technologies for health span multiple domains. In the area of mental health and emotional regulation, smartphone applications and mobile neurofeedback systems target anxiety, depression, and trauma-related stress, supporting the development of emotion regulation skills in both youth and adults (Choi et al., 2024; Hides et al., 2019; Leschallier De Lisle et al., 2024). In neurological and motor rehabilitation, applications provide personalized rhythmic auditory stimulation for gait retraining in Parkinson's disease and support upper extremity motor recovery in stroke survivors (Chen and Norgaard, 2024; Wall et al., 2026; Yu et al., 2025). With respect to aging and cognitive care, digital therapeutics are used to mitigate neuropsychiatric symptoms such as agitation in dementia and to support caregivers in delivering music-based interventions in home settings (Russo et al., 2023; Thompson et al., 2023). Finally, in acute care and symptom management, smart applications are employed to manage acute pain in emergency departments, reduce preoperative anxiety, and alleviate symptoms during outpatient procedures (Chai et al., 2020; Park et al., 2024). Across these domains, a common feature is the use of adaptive systems that respond dynamically to user states, marking a shift from static "music medicine" delivery (Lee, 2016) to responsive, closed-loop music delivery systems.

Problem Statement and Knowledge Gap

Despite the rapid proliferation of these technologies, the current evidence base remains fragmented across disciplines, including music therapy, engineering, and digital health. Studies employ diverse technological frameworks – such as virtual reality, wearable sensors, and mobile applications – implement heterogeneous algorithms, and vary substantially in how health outcomes and intervention fidelity are defined and measured (Bai, 2026; Yu et al., 2025). This fragmentation hinders knowledge consolidation and clinical translation, limiting development of a unified framework for designing, implementing, and evaluating smart music-based interventions. Without this foundation, it is difficult to compare findings, identify effective intervention components, establish dose–response relationships, or determine which technological features best suit specific symptoms and populations (Park et al., 2024; Yu et al., 2025).

Study Aim and Objectives

Therefore, the primary aim of this scoping review is to systematically map and synthesize the existing body of empirical research on digital, mobile, and smart technology-delivered music interventions. Specific objectives include: (a) categorizing the types of smart technologies recently utilized, including artificial intelligence, wearable sensors, and autonomous mHealth systems; (b) identifying the range of clinical and non-clinical populations targeted; and (c) synthesizing reported health outcomes alongside system-level feasibility and usability metrics. This synthesis aims to provide a foundation for standardized frameworks and to inform future research, clinical practice, and digital health innovation in music-based interventions.

Methods

Methodological Framework

This scoping review was conducted following the Joanna Briggs Institute (JBI) methodological guidance for scoping reviews. The reporting of the review process and its results strictly adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al., 2018).

Identifying the Research Questions

The review questions are structured using the Population, Intervention, Comparison, and Outcome (PICO) format to map the available evidence. Population refers to human participants of any age experiencing clinical conditions or seeking health and wellness outcomes. Intervention refers to smart, digital technology-delivered music-based interventions, including those utilizing artificial intelligence, mobile applications, wearable sensors, and digital therapeutics. Comparison refers to standard care, waitlist control, or alternative intervention conditions against which the music-based interventions were evaluated. Outcome refers to the primary health and feasibility measures reported, encompassing psychological, physiological, functional, and usability outcomes. The primary questions guiding this review are: (a) What types of "smart" technologies – such as artificial intelligence, mobile applications, wearable sensors, and digital therapeutics – are utilized to deliver music-based interventions? and (b) What clinical and non-clinical populations are being targeted, and what are the primary health and feasibility outcomes measured?

Inclusion and Exclusion Criteria

Studies were included if they evaluated digital, mobile, or "smart" technologies delivering music-based interventions, encompassing smartphone and tablet applications, AI and machine learning systems, wearable sensors, and digital therapeutics. With respect to populations, included studies involved human participants of any age experiencing clinical conditions or seeking health and wellness outcomes, including individuals with stroke, Parkinson's disease, dementia, and patients undergoing surgical or medical procedures. Studies were required to report on measurable health outcomes – such as psychological improvements, physiological changes, or motor function – or on system feasibility and usability metrics, utilizing tools such as the System Usability Scale (SUS) or the user version of the Mobile Application Rating Scale (uMARS). Eligible study designs included primary empirical research such as randomized controlled trials, pilot and feasibility trials, mixed-methods evaluations, and qualitative co-design research.

Studies were excluded if they evaluated traditional, purely in-person music interventions that lacked a digital, mobile, or software component. Studies strictly focused on computer science, software architecture, or algorithm efficiency without evaluating human health outcomes, clinical usability, or user experience were also excluded, as were studies utilizing non-human animal models. In addition, studies involving virtual reality (VR) or augmented reality (AR) interventions that require head-mounted display devices were excluded due to potential clinical concerns related to user safety and tolerability (Lundin, Yeap, and Menkes, 2023; Palmisano, Allison, and Kim, 2020).

Information Sources and Search Strategy

A comprehensive systematic search was conducted across six electronic databases, four of which were accessed via the EBSCOhost platform: Academic Search Ultimate, APA PsycArticles, Applied Science & Technology Source, and MEDLINE Complete. In addition, Scopus and the ACM Digital Library were searched independently. The search strategy combined three key conceptual blocks using Boolean operators (AND/OR) and truncation. The first block captured smart and digital delivery technologies, including terms such as "smart app*," "digital health," "mobile health," "mHealth," "eHealth," "wearable technolog*," "smart device*," "AI-driven," and "artificial intelligence." The second block targeted clinical populations and medical contexts, encompassing terms such as "chronic disease*," "non-communicable disease*," "cardiovascular disease*," "hypertension," "diabetes," "stroke," "cancer," "dementia," "mild cognitive impairment," "Parkinson*," "Alzheimer*," "multiple sclerosis," "epilepsy," "chronic pain," "postoperative," "rehabilitation," "palliative care," and "medical setting," among others. The third block was limited to music-based interventions, including "music therap*," "music-based intervention*," "music intervention*," "therapeutic music," "music listening," "music medicine," and "sound therapy." The search was restricted to articles published in English, focusing on literature from the past ten years (2015 onward) to capture the trajectory of recent technological advancements in this area. The initial search was conducted in July 2025, followed by an updated search in March 2026 to capture any newly indexed studies. The results reported in this review are based on the updated search.

Study Selection Process

All identified records were exported to a reference management software to automatically identify and remove duplicates. The selection process occurred in two stages. First, two independent reviewers screened the titles and abstracts of all unique records against the pre-defined eligibility criteria, categorizing each as "included," "excluded," or "maybe." Second, the full texts of potentially relevant articles were retrieved and assessed independently by the same two reviewers. Any discrepancies or disagreements during either screening phase were resolved through discussion and consensus, or by consulting a third reviewer when necessary.

Data Charting and Extraction

Data from the included studies were systematically extracted using a standardized data extraction form developed in Microsoft Excel. To ensure accuracy and consistency, one reviewer extracted the data and a second reviewer independently cross-checked the entered information. The extracted data encompassed study characteristics including author names, publication year, country of origin, and study design; participant demographics including sample size, age, gender, and clinical diagnosis or target population; intervention details including the specific type of "smart" technology utilized, music content, and frequency and duration of the intervention; and primary and secondary health outcomes alongside usability and feasibility metrics.

Data Synthesis and Reporting

Given the expected heterogeneity in study designs, technological modalities, and measured outcomes, a narrative and descriptive synthesis approach was employed. The data were mapped and grouped conceptually to address the research objectives. The synthesis categorized the types of digital technologies utilized, mapped the clinical domains addressed, and summarized the empirical evidence regarding therapeutic efficacy and system usability. Results are presented using summary tables, charts, and a narrative summary to highlight current trends and identify existing knowledge gaps.

