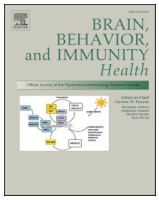
Brain, Behavior, & Immunity - Health 48 (2025) 101092

Contents lists available at ScienceDirect

Brain, Behavior, & Immunity - Health

journal homepage: www.editorialmanager.com/bbih/default.aspx



The role of music in perinatal mental health, with a psychoneuroimmunological perspective

Kiran Kuri *, Rebecca H. Bind, Lavinia Rebecchini

Department of Psychological Medicine, Institute of Psychiatry, Psychology and Neuroscience, King's College, London, United Kingdom

A B S T R A C T

Music has a profound and widespread impact, fostering social connectedness across diverse cultural, ethnic, and socioeconomic groups. It plays a significant role in individuals' lives – used for relaxation, emotional expression, and entertainment. In recent years, a growing body of research has demonstrated the therapeutic potential of music in both mental and physical health contexts. Music-based interventions have been successfully employed in a range of clinical settings, including for the management of anxiety, depression, and autism spectrum disorder. Emerging evidence has highlighted the role of music in supporting perinatal mental health. Studies indicate that music-based interventions can ease anxiety and depressive symptoms during pregnancy and the postnatal period, promote maternal-infant bonding, and assist women in coping during labour. These interventions are increasingly used due to their cost-effectiveness, accessibility, and suitability for individuals with limited verbal communication abilities. Researchers have also begun to explore the psychoneuroimmunological mechanisms that may underlie these effects. This article aims to explore and synthesise current evidence on how music can support perinatal mental health, while examining the biological and psychological pathways through which these benefits may arise.

1. Introduction

Perinatal mental health (PMH) conditions – those that occur during pregnancy or within the first year following childbirth – encompass a range of psychiatric disorders, including depression, anxiety disorders, and postpartum psychosis (NHS, 2024; O'Hara and Wisner, 2014). According to the World Health Organization, nearly one in five women will experience a mental health condition during pregnancy or in the postnatal period (World Health Organization, 2022). This has promoted a rapid expansion of research into PMH in recent years. Evidence suggests that women are approximately 22 times more likely to require psychiatric admission in the month following childbirth than women who have not given birth (Kendell, Chalmers and Platz, 2018). When left untreated, PMH conditions are associated with substantial maternal and foetal morbidity and mortality, along with adverse neonatal, infant, and child developmental outcomes (Howard and Khalifeh, 2020). Specifically, prenatal and postnatal maternal anxiety has been linked to a higher risk of emotional problems in children, as well as increased odds of preterm birth, low birth weight, and reduced gestational age (Rees, Channon and Waters, 2018; Grigoriadis et al., 2018). Additionally, the estimated lifetime cost of perinatal depression per affected woman in the UK is £75,728, placing a considerable burden on already overstretched health and social care systems (Bauer et al., 2016). This underscores the pressing need for accessible, non-pharmacological, evidence-based therapeutic strategies aimed at improving maternal mental health and mitigating the intergenerational consequences of PMH conditions.

Music-based interventions represent a promising avenue for such strategies and encompass a range of approaches with varying degrees of engagement. These interventions can broadly be categorised as active – involving direct participation such as group drumming, singing, or composing music – or receptive/passive, which typically involve listening to music selected for therapeutic purposes, often in a structured clinical or supportive setting (MacDonald, Kreutz and Mitchell, 2012). It is important to note that not all musical experiences constitute formal interventions; clinical applications typically involve goal-directed use within a therapeutic framework.

MacDonald's conceptual model of music, health, and well-being identifies five overlapping domains: music therapy, community music, everyday uses of music, music education, and music medicine (MacDonald, 2013). Music therapy – delivered by trained professionals within a therapeutic relationship – has demonstrated benefits in a range of clinical contexts, including improving social and global functioning in schizophrenia, enhancing motor function in Parkinson's disease, and alleviating depressive symptoms and sleep disturbances (Kamioka et al., 2014). The field of community music, which includes activities such as choir participation or group percussion sessions, has expanded rapidly

This article is part of a special issue entitled: Future of PNI 2nd edition published in Brain, Behavior, & Immunity - Health.

* Corresponding author.
E-mail address: ha20556@qmul.ac.uk (K. Kuri).

https://doi.org/10.1016/j.bbih.2025.101092
Received 18 March 2024; Received in revised form 30 May 2025; Accepted 16 August 2025
Available online 18 August 2025

and shown benefits for mental wellbeing through its emphasis on social connection and creative expression (Hallam, Creech and Varvarigou, 2017). Everyday uses of music refer to informal, often self-directed music engagement in daily life; for instance, listening to prosocial music has been shown to increase interpersonal empathy (Sanfilippo, Steward and Glover, 2021; Greitemeyer, 2009). Music education, while traditionally aimed at developing musical skills, has been associated with psychological benefits such as enhanced self-esteem and a sense of accomplishment (Hallam, 2010). Lastly, music medicine involves the use of pre-recorded music in medical environments without a therapeutic relationship. For example, research has shown that perioperative music can significantly reduce patient anxiety, pain perception, and neurohormonal stress responses (Kakar et al., 2021). Unlike pharmacological interventions, music medicine is low-cost, easy to implement, and free of adverse effects, making it an attractive complementary approach in various healthcare settings (Bradt et al., 2013).

