Music as an aid for postoperative recovery in adults: a systematic review and meta-analysis

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Summary

Background **Music is a non-invasive, safe, and inexpensive intervention that can be delivered easily and successfully. We did a systematic review and meta-analysis to assess whether music improves recovery after surgical procedures.**

Methods **We included randomised controlled trials (RCTs) of adult patients undergoing surgical procedures, excluding those involving the central nervous system or head and neck, published in any language. We included RCTs in which any form of music initiated before, during, or after surgery was compared with standard care or other non-drug interventions. We searched MEDLINE, Embase, CINAHL, and Cochrane Central. We did meta-analysis with RevMan (version 5.2), with standardised mean differences (SMD) and random-effects models, and used Stata (version 12) for meta-regression. This study is registered with PROSPERO, number CRD42013005220.**

Findings **We identified 4261 titles and abstracts, and included 73 RCTs in the systematic review, with size varying between 20 and 458 participants. Choice of music, timing, and duration varied. Comparators included routine care, headphones with no music, white noise, and undisturbed bed rest. Music reduced postoperative pain (SMD –0·77 [95% CI –0·99 to –0·56]), anxiety (–0·68 [–0·95 to –0·41]), and analgesia use (–0·37 [–0·54 to –0·20]), and increased patient satisfaction (1·09 [0·51 to 1·68]), but length of stay did not differ (SMD –0·11 [–0·35 to 0·12]). Subgroup analyses showed that choice of music and timing of delivery made little difference to outcomes. Meta-regression identified no causes of heterogeneity in eight variables assessed. Music was effective even when patients were under general anaesthetic.**

Interpretation **Music could be offered as a way to help patients reduce pain and anxiety during the postoperative period. Timing and delivery can be adapted to individual clinical settings and medical teams.**

Funding **None.**

Lancet 2015; 386: 1659–71

Published Online
August 13, 2015
http://dx.doi.org/10.1016/S0140-6736(15)60169-6

This online publication has been corrected. The corrected version first appeared at thelancet.com on October 5, 2015

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Introduction

Most people undergo a surgical procedure at some point in their lives—more than 51 million operative procedures are done every year in the USA,[1] and 4·6 million hospital admissions per year in England lead to surgical care.[2] A trend is emerging towards undertaking surgical procedures without general anaesthesia—for example, hysteroscopy and caesarean section. Irrespective of whether anaesthesia is used, the postoperative period is a difficult time for patients. The term postoperative recovery has not been precisely defined, but is clinical and includes restoration of the patient's cerebral and motor function. Surgical recovery strategies, such as Enhanced Recovery (a set of interventions aimed at improving patient outcomes and reducing their length of stay in hospital),[3–5] recommend several successful perioperative interventions. Some preoperative strategies, such as patient education and nutritional additives, reduce postoperative analgesia needs and improve patient satisfaction,[3–5] but not all potentially useful interventions have been assessed or incorporated.

Use of music to improve patients' hospital experience has a long history in medical care, including by Florence Nightingale.[6] Music was first described being used to help patients during operations by Evan Kane[7] in 1914. Several studies have investigated music's effect on emotions and neurophysiology.[8–10] Pre-recorded music through headphones, musical pillows, or background sound systems can be a non-invasive, safe, and inexpensive intervention compared with pharmaceuticals, and can be delivered easily and successfully in a medical setting.[11] Music has frequently been investigated in the context of recovery from operative procedures, and several randomised controlled trials (RCTs) have shown positive effects on patients' postoperative recovery.[12,13] This use of music differs from music therapy, which is a cognitive rehabilitation method.[14]

Previous systematic reviews have investigated music and its role in specific surgical procedures, such as colonoscopy,[15,16] or in only one aspect of patient experience in isolation, such as preoperative anxiety[17] or postoperative pain.[18,19] Cepeda and colleagues[20] investigated use of music for pain relief in both surgical and non-surgical settings. Nilsson[21] comprehensively reviewed 60 articles about use of music in the perioperative period but did not do a meta-analysis.[21] No previous reports have provided a comprehensive overview with meta-analyses and meta-regression.

At present, music is not used routinely perioperatively. Until now, scarcity of uptake might be due to ignorance or scepticism about the effectiveness of music.[22]

Despite the large number of relevant studies, music has not been implemented as a therapeutic intervention

For **Enhanced Recovery** see http://www.institute.nhs.uk/quality_and_service_improvement_tools/quality_and_service_improvement_tools/enhanced_recovery_programme.html

in everyday surgical practice because information about effectiveness has not been synthesised and disseminated universally. We assess effectiveness of music in improvement of postoperative recovery, incorporate all available RCTs, review effects of music on common outcome measures for postoperative care (pain, analgesia needs, anxiety, and length of stay), and investigate relevant subgroups (patient choice of music, timing of intervention, and whether general anaesthesia was used).