Results

Study Selection and Characteristics

The systematic database search yielded a total of 355 records across the six databases (ACM Digital Library, n = 6; EBSCOhost, n = 121; Scopus, n = 228). Following the removal of 80 duplicate records, 275 unique records remained for title and abstract screening, of which 231 were excluded as irrelevant. The full texts of the remaining 44 records were sought for retrieval, of which 2 could not be obtained. The remaining 42 reports were assessed for eligibility, and 14 were subsequently excluded for the following reasons: four were conference proceedings, three reported no intervention testing, two involved no participant data, one was a protocol study, one was a review study, and three evaluated virtual reality devices or programs that fell outside the scope of the review. As a result, a final sample of 30 studies was retained for inclusion in this scoping review (see Figure 1 for the PRISMA flowchart). Study designs ranged from randomized controlled trials to single-arm studies, usability evaluations, and qualitative co-design investigations, reflecting significant methodological heterogeneity across the included literature.

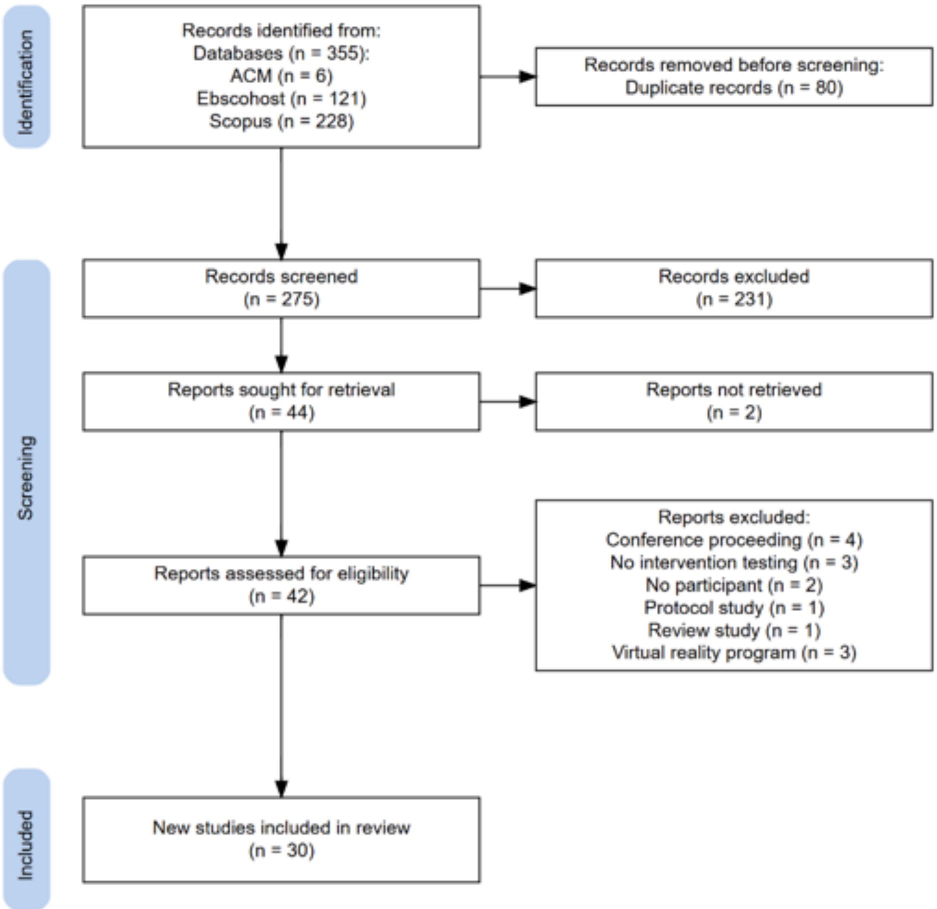

Figure 1. PRISMA Flowchart of Study Selection Process.

Participant Demographics and Clinical Domains

The literature targeted highly diverse populations, which can be categorized into four primary clinical domains. Studies addressing psychological and mental health involved distressed youth and adults managing trauma or PTSD (Choi et al., 2024; Hides et al., 2019). Neurological and motor rehabilitation populations encompassed stroke survivors with aphasia or hemiparesis and individuals with Parkinson's disease (Best et al., 2024; Chen and Norgaard, 2024; Zajac et al., 2023). Aging and cognitive care studies focused on older adults in care homes, dementia patients, and their family caregivers (De Nys et al., 2024; Thompson et al., 2025). Finally, acute care and symptom management interventions were utilized for surgical and oncology patients, emergency department pain management, military veterans with tinnitus, and patients with Long COVID respiratory symptoms (Chai et al., 2020; Howlett and Murphy, 2025; Zhang et al., 2025). The general and participant characteristics of included studies are presented in Figure 2.

1st Author (Year)	Country	Design	Study Objective (< 25 words)	Participant N	Comparison Group	Age & Gender	Population
Afra et al. (2018)	USA	Survey-based study and prototype design,	To describe mobile app development to reduce seizures and assess patient preferences for digital epilepsy treatments.	Total: N=40. Withdrawals: NR.	N/A (Survey and prototype design study).	Age: mean18 years. Gender: NR.	People with epilepsy (PWE).
Bai (2026)	China	Stratified random sampling experimental study	To design and evaluate a closed-loop mobile music therapy system integrating multimodal AI emotion prediction for personalized intervention and adherence.	Total: N=120 (30 per group: closed-loop, traditional, static playlist, random music).	Traditional therapy, static-playlist group, and random music (placebo) group.	Age/Gender: Baseline comparability across age and gender ensured	Anxiety/depressive tendencies (n=40), post-operative rehab (n=40), and healthy controls (n=40).
Baur et al. (2018)	Switzer-land	Prospective randomized single-center study	To test the effects of an audio-haptic creative task and no visual display on motivation in robot-assisted arm therapy.	Total: N=16 (4 per group: A, B, C, D). Withdrawals: 0.	Within-subject design comparing conditions	Mean: 27.2, SD: 4.1. Gender: 10 M, 6 F	Healthy participants testing a robotic arm therapy system.
Best et al. (2024)	Australia	Feasibility and usability study,	To assess usability, adherence, and satisfaction of a mobile music app for post-stroke aphasia.	Total: N=19 (10 in version 1; 9 in version 2). Withdrawals: NR.	N/A (Feasibility study).	Mean: 66, SD: 8.28. Gender: 9 F (48%), 10 M (52%).	People with chronic post-stroke aphasia.
Chai et al. (2020)	USA	Prospective randomized study	To assess feasibility and use of a prescribed brief music app for pain and anxiety in the emergency department.	N=82. Randomized: N=81 (Supervision: no=38, 43 =yes).	Unsupervised (ad lib) use vs. Supervised (RA-prompted) use.	Mean: 43.84, SD: 15. Gender: 24 F (30%), 57 M (70%).	Emergency department (ED) observation unit patients with pain.
Chaitanya et al. (2025)	India	Prospective, observational study	To evaluate the effectiveness, usability, and clinical feedback of a smartphone-integrated bone-conduction platform for personalized digital tinnitus retraining therapy.	Total: N=58 (25 healthcare experts, 33 patients). Lost to follow-up: 2 experts, 4 patients.	N/A (Prospective observational study).	Age/Gender: NR.	Individuals with chronic tinnitus patients.
Chen & Norgaard (2024)	USA	3-week single-group pre-post feasibility study	To understand the feasibility and clinical effects of technology-assisted in-home piano training using a mobile app for stroke survivors.	Screened: 11. Enrolled: N=10. Excluded: 1.	N/A (Single-group pre-post study).	Mean: 56.79, SD: 13.05, Range: 40-78. Gender: 6 M, 4 F.	Stroke patients (mean 2.46 years post-stroke).
Choi et al. (2024)	South Korea	Randomized controlled trial	To evaluate the effectiveness of a mobile app utilizing neurofeedback-based meditation and binaural beat music for traumatic stress management.	Randomized: N=60 (30 exp, 30 control). Withdrawals: 2 dropped out (personal reasons). Analyzed: N=58.	Received brochure information about EEG, brain waves, and binaural beats.	Age: 18-45 years (20s: 25, 30s: 21, 40s: 12). Gender: 8 M (13.8%), 50 F (86.2%).	Individuals experiencing trauma and stress.
De Nys et al. (2024)	UK	Pilot randomized controlled trial with mixed methods,	To evaluate the efficacy of a digital movement and music intervention on health and wellbeing outcomes within care home settings.	Recruited: N=34 (17 int, 17 waitlist); Losses: 3 died, 2 withdrew, 1 left, 1 lost capacity. Analyzed: N=27.	Waitlist control; analyzed as single cohort).	Age: 65-74 (6), 75-84 (16), 85+ (12). Gender: 10 F (59%) int, 14 F (82%) control.	Older adults living in care homes. Severity: Variable (must be capable of chair-based exercise).
Feneberg & Nater (2022)	Austria	Mixed methods feasibility study (uncontrolled pilot),	To thoroughly investigate the feasibility of an ecological momentary music intervention for reducing stress in women's everyday lives.	Total: N=10. Withdrawals: NR.	N/A (Uncontrolled pilot).	Mean: 23.5, SD: 3.3, Range: 19-28. Gender: 10 F (100%).	Chronically stressed women.