Music-based interventions have been applied across a broad spectrum of mental health conditions (Rebecchini, 2021). In children and adolescents, music therapy has been shown to reduce internalising symptoms of anxiety and depression (Geipel et al., 2018; Aalbers et al., 2017). Community music initiatives, such as drumming groups and choir participation, have been associated with enhanced wellbeing and reductions in stress and depressive symptoms (Williams, Dingle and Clift, 2018; Fancourt et al., 2016). Moreover, music therapy has shown promise in the management of severe mental illnesses. For instance, it has been found to improve psychosocial functioning and reduce negative symptoms in individuals with schizophrenia, and patients with psychosis have reported symptom relief from both structured music therapy and music listening sessions (Ulrich, Houtmans and Gold, 2007; Müller et al., 2014). These findings highlight the versatility and potential of music-based interventions as valuable adjuncts in mental health care.

2. Benefits of music-based interventions during pregnancy

A growing body of literature suggests that music-based interventions may improve PMH during pregnancy. Studies have shown that listening to music at home can positively impact sleep quality, stress, and anxiety (Liu, Lee and Yu, 2015). This is important given the association between prenatal sleep disturbances and adverse birth outcomes (Okun et al., 2011). Similar findings were reported in a randomised clinical trial (RCT) involving 236 pregnant women, where those assigned to a music intervention group – comprising two weeks of daily music listening – showed significantly greater reductions in stress, anxiety, and depression compared to controls (Chang, Chen and Huang, 2008). A further study involving 12 weeks of daily listening to specially composed songs reported lower anxiety and depression scores in the intervention group compared to the control group (Nwebube, Glover and Stewart, 2017). However, the small sample size (20 in the intervention group and 16 in the control group) limits the generalisability of these results. Nevertheless, the consistency of findings across studies suggests that music listening at home may offer a simple, non-invasive approach to enhancing prenatal mental wellbeing.

In clinical settings, particularly among high-risk pregnancies, music-based interventions have also demonstrated potential benefits. In a study of 60 patients with pre-eclampsia, those who received music therapy in addition to standard care showed significantly lower systolic and diastolic blood pressure, reduced anxiety and depression scores, and improved quality of life compared to those receiving standard care alone (Cao et al., 2016). However, these results were not replicated in another study which found no significant reduction in anxiety levels following a music intervention among hospitalised women with pre-eclampsia (Toker and Kömürcü, 2017). In contrast, a RCT conducted in China found that pregnant women on hospital bedrest who received 30-min music therapy sessions over three consecutive days had significantly reduced anxiety and improved physiological responses (Yang et al., 2009). These mixed findings highlight the need for larger, well-designed trials to further investigate the utility of music therapy in hospital settings.

Systematic reviews and meta-analyses offer further insight into the role of music in pregnancy. A review of five RCTs concluded that music-based interventions significantly reduced self-reported anxiety during pregnancy (Van Willenswaard et al., 2017). However, the authors noted methodological limitations, including small sample sizes, studies limited to Asian populations, and unclear risk of bias due to insufficient reporting. Similarly, a review of 11 RCTs found that music interventions reduced prenatal anxiety, though variations in music selection, setting, and intervention delivery limited the comparability of studies (Lin et al., 2019). Finally, a broader systematic review of non-pharmacological interventions for prenatal anxiety identified music therapy, alongside behavioural activation, cognitive behavioural therapy, yoga, and relaxation, as one of the most effective strategies (Domínguez-Solís, Lima-Serrano and Lima-Rodríguez, 2021). This supports the growing recognition of music-based interventions as a promising component of PMH care.

3. Benefits of music-based interventions during labour

Labour pain is widely regarded as one of the most intense forms of pain a woman may experience (Nanji and Carvalho, 2020). While the physical pain is primarily driven by physiological factors such as uterine contractions, psychological factors – particularly stress and anxiety – also significantly influence the perception of pain. Elevated anxiety levels during labour have been linked to adverse maternal and neonatal outcomes (Zijlmans et al., 2017; Hishikawa et al., 2019). As a result, there has been growing interest in the potential of music-based interventions to alleviate psychological distress during labour.