Methods

Search strategy and selection criteria

The predefined inclusion criteria were RCTs in any language with adult patients undergoing any form of surgical procedure (with or without sedation or anaesthesia) to any part of the body excluding the central nervous system or head and neck (because of potential hearing impairment). We compared any form of music initiated before, during, or after surgery with standard care or any other non-drug interventions such as massage, undisturbed rest, or relaxation. Outcomes of interest were: postoperative pain, analgesia needs, anxiety, infection rates, wound healing, costs, length of stay, and satisfaction with care. Analgesia use included any opioids or non-steroidal anti-inflammatory drugs (NSAIDs). If both were reported, we included opioid use in the meta-analyses. We measured outcomes up to 6 weeks postoperatively. We investigated subgroups of: pain before surgery and 4 h postoperatively; timing of intervention before, during, or after surgery; general anaesthetic versus no anaesthetic; and whether the patient was given choice of music. We recorded whether music given during surgery was started after induction of anaesthesia.

We searched the following databases: MEDLINE (Jan 1, 1946–Oct 1, 2013), Embase (Jan 1, 1947–Oct 1, 2013), CINAHL (Jan 1, 1960–Oct 1, 2013), and Cochrane Central (Jan 1, 1898–Oct 1, 2013). We did keyword and MeSH searches for "music" or "music therapy" and any of the following: "surg*", "operat*", "recovery", "recuperation", "rehabilitation", "convalescence", or "post-op*". We checked reference lists of relevant reviews for additional studies. We transferred all relevant titles and abstracts to Endnote Web for assessment.

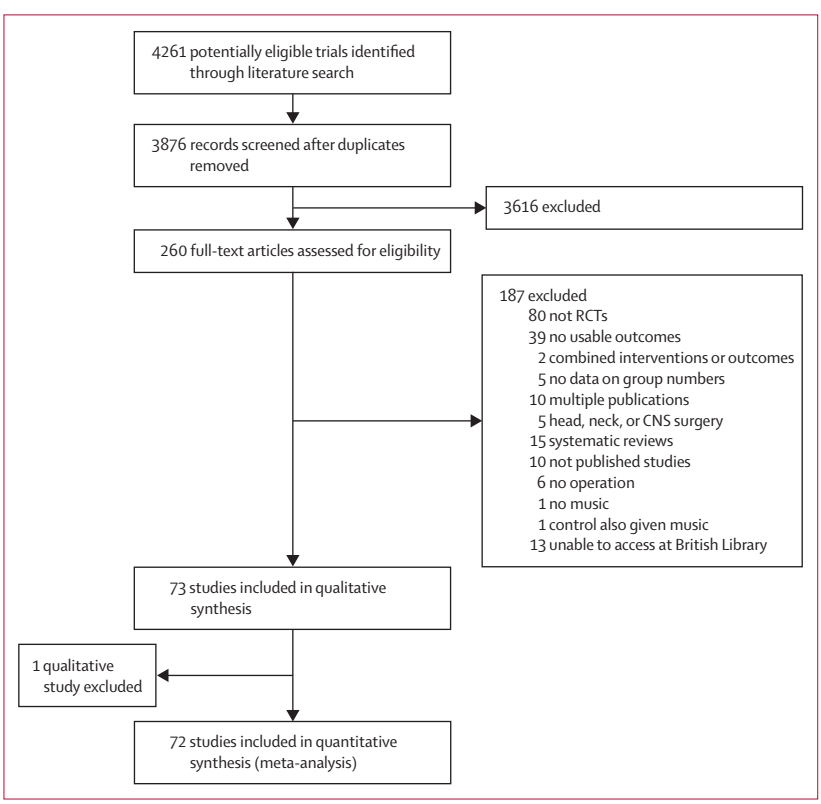

Figure 1: **PRISMA flow diagram**
RCT=randomised controlled trial. CNS=central nervous sytem.

Data extraction and quality assessment

Two investigators (JH and MH) checked study eligibility. Both independently extracted data from studies using a standardised, predesigned extraction form in Microsoft Excel 2007. Disagreements were resolved through discussion or referral to a senior investigator (CM). We assessed quality of included studies with criteria set by The York Centre for Reviews and Dissemination,[23] focusing on randomisation, allocation concealment, presence of masking, explanation of withdrawals, and presence or absence of intention-to-treat analysis.