Figure 2. General Characteristics of Included Studies, part 1.

1st Author (Year)	Country	Design	Study Objective (< 25 words)	Participant N	Comparison Group	Age & Gender	Population
Fleszar-Pavlovic et al. (2025)	USA	Qualitative study (focus groups and usability field-	To refine the content and usability of an eHealth mindfulness-based music therapy intervention for allogeneic stem cell	Consented: 12. Participated: N=11 (1 absent due to illness).	N/A (Focus groups and usability testing).	Mean: 43.6, SD: 17.8, Range: 19-76. Gender: 6 F (55%), 5 M (45%).	Allogeneic stem cell transplantation (allo-SCT) survivors.
Garrido et al. (2022)	Australia	Qualitative co-design study (focus groups),	To determine how to encourage help-seeking behavior and engagement in a mental health app for young people,.	Screened: 25. Excluded: 1. Total: N=24.	N/A (Co-design workshops).	Age: 13-25 years (14 aged <18, 10 aged 18+). Gender: 15 F, 10 M.	Young people with or without depression.
Guerrier et al. (2021)	France	Randomized clinical trial	To demonstrate the effects of a web app-based music intervention on perioperative hypertensive events and anxiety during	Enrolled: N=311. Randomized: N=310 (155 int, 155 control). Analyzed:	Headphones with no music.	Mean: 68.9, SD: 10.8. Gender: 176 F (57%), 133 M.	Patients undergoing elective first eye cataract surgery under local anesthesia.
Hansen (2015)	Iceland	Feasibility pilot study, experimental RCT,	To determine the feasibility and effects of mobile technology-delivered complementary music therapies on surgical patients' anxiety,	Screened: 112. Excluded: 7. Randomized: N=105 (ART 25, MI 25, NVAM	Standard surgical care (no complementary therapy).	Mean ages by group range: 43.9 - 51.2. Gender: 21 M, 84 F.	Same day surgery (SDS) patients (general and gynecological).
Hides et al. (2019)	Australia	Randomized controlled trial	To evaluate the efficacy and outcomes of a music-based emotion regulation mobile app in distressed young people.	Assessed: 209. Randomized: N=169 (85 immediate, 84 delayed).	Delayed-access control (waitlist).	Mean: 19.9, SD: 2.5. Gender: 134 F (79.3%).	Young people experiencing distress.
Howlett & Murphy (2025)	UK	Single arm, within-participants exploratory feasibility study	To investigate the feasibility and acceptability of a non-invasive, wearable white-noise sound therapy device for persistent tinnitus in military veterans.	Total: N=20. Withdrawals: 0 in 1st month; 2 lost to 2-month follow-up.	N/A (Single-arm feasibility study).	Mean: 51.3, SD: 7.7. Gender: 16 M (80%), 4 F (20%).	UK military veterans with persistent tinnitus.
Hutchinson et al. (2020)	USA	Preliminary, proof-of-concept study	To automate a progressive and individualized rhythm-based walking training program for individuals with poststroke hemiparesis.	Total: N=11. Withdrawals: 0 reported.	N/A (Single-group proof-of-concept).	Mean age approx. 57.7. Gender: 9 M, 2 F.	Individuals with chronic poststroke hemiparesis.
Jackson et al. (2025)	UK	Pilot and feasibility trial (mixed methods),	To investigate the feasibility and acceptability of online group peer support, health education, and music interventions for caregivers of unsettled infants.	Total: N=7 (Target was 40).	Treatment as usual vs. health education vs. peer support.	Age: 20-34 years. Gender: 6 Mothers, 1 Father.	Caregivers of infants (<6 months) affected by colic, reflux, GOR(D), and/or CMPA.
Ma et al. (2026)	China	Predictive modeling study (machine learning/deep learning),	To propose and evaluate a dual-stream attention model fusing physiological dynamics with music listening patterns to predict older adults' wellbeing.	Initiators: 132. Completed: N=92 (40 dropouts).	Random Forest, XGBoost, LSTM, and TCN used as algorithmic baselines.	Mean: 67.8, SD: 5.1. Gender: 58% F.	Community-dwelling older adults.
Nasmi Zarudin et al. (2025)	Malaysia	Cross-sectional study	To assess the quality and acceptance of a self-preference musical mobile app as a relaxing tool for dental students and patients.	Total: N=73 (38 dental students, 35 patients).	N/A (Cross-sectional study).	Mean age: 23. Gender: 59 F (81%), 14 M (19%).	Dental students treating anxious patients, and dental patients.

Figure 2. General Characteristics of Included Studies, part 2.