The primary aims of music therapy during labour include distraction from pain, enhancement of maternal control, and anxiety reduction (Ji et al., 2024). In a non-blinded RCT, nulliparous women who listened to music during labour reported significantly lower pain and anxiety levels, as measured using a visual analogue scale where participants could report their own symptom severity (Buglione et al., 2020). These findings are supported by a meta-analysis of RCTs, which reported that women in the music intervention groups had significantly reduced anxiety scores and improvements in physiological indicators such as heart rate and blood pressure (Lin et al., 2019). Further evidence comes from a single-blind RCT that evaluated the effects of music and dance, as well as music alone, on labour pain and fear in nulliparous women (Gönenç and Dikmen, 2020). Both interventions were associated with significant reductions in self-reported pain and fear during labour, with the music-only group also demonstrating measurable benefits. Collectively, these findings suggest that music-based interventions may serve as effective, low-cost adjuncts to standard labour care. By reducing pain perception and anxiety, music may play a supportive role in promoting perinatal mental wellbeing during childbirth.

4. Benefits of post-natal music-based interventions

Postnatal depression affects approximately one in seven women, though the true prevalence may be higher, as up to half of affected women remain undiagnosed due to stigma, fear of judgement, or lack of support (Mughal, Azhar and Siddiqui, 2022; Zauderer, 2009). As a key aspect of PMH, postnatal depression represents a critical target for supportive, accessible interventions – such as music therapy.

Multiple studies have demonstrated a positive association between music-based interventions and reductions in postnatal depressive symptoms (Corey et al., 2019; Fancourt and Perkins, 2018a,b). In a qualitative study involving 223 postpartum and 97 antepartum participants, women reported feeling more relaxed and better connected with their babies following music therapy sessions (Corey et al., 2019). A three-arm RCT comparing singing groups, creative play sessions, and

standard care, found that mothers in the singing group experienced a greater reduction in depressive symptoms than those in the other two groups (Fancourt and Perkins, 2017a,b). In a separate cross-sectional study of 391 new mothers, daily singing was associated with fewer depressive symptoms, enhanced wellbeing and self-esteem, and stronger self-reported mother-infant bonding (Fancourt and Perkins, 2017a,b). However, the inability to establish causality due to the cross-sectional design is a key limitation.

Community music, a growing area within music-based interventions, has shown promise. A RCT of 134 mothers with postnatal depression found that those who participated in community singing sessions with their infants experienced significantly faster improvements in symptoms compared to the control group (Fancourt and Perkins, 2018a,b). Building on this, the SHAPER-PND trial is evaluating the clinical effectiveness of a 10-week community singing programme involving 400 mother with postnatal depression (Estevao et al., 2021). One of the main strengths of community music interventions is their accessibility. Remote delivery is particularly relevant for women facing barriers to in-person care, such as those with severe depressive symptoms or during times of social isolation, like the COVID-19 pandemic. The SHAPER-PNDO study explored the feasibility of a six-week online singing intervention and found significant reductions in depression, anxiety, and stress, along with improvements in life satisfaction and self-worth (Bind et al., 2022, 2023). These results suggest that online music interventions could represent a scalable and effective approach for supporting maternal mental health.

5. The psychoneuroimmunological effects of music in the perinatal period

With the growing recognition of music's benefits on PMH, researchers have increasingly sought to understand the underlying mechanisms – particularly through the lens of psychoneuroimmunology (PNI). PNI explores how psychological experiences like stress or relaxation can influence neurological, endocrine, and immune system functioning. Music is a particularly interesting stimulus in this regard, as it can elicit profound emotional responses, modulate physiological states, and even alter immune biomarkers (Koelsch, 2010). Changes in salivary cortisol, immunoglobulins, cytokines, lymphocyte activity, and autonomic function, have all been observed in response to music (Fancourt, Ockelford and Belia, 2014). However, literature specifically focused on these effects during the perinatal period remains sparse, highlighting a vital area for further investigation.

5.1. Music, stress, and the HPA axis

PMH is shaped by a complex interplay of biological systems, including the hypothalamic-pituitary-adrenal (HPA) axis, autonomic system, immune function, and the microbiota-gut-brain axis (Redpath, Rackers and Kimmel, 2019). Disruptions in these systems are thought to contribute to the onset of perinatal mood and anxiety disorders. Understanding how music influences each of these pathways can shed light on its therapeutic potential.

The HPA axis plays a central role in regulating the body's response to stress. During pregnancy, the maternal HPA is modulated – characterised by increased basal cortisol levels but reduced reactivity to acute stressors, likely as an adaptive mechanism to protect the foetus (Glynn, Davis and Sandman, 2013). However, chronic dysregulation of this system has been linked to the development of anxiety and depressive symptoms (O'Donnell and Meaney, 2017). Music has been shown to reduce cortisol levels and modulate the HPA axis, suggesting it can buffer against stress-induced dysregulation. For example, relaxing music is associated with lower power-stress cortisol release and reduced levels of adrenocorticotropic hormone (Leardi et al., 2007; Fancourt, Ockelford and Belia, 2014). Given that auditory stimuli such as noise can act as stressors that exacerbate oxidative stress and immune imbalance, it is plausible that music acts in an opposing manner – mitigating stress via neuroendocrine regulation (Zhang et al., 2021).