Statistical analysis

We tabulated characteristics and results of all included studies; analysis was quantitative. When standard errors or ranges were provided, standard deviations were calculated with standard formulae. We used Review Manager (version 5.2, Cochrane Library) for meta-analyses. We used random-effects models because of heterogeneity of participants and interventions. All outcomes were continuous measures, and we used standardised mean differences (SMD) when outcomes had differing measurement scales. Risk of publication bias was assessed by use of funnel plots. In addition to presenting SMD, which can be difficult to interpret clinically, we did back transformations of two outcomes (pain and anxiety) used in the included RCTs. We calculated back transformations with Microsoft Excel 2007. For the pain outcome, we used a mean of control group standard deviations from the RCTs measuring pain using a visual analogue scale (VAS). For the anxiety outcome, we used a mean of control group standard deviations from RCTs measuring anxiety with the state-trait anxiety inventory (STAI). To further investigate heterogeneity, we did meta-regressions with Stata version 12.

This study is registered with PROSPERO, number CRD42013005220.

Role of the funding source
There was no funding source for this study. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

We identified 4261 titles and abstracts, of which we assessed 260 articles for inclusion (238 from database searches and 22 from reference lists; figure 1). We included 73 RCTs in the qualitative synthesis and 72 RCTs in quantitative syntheses (listed in the appendix), excluding one study that did not have quantitative data. Publication bias is not likely to have much effect on our findings because studies are evenly distributed either side of the SMD for postoperative pain (–0·77) (figure 2).

Characteristics of included studies are shown in table 1. The size of the studies varied between 20 and 458 participants, and participants underwent various surgical procedures ranging from minor endoscopic interventions to transplantation surgery. Most studies included only elective procedures. Choice of music could be made by patient or researcher. Patients chose a wide variety of styles. Researchers identified single types of music such as Chinese classical music, or gave patients choice from a list of six or more styles. Most styles were soothing. Delivery could be by headphones or music pillows for patients only to hear or by loudspeakers, which could be heard by the medical team. Music delivered by headphones was often at a sufficiently low volume for patients to be able to communicate easily. Timing could be before, during, or after surgery, or a combination of these timings. Music could be played when patients were awake or anaesthetised. Duration of music varied between a few minutes to repeated episodes for several days. Comparator descriptions varied and included routine care, headphones with no music, white noise, and undisturbed bed rest. Duration and timing was usually similar to that of interventions. Outcomes included postoperative pain, analgesia needs, anxiety, length of stay, and satisfaction with care. None of the RCTs measured infection rates, wound healing, or costs. Some outcomes were measured during or soon after the procedure, others were measured at several times during the hospital stay.

Studies measured various outcomes (table 2). Pain was usually measured with VAS or numerical rating scales (NRS). An indirect measure of pain was use of analgesia, which varied substantially among studies, including paracetamol, opioid-based drugs such as pethidine, fentanyl, and morphine, and NSAIDs such as diclofenac and ibuprofen.

Quality of included studies varied (table 3), but several studies gave insufficient details to assess all aspects of quality. An intervention such as music cannot be masked to the patient unless the patient is under general anaesthesia; masking of investigators and outcome assessment is possible, but was not stated in many studies. When music was delivered to a patient under anaesthesia, whether masking was used was unclear.

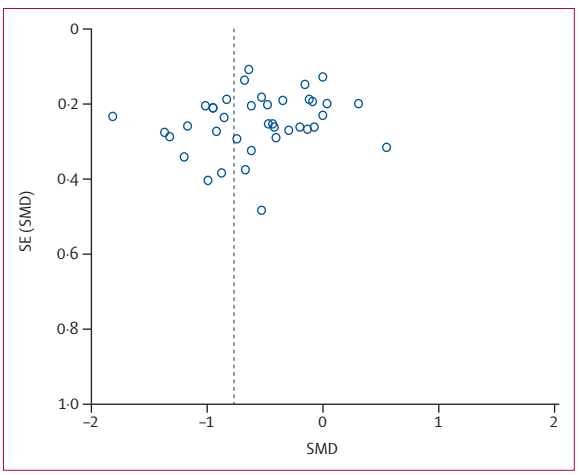

Figure 2: **Funnel plot with pain outcome**
SE=standard error. SMD=standardised mean difference.

Music reduced postoperative pain (45 RCTS, SMD –0·77 [95% CI –0·99 to –0·56]), anxiety (43 RCTS, –0·68 [–0·95 to –0·41]), and analgesia use (34 RCTS, –0·37 [–0·54 to –0·20]), and increased patient satisfaction (16 RCTS, 1·09 [0·51 to 1·68]), but did not affect length of stay (seven RCTs, –0·11 [–0·35 to 0·12]; figure 3). SMDs for the pain and anxiety outcomes were back calculated into specific measurements most used in the RCTs. Pain results (measured by 100 mm VAS) suggested that music reduced pain scores by 23 mm (95% CI 16·9–29·9) on average, compared with placebo. Anxiety results (measured by STAI on a scale of 20–80) were reduced by 6·4 units (3·86–8·94; on average, compared with placebo).