1st Author (Year)	Country	Design	Study Objective (< 25 words)	Participant N	Comparison Group	Age & Gender	Population
Russo et al. (2023)	Canada / USA	Development/training database study	To develop an AI for affective music recommendation to help manage the neuropsychiatric symptoms of dementia,.	Total: N=32 (Training database study).	N/A (Training database study).	Age/Gender: NR.	Older adults experiencing cognitive decline.
Salirrosas et al. (2026)	USA	Within-subject change-from-baseline design	To evaluate the role of deep neural networks-based AI for optimized music selection to reduce postoperative stress in surgical cancer patients,.	Total: NR (Recorded 7255.5 mins of HRV data over >1969 songs).	N/A (Within-subject pilot).	Mean: 63. Gender: 57% F.	Surgical cancer patients.
Sorkpor et al. (2023)	USA	Pilot study with fNIRS neuroimaging,	To assess the impact of preferred web app-based music listening on central nervous pain processing in older Black adults with low	Approached: 21. Enrolled: N=20. (1 opted out due to transportation).	N/A (Single-arm pre-post).	Mean: 71.60, SD: 5.04. Gender: 13 F (65%), 7 M (35%).	Community-dwelling older Black adults with Low Back Pain (LBP).
Thompson et al. (2023)	Australia	Validation study (face and content validity),	To develop and evaluate the face and content validity of a mobile app designed to train caregivers in music therapy strategies.	Invited: 28. Consented: N=20 (11 MT, 9 Caregivers). Partially	N/A (Content validation study).	Age/Gender: NR (demographic data was not collected).	Expert music therapists and expert family caregivers of people with dementia.
Thompson et al. (2025)	Australia	Mixed-methods proof-of-concept study	To evaluate a music-training app prototype's acceptability, usability, and preliminary effects on neuropsychiatric symptoms and	Consented: 18 dyads. Commenced: 17 dyads. Completed: 13 dyads.	N/A (Single-arm proof-of-concept).	*PwD:* Median 79 (62-93); 11 F, 6 M. *CG:* Median 60 (31-84); 14	Co-habiting dyads (caregiver & care-recipient).
Verna et al. (2020)	Italy	Randomized controlled trial	To evaluate an app using temporal musical mismatch for neurorehabilitation in stroke patients,.	Enrolled: 30. Withdrawals: 4 released, 2 dropped out. Analyzed: N=24 (12 Mg, 12 CTRLg).	Standard active control group (CTRLg).	Mg: 50.87 \pm 12.37 (6M). CTRLg: 64.20 \pm 10.94 (7M).	Stroke patients in sub-acute phase.
Wall et al. (2026)	UK	Qualitative focus group study,	To explore the perceptions and preferences of people with Parkinson's disease regarding a personalized, smartphone-based music cueing application for gait rehabilitation.	Total: N=8 (7 PwPD, 1 caregiver).	N/A (Focus group).	Age: 60-73 years. Gender: 3 F, 5 M.	People with Parkinson's Disease (PwPD) and caregivers.
Williams et al. (2020)	UK	Experimental machine learning evaluation study,	To design and evaluate a machine learning system generating functional music informed by biophysiological measurement to improve listener affective states.	Total: Human survey participants; Specific sample size NR.	Compared to familiar music from a popular film corpus.	Age/Gender: NR.	Human listeners analyzing affective states based on musical sequences.
Zajac et al. (2023)	USA	Single-group pilot clinical trial	To evaluate the feasibility and proof-of-concept of an autonomous music-based digital walking intervention for individuals with Parkinson's disease,.	Completed: N=23 (12 BU, 11 JHU). Withdrawals: NR.	N/A (Single-group pilot clinical trial).	Mean: 66.91, SD: 8.78. Gender: 17 M (73.9%), 6 F (26.1%).	Idiopathic Parkinson's Disease.
Zhang et al. (2025)	USA	Within-subject experimental design	To evaluate the potential efficacy and feasibility of an online music therapy respiratory telehealth protocol for adults with long COVID symptoms.	Enrolled: N=24. Withdrawals: 2 dropped out during tx; 5 stopped responding post-tx.	Full within-subject experimental design.	Mean: 45.9, SD: 13.6, Range: 22-70. Gender: 17 F (70.8%), 5 M (20.8%).	Individuals previously diagnosed with COVID-19. Severity: Residual pulmonary issues (shortness of breath).

Figure 2. General Characteristics of Included Studies, part 3.

Technology and "Smart" Intervention Modalities

The included studies employed four primary categories of smart technology. Mobile and web applications were the predominant delivery mechanism, with smartphones and tablets used to provide accessible, at-home care through platforms such as Music eScape, MoodyTunes, MATCH, and Te.M.P.O. (Garrido et al., 2022; Hides et al., 2019; Thompson et al., 2025; Verna et al., 2020). Artificial intelligence and machine learning systems utilized AI for dynamic, closed-loop music prescription based on emotion prediction, physiological metrics, or reinforcement learning, including the FAT-Net model and the LUCID digital therapeutic (Bai, 2026; Ma et al., 2026; Russo et al., 2023). Sensor and wearable biofeedback hardware integrations included EEG headsets, continuous physiological monitors such as the Empatica E4 wristband, fNIRS neuroimaging, and 3D foot sensors for gait tracking (Choi et al., 2024; Ma et al., 2026; Sorkpor et al., 2023; Zajac et al., 2023). A fourth category encompassed alternative interfaces including bone-conduction devices, robotic arm exoskeletons, and virtual and augmented reality (Baur et al., 2018; Chaitanya et al., 2025; Yu et al., 2025). Technological characteristics of included studies are presented in Figure 3.

Music-Specific Characteristics and Selection

Music selection mechanisms varied widely across included studies. Approaches ranged from algorithm-generated functional music (Williams et al., 2020) and pre-selected clinical tracks (Hansen, 2015) to patient-selected or self-compiled playlists (Best et al., 2024; Feneberg and Nater, 2022). Interventions also differentiated between passive and receptive listening for relaxation and pain management (Chai et al., 2020) and active or interactive engagement, such as rhythmic auditory stimulation for walking or interactive digital piano training (Chen and Norgaard, 2024; Hutchinson et al., 2020). The musical characteristics of included studies are presented in Figure 4.

Health Outcomes and Clinical Efficacy

Psychological outcomes were the most frequently reported, with studies demonstrating significant reductions in anxiety, depression, and stress across diverse cohorts using measures such as the STAI and DERS (Bai, 2026; De Nys et al., 2024; Hides et al., 2019). Physiological and biomarker outcomes provided objective evidence of efficacy, including improvements in heart rate variability, alterations in salivary cortisol and DHEA, and modulated galvanic skin responses (Bai, 2026; De Nys et al., 2024; Ma et al., 2026; Williams et al., 2020). In the area of rehabilitation, interventions yielded improvements in motor function, walking speed and cadence, and specific symptom relief such as reduced tinnitus severity and dyspnea (Chaitanya et al., 2025; Hutchinson et al., 2020; Zajac et al., 2023; Zhang et al., 2025).

System Feasibility, Usability, and Adherence

System feasibility was generally high, with standardized scores on the System Usability Scale and uMARS indicating high user satisfaction and ease of use (Best et al., 2024; Nasmi Zarudin et al., 2025). However, adherence rates varied substantially across studies. One study reported an "empty trial" due to exceptionally poor recruitment and adherence among caregivers of infants with colic (Jackson et al., 2025). Qualitative user experience feedback emphasized the importance of app aesthetics, intuitive design, data privacy and anonymity, and the psychological risks of achievement-based gamification that may introduce performance-related stress (Garrido et al., 2022; Wall et al., 2026).

1st Author (Year)	Types of Technology	Modality	Device(s) Needed	Software Needed	Feedback from Technology	AI Workflow / Datasets
Afra et al. (2018)	Prototype web-based/mobile app.	Mobile/Web Application	Smartphone, tablet, or computer	Prototype web-based or mobile app	Audio/visual interaction with emoticons; home setting for epilepsy self-care and antiseizure music.	N/A
Bai (2026)	Mobile app, wearable sensors (HRV, EDA), smartphone camera.	AI App & Wearable Sensors	Smartphone (with camera), Empatica E4 wearable wristband	Custom AI-driven mobile music therapy app	Empathic UI (visual cues, voice guidance, haptic responses); home/clinical for emotional regulation and sleep.	CNN-LSTM hybrid model fusing physiological, behavioral, and subjective data
Baur et al. (2018)	ARMin rehabilitation robot, virtual game environment.	Robotics & Virtual Game	ARMin rehab. robot, headphones, computer/monitor, keyboard	Unity game environment software	Haptic feedback with/without visual monitor and auditory music creation; clinical neurorehabilitation.	N/A
Best et al. (2024)	Custom iOS mobile app on iPad mini.	Mobile Application	Apple iPad mini, headphones	Custom iOS music listening application	Visual (album covers) and simple audio player controls; home setting for post-stroke aphasia.	N/A
Chai et al. (2020)	Smartphone-based app (Unwind) on iPhone.	Mobile Application	Smartphone (iPhone 6), noise-canceling headphones	"Unwind" iOS application (by Bose)	Auditory music tracks; Emergency Department observation unit for acute pain/anxiety.	A machine learning algorithm selects features to generate “thrill”-inducing backing music.
Chaitanya et al. (2025)	Tinnicare Android app & Tinnipatch wearable bone-conduction device.	App & Bone-Conduction	Smartphone, Tinnipatch wearable bone-conduction device	"Tinnicare" Android application	Bone-conduction vibrations (white/narrow band noise); home use for Tinnitus Retraining Therapy.	N/A
Chen & Norgaard (2024)	Commercial app (Yousician) & digital piano keyboard.	App & Digital Instrument	Tablet (Apple iPad), digital piano keyboard	"Yousician" mobile application	Visual/auditory interactive piano feedback; home setting for upper extremity stroke rehab.	N/A
Choi et al. (2024)	"Mind Therapy" mobile app & 2-channel Bluetooth EEG headset.	App & EEG Neurofeedback	Smartphone, 2-channel Bluetooth EEG headset	"Mind Therapy" mobile application	Auditory feedback (bell rings when alpha waves increase) & binaural beats; home for trauma stress.	N/A (Utilizes real-time neurofeedback).
De Nys et al. (2024)	Digital PA and music video resource.	Digital AV Resource	Digital screen / TV / Audio-visual equipment	"danceSing Care" digital music & movement resource	Audio-visual delivery via digital screen; group sessions in older adult care homes.	N/A
Feneberg & Nater (2022)	movisensXS smartphone app.	Mobile Application	Smartphone, head/earphones, USB stick (optional)	"movisensXS", "Musik Player" / personal streaming	Alarms/prompts, self-selected music streaming; daily life (ambulatory assessment) for acute stress.	N/A
Fleszar-Pavlovic et al. (2025)	SmartManage web eHealth platform.	eHealth Web Platform	Smartphone, tablet, or computer, headphones	"SmartManage" web platform (by BrightOutcome)	Audio-recorded content, guided exercises, journaling; remote home setting for allo-SCT survivors.	N/A
Garrido et al. (2022)	"MoodyTunes" smartphone app	Mobile Application	Smartphone	"MoodyTunes" app prototype, Spotify	Spotify background linking, mood tracking graphs; daily life for youth mental health.	N/A
Guerrier et al. (2021)	Music Care web app on a tablet.	Web Application	Tablet (Samsung Galaxy), headphones	"Music Care" web application	Audio via headphones (U-shaped relaxation sequence); operating/recovery room for cataract surgery.	N/A
Hansen (2015)	Apple iPods and iPads.	Mobile Media Players	Apple iPod, Apple iPad	Custom audio/video players, "Salumedia" nature video app	Audio (music/relaxation) or audiovisual (nature scenes); hospital/home pre- and post-surgery.	N/A