5.2. Music and the autonomic nervous system

Pregnancy induces a shift in autonomic balance towards increased sympathetic activity to meet heightened metabolic demands (Kudo, Shinohara and Kodama, 2014). However, prolonged sympathetic dominance has been implicated in heightened anxiety, poor sleep, and reduced resilience to stress (Thayer and Lane, 2000). Music has well-documented effects on the autonomic nervous system. Listening to calming music can enhance parasympathetic tone, decrease heart rate and blood pressure, and promote a state of physiological relaxation (Xiao, Chen and Zhang, 2023). In the perinatal context, one study demonstrated that music influenced foetal heart rate variability, indicating a regulatory effect on the foetal autonomic nervous system, possibly mediated through maternal relaxation (Massimello et al., 2022). This supports the notion that music's impact on maternal autonomic regulation could benefit both mother and foetus.

5.3. Immune system modulation

Pregnancy is marked by a dynamic immune adaptation rather than uniform suppression. The first trimester tends to be pro-inflammatory to facilitate implantation, the second trimester is predominantly anti-inflammatory to support foetal growth, and the third trimester returns to a pro-inflammatory state to prepare for parturition (Mor, Abrahams and Arici, 2002; Romero et al., 2021). Disruptions in this delicate immune balance have been associated with increased vulnerability to perinatal mood disorders. Music has been shown to influence several aspects of immune function. Studies report increases in salivary immunoglobulin A, reduced levels of pro-inflammatory cytokines (IL-6, TNF-α), and enhanced lymphocyte activity in response to music interventions (Fancourt, Ockelford and Belia, 2014; Rebecchini, 2021). These changes suggest that music may exert anti-inflammatory effects, which are particularly relevant during the second and third trimesters when immune modulation becomes critical for foetal protection and maternal wellbeing.

5.4. Music and the microbiota-gut-brain axis

A newer area of interest in PNI is the microbiota-gut-brain axis, which refers to the bidirectional communication between the central nervous system, gut microbiota, and immune system. Emerging evidence suggests that stress, especially chronic stress during pregnancy, can alter gut microbial composition, which in turn can influence neurotransmitter production, immune activation, and behaviour (Redpath, Rackers and Kimmel, 2019). While direct studies on music's effect on gut microbiota are limited, the indirect effects via stress reduction, vagal tone enhancement, and immunomodulation suggest a plausible pathway through which music could promote gut-brain homeostasis (Foster and Neufeld, 2013). By mitigating stress-related dysbiosis and systemic inflammation, music could help preserve gut microbial diversity – an emerging marker of mental health.

5.5. Neurochemical effects

Music also engages a wide range of brain areas involved in emotion regulation, reward processing, and attachment – such as the amygdala, nucleus accumbens, and prefrontal cortex (Koelsch, 2014). Listening to pleasurable music has been associated with increased dopamine release, which may help counter anhedonia, a common feature of perinatal depression (Salimpoor et al., 2011). Furthermore, oxytocin release – linked to social bonding and maternal behaviours – has been associated with group music-making and singing, suggesting a neurohormonal mechanism underlying mother-infant bonding in musical interventions (Keeler, Hamilton and Rust, 2015).

6. Discussion

Taken together, the evidence suggests that music-based interventions hold significant therapeutic potential throughout the perinatal period – from pregnancy to labour and the postnatal phase. These benefits appear to be mediated by complex PNI mechanisms, including stress regulation, autonomic balance, immunomodulation, and neurohormonal shifts. While current findings are promising, much of the evidence is extrapolated from non-perinatal populations, and the precise biological pathways in pregnant and postpartum women remain incompletely understood. As such, large-scale, longitudinal studies are needed to clarify these mechanisms and inform clinical implementation.

The clinical use of music-based interventions has expanded rapidly in recent decades, with applications across a wide range of healthcare settings. As outlined in this review, music is a low-cost, accessible, and non-invasive adjunct to existing therapies – many of which are limited by side effects, accessibility barriers, or stigma. Despite the abundance of literature, this review focused on a select group of studies to highlight the breadth of music's application across the perinatal timeline. Given the unique physiological and emotional demands of the perinatal period, music-based interventions may represent an invaluable tool for supporting maternal mental health. However, further research – particularly on the PNI effects of music in this population – is essential to optimise intervention design and maximise therapeutic benefit.

CRediT authorship contribution statement

Kiran Kuri: Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rebecca H. Bind:** Writing – review & editing, Visualization, Validation, Supervision. **Lavinia Rebecchini:** Writing – review & editing, Visualization, Validation, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

References

Aalbers, S., Fusar-Poli, L., Freeman, R.E., Spreen, M., Ket, J.C.F., Vink, A.C., Maratos, A., Crawford, M., Chen, X., Gold, C., 2017. Music therapy for depression. Cochrane Database Syst. Rev. (11), CD004517. https://doi.org/10.1002/14651858.CD004517.pub3.

Bauer, A., Knapp, M., Parsonage, M., 2016. Lifetime costs of perinatal anxiety and depression. J. Affect. Disord. 1 (192), 83–90. https://doi.org/10.1016/j.jad.2015.12.005.

Bind, R.H., Estevao, C., Fancourt, D., Hazelgrove, K., Sawyer, K., Rebecchini, L., Miller, C., Dazzan, P., Sevdalis, N., Woods, A., Crane, N., Manoharan, M., Burton, A., Dye, H., Osborn, T., Greenwood, L., Bakolis, I., Lopez, M.B., Davis, R., Perkins, R., Pariante, C.M., 2022. Online singing interventions for postnatal depression in times of social isolation: a feasibility study protocol for the SHAPER-PNDO single-arm trial. Pilot Feasibility Stud. 8, 148. https://doi.org/10.1186/s40814-022-01112-1.

Bind, R.H., Sawyer, K., Hazelgrove, K., Rebecchini, L., Miller, C., Ahmed, S., Dazzan, P., Sevdalis, N., Bakolis, I., Davis, R., Lopez, M.B., Woods, A., Crane, N., Manoharan, M., Burton, A., Dye, H., Osborn, T., Greenwood, L., Perkins, R., Fancourt, D., Pariante, C. M., Estevao, C., 2023. Feasibility, clinical efficacy, and well-being outcomes of an online singing intervention for postnatal depression in the UK: SHAPER-PNDO, a single-arm clinical trial. Pilot Feasibility Stud. 9 (1), 131. https://doi.org/10.1186/s40814-023-01360-9.

Buglione, A., Saccone, G., Mas, M., Raffone, A., Meglio, L.D., Meglio, L.D., Toscano, P., Travaglino, A., Zapparella, R., Duval, M., Zullo, F., Locci, M., 2020. Effect of music on labor and delivery in nulliparous singleton pregnancies: a randomized clinical trial. Arch. Gynecol. Obstet. 301 (3), 693–698. https://doi.org/10.1007/s00404-020-05475-9.

Cao, S., Sun, J., Wang, Y., Zhao, Y., Sheng, Y., Xu, A., 2016. Music therapy improves pregnancy-induced hypertension treatment efficacy. Int. J. Clin. Exp. Med. 9 (5), 8833–8838.

Chang, M., Chen, C., Huang, K., 2008. Effects of music therapy on psychological health of women during pregnancy. J. Clin. Nurs. 17 (19), 2580–2587. https://doi.org/10.1111/j.1365-2702.2007.02064.x.

Corey, K., Fallek, R., Benattar, M., 2019. Bedside music therapy for women during antepartum and postpartum hospitilization. MCN Am. J. Matern./Child Nurs. 44 (5), 277–283. https://doi.org/10.1097/nmc.0000000000000557.

Domínguez-Solís, E., Lima-Serrano, M., Lima-Rodríguez, J.S., 2021. Non-pharmacological interventions to reduce anxiety in pregnancy, labour and postpartum: a systematic review. Midwifery 102, 103126. https://doi.org/10.1016/j.midw.2021.103126.

Estevao, C., Bind, R., Fancourt, D., Sawyer, K., Dazzan, P., Sevdalis, N., Woods, A., Crane, N., Rebecchini, L., Kazelgrove, K., Manoharan, M., Burton, A., Dye, H., Osborn, T., Greenwood, L., David, R.E., Soukup, T., de la Torre, J.A., Bakolis, I., Healey, A., Perkins, R., Pariante, C., 2021. SHAPER-PND trial: clinical effectiveness protocol of a community singing intervention for postnatal depression. BMJ Open 11, e052133. https://doi.org/10.1136/bmjopen-2021-052133.

Fancourt, D., Ockelford, A., Belia, A., 2014. The psychoneuroimmunological effects of music: a systematic review and a new model. Brain Behav. Immun. 36, 15–26. https://doi.org/10.1016/j.bbi.2013.10.014.

Fancourt, D., Perkins, R., Ascenso, S., Carvalho, L.A., Steptoe, A., Williamon, A., 2016. Effects of group drumming interventions on anxiety, depression, social resilience and inflammatory immune response among mental health service users. PLoS One 11 (3), e0151136. https://doi.org/10.1371/journal.pone.0151136.