Figure 3. Technological Characteristics of Included Studies, part 1.

1st Author (Year)	Types of Technology	Modality	Device(s) Needed	Software Needed	Feedback from Technology	AI Workflow / Datasets
Hides et al. (2019)	"Music eScape" mobile app (iOS).	Mobile Application	Smartphone (iPhone)	"Music eScape" iOS application, TestFlight	Mood mapping visual interface (valence-arousal circumplex); daily life for youth emotion regulation.	Echo Nest extracts valence/ arousal from the user's library.
Howlett & Murphy (2025)	TinniSoothe wearable white-noise device.	Wearable Sound Device	TinniSoothe wearable device, docking station, lanyard	N/A (embedded device firmware)	Continuous, adjustable white noise; home day and night use for military veterans.	N/A
Hutchinson et al. (2020)	Smartphone app, 3D gyroscope sensors, bone-conducting	App & Wearable Sensors	Smartphone, 3D gyroscope sensors, bone-conducting headphones (AfterShokz)	Custom digital therapeutic smartphone	Real-time audio tempo modulation (BPM); overground walking in clinical/community settings post-stroke.	Decision algorithms autonomously adapt music tempo based on user's real-time
Jackson et al. (2025)	Online video conferencing &	Online Communication	Smartphone or computer	Zoom, WhatsApp	Online group sessions; remote home environment for caregivers of infants.	N/A
Ma et al. (2026)	Empatica E4 wearable wristband & online surveys.	Wearable Sensors	Empatica E4 wearable wristband, smartphone or computer	Google Forms (for survey logs), personal music streaming app	Continuous physiological monitoring; daily life for community-dwelling older adults.	FAT-Net predicts health scores using HRV and behavioral logs.
Nasmi Zarudin et al. (2025)	ACOU@PLAY mobile app.	Mobile Application	Smartphone, headphones	"ACOU@PLAY" mobile application	Auditory music & in-app anxiety/gagging assessments; clinical dental setting.	N/A
Russo et al. (2023)	LUCID/VIBE digital therapeutic app.	AI Digital Therapeutic	Smartphone or tablet	"LUCID/VIBE" digital therapeutic app	Audio playlists to induce target emotional states; home/long-term care for dementia.	BioMIR and AMRS use reinforcement learning.
Salirrosas et al. (2026)	Physiology-adaptive music software using DNNs.	AI App & Sensors	Smartphone, physiological sensors (HRV monitor)	"Rubato Life" application	Real-time audio adaptation; postoperative recovery for surgical oncology patients.	A DNN algorithm optimizes music selection from real-time stress data.
Sorkpor et al. (2023)	MUSIC CARE web app, fNIRS neuro imaging, headphone	Web App & Neuroimaging	Smartphone or tablet, over-ear noise-isolating headphone, fNIRS device	"MUSIC CARE" web application, AnalyzIR software (for fNIRS)	Algorithmic "U" sequence audio; home setting for Low Back Pain management.	Algorithmic sequence composition based on tempo/orchestral modulation.
Thompson et al. (2023)	MATCH mobile app.	Mobile Application	Smartphone or tablet	"MATCH" mobile application	Video modules, case studies, checklists; home setting training for dementia caregivers.	N/A
Thompson et al. (2025)	MATCH mobile app prototype.	Mobile Application	Smartphone or tablet	"MATCH" mobile application	Embedded training videos & in-built music streamer; home setting for dementia dyads.	N/A
Verna et al. (2020)	"Te.M.P.O." mobile app.	Mobile Application	Android device (smartphone or tablet)	"Te.M.P.O." Android application	Temporal musical mismatch; clinical neurorehabilitation for stroke patients.	N/A
Wall et al. (2026)	CuePD smartphone app.	Mobile Application	Smartphone, headphones, 3D printed smartphone cradle/belt	"CuePD" smartphone application	Music sonification and tempo adjustment; outdoor/home walking for Parkinson's disease.	Algorithms alter user's BPM to match 10% of baseline cadence.
Williams et al. (2020)	Custom generative music system, GSR biosensors.	AI System & Biosensors	Computer, GSR (galvanic skin response) biosensors	Custom generative music system (Hidden Markov Models)	Real-time audio synthesis; experimental mindfulness/mental health setting.	Supervised learning and HMMs use human-labeled and GSR data.
Zajac et al. (2023)	MR-005 mobile app, 3D foot sensors, bone-conduction headphones.	App & Wearable Sensors	Locked Android touchscreen device, 3D foot sensors, bone-conduction headphones	"MR-005" proprietary software mobile application	Real-time auditory rhythmic cues; unsupervised community walking for Parkinson's disease.	A closed-loop algorithm adapts music tempo based on gait.
Zhang et al. (2025)	Online telehealth protocol.	Telehealth Platform	Computer, tablet, or smartphone	Zoom video conferencing software	Video conferencing; remote home care for Long COVID respiratory symptoms.	N/A

Figure 3. Technological Characteristics of Included Studies, part 2.

1st Author (Year)	Involve MT	Musical Characteristic	Music Selection Process	Music Playing Device	IX duration/ Frequency	Primary Outcome	Time Points Reported	Main Finding	Program Feasibility
Afra et al. (2018)	No	Mozart's K.448 and relaxing music; passive listening	Pre-selected (Mozart) & Patient-selected	Prototype web/mobile app (HTML5)	10 min daily; proposed for 1 year or longer	Preference for mobile apps for seizure control	N/A (Survey)	N/A (Prototype design)	90% interested in app; 75% in music for seizures.
Bai (2026)	No	Empathic UI, biofeedback-driven tempo/volume; passive listening	Algorithm-generated (CNN-LSTM matching)	Mobile app, wearable sensors (E4)	30 min daily; 4 weeks	SAS, SDS, Cortisol, HRV, EEG	Baseline, Wks 1, 2, 4	Sig. reduction in anxiety (-12.6) and depression (-11.8). Increased HRV.	Adherence 85.3% (anxiety group); high SUS scores (70-90).
Baur et al. (2018)	No	Synthesized instruments; active music creation via movement	Patient-selected (triggered via movement)	ARMin robot, virtual game, headphones	Three ~5 min rounds; single session	Intrinsic Motivation Inventory (IMI), perceived effort	Post-task	Increased motivation, autonomy, and enjoyment.	High desire to keep created music; safe to use.
Best et al. (2024)	No	General music tracks; passive listening	Patient-selected	Custom iOS mobile app on iPad mini	Target ≥1 hour daily; 2 weeks	Adherence, instances of support, satisfaction	Post-intervention (2 Wks)	N/A (Focus on usability)	74% adherence (≥7 hrs). Median satisfaction 83%; high SUS (75.26).
Chai et al. (2020)	No	Instrumental relaxing tracks; passive listening	Algorithm-generated feature, Patient-selected track	Unwind app on iPhone	10 min session; up to 3x/stay or ad lib	Pain (BPI), Anxiety (0-10 scale), Opioid use	Pre- and post-session	Sig. reduction in pain (-0.81) and anxiety (-0.72).	92% found app easy to use; no difference between supervised/unsupervised.
Chaitanya et al. (2025)	No	White/narrow band noise vibrations; passive listening	Pre-selected (matched to tinnitus frequency)	Tinnicare Android app & Tinnipatch device	Daily; 8 months	TRT score, THI, sleep quality, anxiety	Baseline, Monthly to 8 Mos	Sustained improvement in TRT scores (64.6 to 44.84).	81.8% successful usage; 92% positive/neutral expert feedback.
Chen & Norgaard (2024)	No	Interactive digital piano playing; active instrument playing	Patient-selected (from app curriculum)	Yousician app & Yamaha piano keyboard	Goal of 1 hour daily; 3 weeks	Fugl-Meyer (FM), ARAT, 9HPT	Baseline, Post-training (3 Wks)	Positive improvements in upper extremity motor function.	Avg usage 33 min/day. Positive feedback but some got "stuck" on difficulty levels.
Choi et al. (2024)	No	Binaural beats & neurofeedback meditation; passive listening	Pre-selected	"Mind Therapy" mobile app & EEG headset	50 min(Music & meditation), ≥3 days/week; 4 weeks	SCL-47-R, Psychological Well-Being, EEG indicators	Pretreatment, 1-Mo follow-up	Sig. improvements in well-being, emotional stability, and anti-stress index.	2 dropouts; remote logging confirmed adherence.
De Nys et al. (2024)	No	Group-base4d movement and music; active and passive	Pre-selected	Digital PA and music video screen	3 sessions /week; 12 weeks	Anxiety/depression, fear of falling, loneliness, cortisol, physical function	Baseline, Post-intervention (12 Wks)	Sig. improvements in anxiety, DHEA, fear of falling, loneliness. No change in physical function.	88% of sessions delivered; deemed acceptable with moderate fidelity.
Feneberg & Nater (2022)	No	Calming/relaxing tracks; passive listening	Patient-selected (self-compiled playlist)	Musik Player app or personal streaming app	5–30 min per stressful event; 18 days	Subjective stress, compliance	Baseline, Pre/Post-event, 15m Post	Music was perceived as highly calming.	Good compliance; 62% wanted to listen longer than the chosen duration.

Figure 4. Musical Characteristics of Included Studies, part 1. Note. MT: music therapist.

1st Author (Year)	Involve MT	Musical Characteristic	Music Selection Process	Music Playing Device	IX duration/ Frequency	Primary Outcome	Time Points Reported	Main Finding	Program Feasibility
Fleszar-Pavlovic et al. (2025)	Board Certified MT	Active and receptive MT, imagery, vocal/singing, mindfulness	Patient-selected	SmartManage web platform	60 min sessions; 8 total sessions	USE questionnaire, qualitative feedback	Post-focus group	N/A (Content refinement)	Seen as easy to navigate; content was refined to reduce text and increase audio/video.
Garrido et al. (2022)	No	Mood-tracking background music; passive listening	Patient-selected (Spotify integration)	"MoodyTunes" app prototype	N/A (Focus group)	Qualitative design feedback	N/A (Focus group)	N/A (Co-design)	Feedback guided app gamification and privacy functions.
Guerrier et al. (2021)	No	"U" sequence (tempo/volume modulation); passive listening	Algorithm-generated list, Patient-selected genre	Music Care web app on tablet	20 min; single pre-op session	Hypertensive events, VAS anxiety, BP, HR	Pre- and Post-session	Sig. reduction in hypertensive events (14% vs 53%) and anxiety.	Session achieved in all but 12 participants; highly feasible.
Hansen (2015)	No	Non-lyrical audio, nature videos; passive listening	Pre-selected	Apple iPod or iPad	≥15 min, 2x/day; 10 days	State Anxiety (SAI), Pain (NRS), Self-Efficacy	Baseline, Pre-op, Post-op, Day 10	Sig. within-group decreases in pain and anxiety, but no sig. between-group differences.	Confirmed feasibility for clinical/home delivery via iPod/iPad.
Hides et al. (2019)	No	Mapping library by valence/arousal; passive listening	Patient-selected, Algorithm-mapped	"Music eScape" mobile app	Ad lib; up to 6 months	DERS-SF, Kessler 10, MHC-SF, uMARS	Baseline, 1, 2, 3, 6 Mos	Sig. long-term improvements in emotion regulation, distress, and well-being.	uMARS score 3.8/5. Engagement varied (median 2 playlists generated).
Howlett & Murphy (2025)	No	Continuous white noise; passive listening	Pre-selected	TinniSoothe wearable device	24/7 or ad lib; 28 days	TFI, PCL-5, ISI, PHQ-15, SWLS, GHQ-12	Baseline, 1 Mo, 2 Mos	Sig. improvements in tinnitus symptoms and sleep disturbances.	100% completion at 1 month; 13/20 retained device at 2 months.
Hutchinson et al. (2020)	No	4/4 meter strong beat; rhythmic auditory stimulation	Pre-selected music, Algorithm-adjusted tempo	Smartphone app & bone-conduction headphones	30 min; 1 to 3 sessions	10-m walk test, cadence, entrainment precision	Pre- and Post-training	Increased usual and fast walking speeds.	No trips/falls; 100% said it helped them walk faster; 70% would use at home.
Jackson et al. (2025)	No	Infant-Directed Singing (lullabies); active singing	Patient-selected (guided)	Zoom/WhatsApp	1 hr weekly for 3 wks; 3 wks independent	EPDS, PSI, SAPS, attendance	Baseline, Wks 2-5, Post-intervention	N/A (Feasibility focus)	Exceptionally poor participant recruitment (n=7).
Ma et al. (2026)	No	Daily preferred listening; passive listening	Patient-selected	Wearable (E4) & personal streaming	Ad lib daily; 45 days	PANAS, sleep quality, HRV, RHR	Daily for 45 days	Dual-stream AI accurately predicted daily wellbeing ($R2$=0.87).	Robust and interpretable prediction framework.
Nasmi Zarudin et al. (2025)	No	Pop, classical, kids, instrumental; passive listening	Patient-selected	ACOU@PLAY mobile app	10 min; single session	uMARS (engagement, functionality, aesthetics)	Post-use	N/A (Quality rating focus)	Avg app quality 3.96/5. Well accepted by dental students and patients.

Figure 4. Musical Characteristics of Included Studies, part 2. Note. MT: music therapist.