Fancourt, D., Perkins, R., 2017a. Associations between singing to babies and symptoms of postnatal depression, wellbeing, self-esteem and mother-infant bond. Public Health 145, 149–152. https://doi.org/10.1016/j.puhe.2017.01.016.

Fancourt, D., Perkins, R., 2017b. Maternal engagement with music up to nine months post-birth: findings from a cross-sectional study in England. Psychol. Music 46 (2). https://doi.org/10.1177/0305735617705720.

Fancourt, D., Perkins, R., 2018a. Could listening to music during pregnancy be protective against postnatal depression and poor wellbeing post birth? Longitudinal associations from a preliminary prospective cohort study. BMJ Open 8, e021251. https://doi.org/10.1136/bmjopen-2017-021251.

Fancourt, D., Perkins, R., 2018b. Effect of singing interventions on symptoms of postnatal depression: three-arm randomised controlled trial. BJPsych 212 (2), 119–121. https://doi.org/10.1192/bjp.2017.29.

Foster, J.A., Neufeld, K.A.M., 2013. Gut–brain axis: how the microbiome influences anxiety and depression. Trends Neurosci. 36 (5), 305–312. https://doi.org/10.1016/j.tins.2013.01.005.

Geipel, J., Koenic, J., Hillecke, T.K., Resch, F., Kaess, M., 2018. Music-based interventions to reduce internalizing symptoms in children and adolescents: a meta-analysis. J. Affect. Disord. 224, 647–656. https://doi.org/10.1016/j.jad.2017.08.035.

Glynn, L.M., Davis, E.P., Sandman, C.A., 2013. New insights into the role of perinatal HPA-axis dysregulation in postpartum depression. Neuropeptides 47 (6), 363–370. https://doi.org/10.1016/j.npep.2013.10.007.

Gönenç, I.M., Dikmen, H.A., 2020. Effects of dance and music on pain and fear during childbirth. J. Obstet. Gynecol. Neonatal Nurs. 49 (2), 144–153. https://doi.org/10.1016/j.jogn.2019.12.005.

Greitemeyer, T., 2009. Effects of songs with prosocial lyrics on prosocial behaviour: further evidence and a mediating mechanism. Pers. Soc. Psychol. Bull. 35 (11), 1500–1511. https://doi.org/10.1177/0146167209341648.

Grigoriadis, S., Graves, L., Peer, M., Mamisashvili, L., Tomlinson, G., Vigod, S.N., Dennis, C., Steiner, M., Brown, C., Cheung, A., Dawson, H., Rector, N.A., Guenette, M., Richter, M., 2018. Maternal anxiety during pregnancy and the association with adverse perinatal outcomes: a systematic review and meta-analysis. J. Clin. Psychiatry 79 (5), 17r12011.

Hallam, S., Creech, A., Varvarigou, M., 2017. The Power of Music: an Exploration of the Evidence. Music Education Council, London.

Hallam, S., 2010. Music education: the power of music: its impact on the intellectual, social and personal development of children and young people. Int. J. Music Educ. 28 (3), 269–289. https://doi.org/10.1177/0255761410370658.

Hishikawa, K., Kusaka, T., Fukuda, T., Kohata, Y., 2019. Anxiety or nervousness disturbs the progress of birth based on human behavioral evolutionary biology. J. Perinat. Educ. 28 (4), 218–223. https://doi.org/10.1891/2F1058-1243.28.4.218.

Howard, L.M., Khalifeh, H., 2020. Perinatal mental health: a review of progress and challenges. World Psychiatry 19 (3), 313–327. https://doi.org/10.1002/2Fwps.20769.

Ji, C., Zhao, J., Nie, Q., Wang, S., 2024. The role and outcomes of music therapy during pregnancy: a systematic review of randomised controlled trials. J. Psychosom. Obstet. Gynaecol. 45 (1), 2291635. https://doi.org/10.1080/0167482X.2023.2291635.

Kakar, E., Billar, R.J., Rosmalen, J.V., Klimek, M., Takkenberg, J.J.M., Jeekel, J., 2021. Music intervention to relieve anxiety and pain in adults undergoing cardiac surgery: a systematic review and meta-analysis. Open Heart 8, e001474. https://doi.org/10.1136/openhrt-2020-001474.

Kamioka, H., Tsutani, K., Yamada, M., Park, H., Okuizumi, H., Tsuruoka, K., Honda, T., Okada, S., Park, S., Kitayuguchi, J., Abe, T., Handa, S., Oshio, T., Mutoh, Y., 2014. Effectiveness of music therapy: a summary of systematic reviews based on randomized controlled trials of music interventions. Patient Prefer. Adherence 8, 727–754. https://doi.org/10.2147/PPA.S61340.