1st Author (Year)	Involve MT	Musical Characteristic	Music Selection Process	Music Playing Device	IX duration/ Frequency	Primary Outcome	Time Points Reported	Main Finding	Program Feasibility
Russo et al. (2023)	No	Affective music recommendation; passive listening	Algorithm-generated (reinforcement learning)	LUCID/VIBE app	N/A (Training database study)	Valence, arousal, absorption ratings	N/A (Database study)	Provided training dataset for AI affective recommendation systems.	N/A
Salirrosas et al. (2026)	No	Physiology-adaptive acousticness/tempo; passive listening	Algorithm-generated (DNN self-learning)	Rubato Life app	≥45 min daily; 2 weeks	HRV-derived stress, STAI-S	Pre/Post-session & every 25s	Sig. reductions in physiological and emotional stress over time.	Accessible, low-risk, and highly feasible in post-op setting.
Sorkpor et al. (2023)	No	"U" sequence composition; passive listening	Algorithm-generated list, Patient-selected genre	MUSIC CARE app & fNIRS	20 min, 2x/day; 4 days	Cortical hemodynamic activity (HbO, HbR)	Pre- and Post-intervention scans	Sig. reduction in hemodynamic activities in somatosensory regions (reduced pain processing).	High acceptability for home use; no adverse events.
Thompson et al. (2023, 2025)	Certified MT	Singing, movement, relaxation, reminiscence; active/passive	Caregiver/Patient-selected	MATCH mobile app	≥30 min, 2x/week; 8 weeks	NPI-Q, CMAI, AES, SUS, Knowledge	Post-training; Pre/Post 8 Wks	Sig. reduction in BPSD severity and caregiver distress.	Acceptability (AES 28), Usability (SUS 73.5). Highly valid content but some tech barriers.
Verna et al. (2020)	No	Temporal musical mismatch (deviations); active listening	Pre-selected (ad hoc compositions)	Te.M.P.O. Android app	20 min, 3x/week; 4 weeks	DRS, MBI, SSQoL	Baseline, 4 Wks	Major improvement in disability and quality of life compared to control.	Feasible adjunct to cognitive rehab.
Wall et al. (2026)	No	Tempo-adjusted contemporary music; rhythmic cueing	Patient-selected music, Algorithm-adjusted tempo	CuePD smartphone app	N/A (Focus groups)	Insights on daily challenges, use of app	N/A (Focus groups)	Subconsciously encouraged faster walking.	Music was significantly more engaging than a metronome.
Williams et al. (2020)	No	Generative functional music; passive listening	Algorithm-generated	Custom system & GSR sensors	Ad lib; single experimental session	GSR, self-reported emotion	During/Post-listening	Elevated GSR for negative pieces, lowered GSR for calm generated pieces.	Successfully induced specific emotions via AI generation.
Zajac et al. (2023)	No	Rhythmic auditory stimulation; passive listening while walking	Algorithm-adjusted tempo based on entrainment	MR-005 app & 3D foot sensors	30 min, 5x/week; 4 weeks	MDS-UPDRS III, 6MWT, PDQ-39, adverse events	Baseline, 4 Wks	Sig. improvements in motor severity, walking endurance, and quality of life.	High adherence (mean 17.2 sessions); safe, highly usable.
Zhang et al. (2025)	Board Certified MT	Wind instruments, singing, music visualizations; active	Patient-selected & Therapist-guided improvisation	Zoom video conferencing		MRC Dyspnea, CRQ Mastery, VAS, BDI, GAD-7	Bi-weekly over 16 Wks	Sig. decrease in dyspnea (MRC) and Breathing VAS; improved CRQ Mastery.	83.3% attendance rate; protocol deemed highly feasible.

Figure 4. Musical Characteristics of Included Studies, part 3. Note. MT: music therapist

Discussion

Summary of Main Findings

The aim of this scoping review was to systematically map and synthesize empirical research on smart, digital technology-delivered music interventions for health. The 30 included studies span four clinical domains and employ four primary categories of smart technology. The findings broadly confirm that these interventions are feasible and acceptable, and demonstrate preliminary evidence of efficacy across diverse populations. The following sections interpret the main findings, address comparative patterns across clinical domains, and identify knowledge gaps and future research directions.

The synthesized findings confirm that smart digital music interventions are feasible and acceptable across clinical domains, despite substantial variation in technology and outcome measures. Mobile and web applications were the most prevalent delivery modality, while AI and biosensor integration represent the most rapidly evolving area. Overall, short-term usability is well supported, but longitudinal efficacy, theoretical grounding, and ethical accountability remain underdeveloped.

The Implementation of Adaptive, Closed-Loop Systems

A notable development emerging from the included literature is the implementation of the adaptive, closed-loop systems. These tools use AI and biofeedback to respond to real-time patient states, for example, matching music tempo to gait cadence or adjusting valence to physiological stress indicators, without continuous clinician oversight (Salirrosas et al., 2026; Zajac et al., 2023). This enables individualized, responsive delivery at a scale traditional music medicine cannot achieve.. Studies such as Bai (2026) and Ma et al. (2026) reported technically sophisticated architectures capable of predicting wellbeing states with high explained variance ($R^2 = 0.87$). However, these results should be interpreted with caution, as predictive accuracy within a controlled dataset does not necessarily generalize to heterogeneous real-world clinical populations. The shift to closed-loop systems is thus both a significant technical achievement of the field and a pressing clinical challenge.

Digital Devices and Access to Care

The included studies suggest that digital tools hold significant public health implications by addressing the shortage of trained music therapists and reducing geographical access barriers. Applications such as MATCH and Tinnicare demonstrated the potential to empower patients and informal caregivers to manage symptoms independently at home, thereby extending clinical reach without requiring proportional increases in staffing resources (Chaitanya et al., 2025; Thompson et al., 2025). However, most included studies were conducted in high-income, anglophone countries, and the devices required (smartphones, EEG headsets, wearable biosensors) pose a financial barrier that may restrict access in the very settings where music therapists are most scarce. Future research should examine whether digital delivery truly reduces access inequity or merely shifts it, especially in under-resourced settings with limited device affordability and digital infrastructure (Thompson et al., 2023). Furthermore, access alone does not necessarily translate into meaningful engagement, as participation is shaped by individuals' intrinsic motivation, sense of connection, and willingness to be involved (Meetiyagoda et al., 2023). This highlights the need for future research to examine motivational and engagement-related factors that influence the effective use of digital music interventions across diverse populations.

User-Centered Design and Co-Design

Qualitative findings across included studies consistently identified intuitive interface design and data privacy as central user requirements for effective digital therapeutics (Fleszar-Pavlovic et al., 2025; Garrido et al., 2022). Users also highlighted the importance of non-clinical language and expressed concerns about gamification elements that may introduce performance-related stress (Garrido et al., 2022; Wall et al., 2026). The co-design approach documented by Garrido et al. (2022) offers a useful model, as young people prioritized anonymity, mood-tracking transparency, and the ability to disengage without penalty. Future smart music applications should therefore integrate user perspectives across all design stages, especially for clinical populations whose health conditions may complicate self-monitoring and performance evaluation.

Ethical Considerations

The ethical dimensions of smart music interventions remain largely unaddressed in the included literature. Several concerns warrant attention as the field moves from proof-of-concept to clinical deployment.

Informed consent in vulnerable populations presents a primary challenge. Many of the target groups in this review – including individuals with dementia, post-stroke aphasia, PTSD, and cognitive decline – have a reduced capacity to provide fully informed consent (Russo et al., 2023; Thompson et al., 2025). When AI systems continuously adjust music parameters in response to real-time physiological monitoring, users may be unable to adequately understand what data are being collected or how algorithmic decisions are made. Future studies should develop accessible consent frameworks suited to participants' cognitive and linguistic capacities, and address proxy consent for those unable to provide sustained autonomous authorization throughout an intervention.

A related concern is algorithmic transparency. Several studies used deep learning architectures (the CNN–LSTM hybrid in Bai, 2026; the dual-stream FAT-Net model in Ma et al., 2026; and a hidden Markov model in Williams et al., 2020) whose decision logic is not readily interpretable by clinicians or patients. Notably, none of these studies involved certified clinicians in validating the algorithms; instead, they relied on computational performance metrics and user response data. Strong average performance across a sample does not guarantee clinical accountability for individual patients. The development of interpretable AI frameworks for clinical music therapeutics is therefore an important direction for future research.