Keeler, J., Hamilton, C., Rust, J., 2015. Music and oxytocin: a review of the literature and clinical implications. Front. Psychol. 6, 1073. https://doi.org/10.3389/fpsyg.2015.01073.
Kendell, R.E., Chalmers, J.C., Platz, C., 2018. Epidemiology of puerperal psychoses. BJPsych 150 (5), 662–673. https://doi.org/10.1192/bjp.150.5.662.
Koelsch, S., 2014. Brain correlates of music-evoked emotions. Nat. Rev. Neurosci. 15 (3), 170–180. https://doi.org/10.1038/nrn3666.
Koelsch, S., 2010. Towards a neural basis of music-evoked emotions. Trends Cognit. Sci. 14 (3), 131–137. https://doi.org/10.1016/j.tics.2010.01.002.
Kudo, N., Shinohara, H., Kodama, H., 2014. Heart rate variability biofeedback intervention for reduction of psychological stress during the early postpartum period. Appl. Psychophysiol. Biofeedback 39, 203–211. https://doi.org/10.1007/s10484-014-9259-4.
Leardi, S., Pietroletti, R., Angeloni, G., Necozione, S., Ranalletta, G., Gusto, B.D., 2007. Randomized clinical trial examining the effect of music therapy in stress response to day surgery. Br. J. Surg. 94 (8), 943–947. https://doi.org/10.1002/bjs.5914.
Lin, C., Chang, Y., Chang, Y., Hsiao, Y., Lin, H., Liu, S., Chao, C., Wang, H., Yeh, T., 2019. Music interventions for anxiety in pregnant women: a systematic review and meta-analysis of randomized controlled trials. J. Clin. Med. 8 (11), 1884. https://doi.org/10.3390/jcm8111884.
Lin, H., Chang, Y., Chou, H., Chang, C., Huang, M., Liu, S., Tsai, C., Lei, W., Yeh, T., 2019. Effect of music interventions on anxiety during labour: a systematic review and meta-analysis of randomized controlled trials. PeerJ 7, e6945. https://doi.org/10.7717/2Fpeerj.6945.
Liu, Y., Lee, C.S., Yu, C., 2015. Effects of music listening on stress, anxiety, and sleep quality for sleep-disturbed pregnant women. Women Health 56 (3), 296–311. https://doi.org/10.1080/03630242.2015.1088116.
MacDonald, R.A.R., 2013. Music, health and well-being: a review. Int. J. Qual. Stud. Health Well-Being 8 (1), 20635. https://doi.org/10.3402/2Fqhw.v8i0.20635.
MacDonald, R., Kreutz, G., Mitchell, L. (Eds.), 2012. Music, Health, and Wellbeing. Oxford University Press, Oxford.
Massimello, F., Billeci, L., Canu, A., Montt-Guevara, M.M., Impastato, G., Varanini, M., Giannini, A., Simoncini, T., Mannella, P., 2022. Music modulates autonomic nervous system activity in human fetuses. Front. Med. 9. https://doi.org/10.3389/fmed.2022.857591.
Mor, G., Abrahams, V., Arici, A., 2002. Immunology of pregnancy: strategies for immune modulation. Immunol. Allergy Clin. 22 (3), 545–565.
Mughal, S., Azhar, Y., Siddiqui, W., 2022. Postpartum depression. StatPearls. Available at: https://www.ncbi.nlm.nih.gov/books/NBK519070/. (Accessed 30 May 2025).
Müller, W., Haffelder, G., Schlotmann, A., Schaefers, A.T.U., Teuchert-Noodt, G., 2014. Amelioration of psychiatric symptoms through exposure to music individually adapted to brain rhythm disorders – a randomised clinical trial on the basis of fundamental research. Cogn. Neuropsychiatry 19 (5), 399–413. https://doi.org/10.1080/13546805.2013.879054.
Nanji, J.A., Carvalho, B., 2020. Pain management during labour and vaginal birth. Best Pract. Res. Clin. Obstet. Gynaecol. 67, 100–112. https://doi.org/10.1016/j.bpobgyn.2020.03.002.
NHS, 2024. Perinatal mental health. Available at: https://www.england.nhs.uk/mental-health/perinatal/#:~:text=Perinatal%20mental%20health%20(PMH)%20problems,a%20wide%20range%20of%20conditions. (Accessed 30 May 2025).
Nwebube, C., Glover, V., Stewart, L., 2017. Prenatal listening to songs composed for pregnancy and symptoms of anxiety and depression: a pilot study. BMC Compl. Alternative Med. 17 (256). https://doi.org/10.1186/s12906-017-1759-3.
O'Donnell, K.J., Meaney, M.J., 2017. Fetal origins of mental health: the developmental origins of health and disease hypothesis. Am. J. Psychiatr. 174 (4), 319–328. https://doi.org/10.1176/appi.ajp.2016.16020138.
O'Hara, M.W., Wisner, K.L., 2014. Perinatal mental illness: definition, description and aetiology. Best Pract. Res. Clin. Obstet. Gynaecol. 28 (1), 3–12. https://doi.org/10.1016/j.bpobgyn.2013.09.002.
Okun, M.L., Schetter, C.D., Glynn, L.M., 2011. Poor sleep quality is associated with preterm birth. Sleep 34 (11), 1493–1498. https://doi.org/10.5665/sleep.1384.
Rebecchini, L., 2021. Music, mental health, and immunity. Brain Behav Immun. Health 21, 100374. https://doi.org/10.1016/j.bbih.2021.100374.
Redpath, N., Rackers, H.S., Kimmel, M.C., 2019. The relationship between perinatal mental health and stress: a review of the microbiome. Curr. Psychiatry Rep. 21 (18). https://doi.org/10.1007/s11920-019-0998-z.
Rees, S., Channon, S., Waters, C.S., 2018. The impact of maternal prenatal and postnatal anxiety on children's emotional problems: a systematic review. Eur. Child Adolesc. Psychiatr. 28, 257–280. https://doi.org/10.1007/s00787-018-1173-5.
Romero, R., Espinoza, J., Gonçalves, L.F., Kusanovic, J.P., Friel, L.A., Nien, J.K., 2021. Inflammation in preterm and term labor and delivery. Semin. Fetal Neonatal Med. 11 (5), 317–326. https://doi.org/10.1016/2Fj.siny.2006.05.001.
Sanfilippo, K.R.M., Steward, L., Glover, V., 2021. How music may support perinatal mental health: an overview. Arch. Womens Ment. Health 24, 831–839. https://doi.org/10.1007/s00737-021-01178-5.
Thayer, J.F., Lane, R.D., 2000. A model of neurovisceral integration in emotion regulation and dysregulation. J. Affect. Disord. 61 (3), 201–216. https://doi.org/10.1016/S0165-0327(00)00338-4.
Toker, E., Kömürcü, N., 2017. Effect of Turkish classical music on prenatal anxiety and satisfaction: a randomised controlled trial in pregnant women with pre-eclampsia. Compl. Ther. Med. 30, 1–9. https://doi.org/10.1016/j.ctim.2016.11.005.
Ulrich, G., Houtmans, T., Gold, C., 2007. The additional therapeutic effect of group music therapy for schizophrenic patients: a randomized study. Acta Psychiatr. Scand. 116 (5), 362–370. https://doi.org/10.1111/j.1600-0447.2007.01073.x.
Van Willenswaard, C.K., Lynn, F., McNeill, J., McQueen, K., Dennis, C., Lobel, M., Alderdice, F., 2017. Music interventions to reduce stress and anxiety in pregnancy: a systematic review and meta-analysis. BMC Pyschiatry 17 (271). https://doi.org/10.1186/s12888-017-1432-x.
Williams, E., Dingle, G.A., Clift, S., 2018. A systematic review of mental health and wellbeing outcomes of group singing for adults with a mental health condition. Eur. J. Publ. Health 28 (6), 1035–1042. https://doi.org/10.1093/eurpub/cky115.
World Health Organization, 2022. Launch of the WHO guide for integration of perinatal mental health in maternal and child health services. Available at: https://www.who.int/news/item/19-09-2022-launch-of-the-who-guide-for-integration-of-perinatal-mental-health#:~:text=Almost%201%20in%205%20women,the%20year%20after%20the%20birth. (Accessed 30 May 2025).
Xiao, X., Chen, W., Zhang, X., 2023. The effect and mechanisms of music therapy on the autonomic nervous system and brain networks of patients of minimal conscious states: a randomized controlled trial. Front. Neurosci. 17, 1182181. https://doi.org/10.3389/fnins.2023.1182181.
Yang, M., Li, L., Zhu, H., Alexander, I.M., Liu, S., Zhou, W., Ren, X., 2009. Music therapy to relieve anxiety in pregnant women on bedrest. Mot. Cycle News (MCN) 34 (5), 316–323. https://doi.org/10.3389/fnins.2023.1182181.
Zauderer, C., 2009. Postpartum depression: how childbirth educators can help break the silence. J. Perinat. Educ. 18 (2), 23–31. https://doi.org/10.1624/2F105812409X426305.
Zhang, A., Zou, T., Guo, D., Wang, Q., Shen, Y., Hu, H., Ye, B., Xiang, M., 2021. The immune system can hear noise. Front. Immunol. 11, 619189. https://doi.org/10.3389/fimmu.2020.619189.
Zijlmans, M.A.C., Beijers, R., Riksen-Walraven, M.J., de Weerth, C., 2017. Maternal late pregnancy anxiety and stress is associated with children's health: a longitudinal study. Stress 20 (5), 495–504. https://doi.org/10.1080/10253890.2017.1348497.