Data governance represents a third area of concern. Studies such as Ma et al. (2026) and Bai (2026) collected continuous physiological data over extended intervention periods, yet none of the included studies reported detailed data governance protocols or addressed data retention policies. Future research must address these issues within applicable regulatory frameworks, given the ethical sensitivities of biometric and emotional data in clinical and research contexts.

Finally, the risk of treatment-related harm associated with gamification and algorithmic music selection warrants careful consideration. The included literature indicates that gamification elements may induce performance-related stress in mental health applications for young people, for example due to losing winning streaks (Garrido et al., 2022). In addition, algorithmic music selection carries the risk of inadvertently eliciting unwanted emotional responses, exposing users to non-preferred music, or reinforcing undesired mood states. (Williams et al., 2020). Future feasibility and usability studies should include robust adverse event monitoring to adequately address this risk.

Implications for Music Therapy Practice

An important pattern in the included literature is the limited involvement of qualified music therapists. Only three of the thirty included studies incorporated board-certified or credentialed music therapists as active program developers. (Fleszar-Pavlovic et al., 2025; Thompson et al., 2023, 2025; Zhang et al., 2025). The remaining twenty-seven studies delivered music-based interventions through algorithm, application, or trained caregiver without professional music therapy input.

This pattern raises important questions about the appropriate scope of digital delivery in music-based care. Smart technologies demonstrably replicate certain functional dimensions of music therapy – including individualized music selection, adaptive parameter adjustment, and ongoing preference responsiveness – and hold genuine promise for populations whose primary needs are symptom management, motor rehabilitation, or accessible wellness support. However, presentations involving trauma, relational disruption, identity reconstruction, or challenges to self-worth are qualitatively distinct: they arise within human relationships and are most effectively addressed through a relational therapeutic process (Bordin, 1979; Wampold and Imel, 2015). For these populations, the therapeutic relationship is not a delivery mechanism that technology might eventually replicate – it is the treatment itself. Future research should therefore ask not whether digital tools can substitute for music therapists, but which clinical needs are well-served by digital delivery and which require human therapeutic contact.

Additionally, passive receptive listening dominated the included literature, appearing as the primary modality in the majority of studies. While still a minority approach compared to passive listening, active music engagement – including improvisation, instrument playing, singing, and movement-based music activities – was represented in several studies, particularly within contexts emphasizing specific physical rehabilitation or interactive caregiver-led care (Baur et al., 2018; Chen and Norgaard, 2024; De Nys et al., 2024; Fleszar-Pavlovic et al., 2025; Jackson et al., 2025; Thompson et al., 2023; Thompson et al., 2025; Zhang et al., 2025). This imbalance likely reflects digital platforms' bias toward easily automated modalities: passive listening requires only a playback mechanism, whereas active music-making requires far more complex interactive systems. The clinical consequences are notable: active music engagement may produce therapeutic effects distinct from passive reception, especially in trauma recovery, identity reconstruction after neurological injury, and meaning-making in palliative care (Bruscia, 2014), effects not visible in the current digital therapeutics literature.

Limitations of Digital Therapeutics

The included literature consistently reports positive short-term outcomes, yet several structural limitations of digital therapeutics warrant consideration for responsible clinical implementation.

The therapeutic relationship is notably absent from digital delivery models. Evidence across psychological and health interventions broadly, and music therapy specifically, consistently identifies the quality of the therapeutic alliance as among the strongest predictors of clinical outcome (Norcross and Lambert, 2019; Wampold and Imel, 2015). Future research should examine how digital interventions can be embedded within clinical frameworks that preserve the relational dimensions of therapeutic work, rather than being positioned as fully autonomous treatments.

Beyond the absence of the therapeutic alliance, digital delivery may also constrain opportunities for interpersonal connection among users. As music functions as a relational medium that supports shared emotional experience and social cohesion (Jurková et al., 2025), future research should consider how digital interventions can better facilitate not only individual use but also social interaction and shared engagement.

Intervention durations across the included literature were predominantly short, with the majority of studies using periods of four weeks or less. Such timeframes suffice for evaluating acute symptom relief and immediate usability, but are inadequate for longer-term outcomes such as sustained emotion regulation, identity reconstruction after neurological injury, or relational support in dementia care. The promising preliminary results should therefore be read as evidence of feasibility and proximal efficacy, not as evidence that the full therapeutic potential of music-based intervention has been captured.

Finally, several studies successfully deployed interventions in unsupervised, naturalistic settings and reported positive outcomes (Feneberg and Nater, 2022; Zajac et al., 2023). However, therapeutic context shapes therapeutic outcome: the same musical stimulus may function differently across clinical and non-clinical settings, especially for populations with trauma histories or acute psychiatric presentations. Home-delivered digital interventions should therefore be accompanied by clearly specified clinical governance structures and accessible pathways to human clinical support.

Knowledge Gaps and Future Directions

This scoping review identifies several priority areas for future research. First, standardized outcome frameworks are needed that accommodate biomedical metrics alongside the relational and meaning-making dimensions of therapeutic change. Second, longitudinal studies are necessary to assess whether engagement and therapeutic benefits are maintained beyond short-term trial periods. Third, clinical validation of AI models is essential to ensure safety, interpretability, and the prevention of unintended emotional or physiological effects (Ma et al., 2026). Fourth, explainable AI standards appropriate to clinical music therapeutics should be developed and adopted. Fifth, clinical governance frameworks for unsupervised home delivery to vulnerable populations should be established.

Limitations of the Scoping Review

Several limitations of this scoping review warrant acknowledgment. The restriction to English-language publications may have resulted in the exclusion of relevant studies published in other languages, potentially introducing geographic and cultural bias into the evidence base. Potential publication bias cannot be excluded, as studies reporting positive findings are more likely to be published; notably, only one explicitly unsuccessful trial was included in this review (Jackson et al., 2025), which is unlikely to reflect the true distribution of outcomes in the field. Additionally, the extreme heterogeneity of study designs, interventions, and measured outcomes precluded the conduct of a formal meta-analysis, limiting the precision of the quantitative conclusions that can be drawn. Despite these limitations, the mapping across four clinical domains and four technology categories provides a useful foundation for more rigorous, theoretically integrated future research.

Conclusion

The aim of this scoping review was to systematically map and synthesize empirical research on smart, digital technology-delivered music interventions for health. Analysis of 30 studies indicated that these interventions are feasible, acceptable, and demonstrate preliminary efficacy across psychological, physiological, and functional outcomes. The field's most significant technical development is the adaptive, closed-loop system, which adjusts musical parameters to real-time physiological data and extends responsive music-based care to settings without continuous clinician presence. This expands access rather than displacing clinical practice: while promising for symptom management and rehabilitation, these systems do not encompass the relational, identity-oriented, and trauma-informed dimensions of care that require sustained human therapeutic contact.

However, these findings should be interpreted with caution due to predominantly short-term, small-sample designs, substantial outcome heterogeneity, and potential publication bias. The current evidence base remains insufficient for widespread clinical implementation. Beyond methodological limitations, AI-driven and biosensor-integrated music therapeutics have proliferated faster than the ethical and governance frameworks needed for responsible clinical use. Issues of informed consent in cognitively vulnerable populations, algorithmic transparency, biometric data governance, and potential treatment harm from unsupervised closed-loop systems remain largely unaddressed.

Furthermore, the limited involvement of qualified music therapists across twenty-seven of the thirty studies reflects a field that has developed largely without professional music therapy input. While some studies ground digital tools in established frameworks (e.g., Neurologic Music Therapy or receptive methods), the therapeutic relationship remains structurally absent from current autonomous delivery models. Smart music technologies offer meaningful potential for accessible, personalized care, best realized through technical innovation, clinical rigor, and robust ethical oversight.

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