Heterogeneity was high for pain, anxiety, and analgesia use, with I^2 varying between 75% and 92%; heterogeneity for length of stay was 0%. No RCTs reported wound healing rates, costs, wound infections, or serious adverse events. A subgroup analysis by type of control (routine care *vs* control with attention) showed that type of control made no difference to effectiveness of music. Univariate meta-regression analysis to explain heterogeneity did not show a statistically significant effect of any of the eight variables (patient choice, timing of music, general anaesthetic, use of VAS to measure pain *vs* other pain measures, routine care *vs* other comparisons, endoscopy-type procedures *vs* surgery, allocation concealment, and masking of outcome assessment) on the pain outcome. Because we identified no significant outcomes by univariate meta-regression, we did not do multivariate meta-regression.

We categorised pragmatically into pain measured between 0 h and 4 h after surgery and pain measured more than 4 h after surgery. We identified no difference between pain measured at 0–4 h after surgery (SMD –0·79 [95% CI –1·06 to –0·52]) and pain

See Online for appendix

	Number of participants		Control groups	Procedure	General anaesthetic?	Music type	Patient choice?	Timing of delivery	Duration of music
	Intervention	Control							
Agwu and Okoye (2006)	50	50	Routine care	Hysterosalpingography	No	Patient's own	Yes	Intraoperative	Duration of procedure
Allred et al (2010)	39	39	Rest period	Knee arthroplasty	Not specified	Easy listening	Yes	Postoperative	20 min
Angioli et al (2013)	185	187	Routine care	Hysteroscopy	No	Patient choice	Yes	Intraoperative	Duration of procedure
Argstatter et al (2006)	28 (music); 28 (music and coaching)	27	Routine care	Intracardiac catheterisation	No	Relaxation	No	Intraoperative	Duration of procedure
Ayoub et al (2005)	31	28 (operating room noise); 31 (white noise)	Operating room noise; white noise	Urological procedures	No	Patient own CD/choice	Yes	Intraoperative	Duration of procedure
Bally et al (2003)	58	55	Routine care	Coronary angiography	No	Patient's own	Yes	Preoperative, intraoperative, and postoperative	Not specified
Barnason et al (1995)	33 (music); 29 (music and visual imaging)	34	Undisturbed bed rest	CABG	Yes	Soothing	Yes	Postoperative	30 min
Bechtold et al (2006)	85	81	Routine care	Colonoscopy	No	Watermark by Enya	No	Preoperative and intraoperative	Duration of procedure
Binns-Turner et al (2011)	15	15	Blank iPod	Mastectomy	Yes	Various	Yes	Preoperative and intraoperative	Duration of procedure
Blankfield et al (1995)	32 (music); 34 (music and therapeutic suggestion)	29	Blank cassette tape	CABG	Yes	Dream flight 2	No	Intraoperative and postoperative	Duration of procedure
Chan et al (2003)	112	108	Routine care	Colposcopy	No	Slow, rhythmic	No	Intraoperative	Duration of procedure
Chan (2007)	35	35	Undisturbed bed rest	C-clamp post PCI	No	Slow and soft	No	Intraoperative	45 min
Chlan et al (2000)	30	34	Routine care	Sigmoidoscopy	No	Various	Yes	Intraoperative	Duration of procedure
Colt et al (1999)	30	30	Headphones only	Bronchoscopy	No	Soft piano	No	Intraoperative	Duration of procedure
Costa et al (2010)	56	53	Mute headphones	Colonoscopy	No	Various	Yes	Preoperative and intraoperative	Duration of procedure; preoperative not specified
Cutshall et al (2011)	49	51	Bed rest	Cardiac surgery	Yes	Relaxing	Yes	Postoperative	20 min
Danhauer et al (2007)	56	58 (routine care); 56 (guided imagery)	Routine care; guided imagery	Colposcopy	No	Relaxing	Yes	Intraoperative	Duration of procedure
Ebneshahidi and Mohseni (2008)	38	39	No music, headphones	Caesarean section	Not specified	Patient choice	Yes	Postoperative	30 min
Fredriksson et al (2009)	25 (music–ordinary sound–music); 25 (ordinary sound–music–ordinary sound)	..	..	Various	Not specified	Musicure	No	Postoperative	30 min per sound
Ghetti (2011)	9 (music); 11 (music and discussion)	9	Routine care	Transplant surgery	Yes	Instrumental	Yes	Postoperative	30–40 min
Good (1995)	21 (music); 21 (music and relaxation)	21 (routine care); 21 (jaw relaxation)	Routine care; jaw relaxation	Abdominal surgery	Yes	Sedative	Yes	Postoperative	2 min, and whenever else the patient chose
Good et al (1999)	122 (music); 109 (jaw relaxation)	111	Routine care	Abdominal surgery	Yes	Sedative	Yes	Postoperative	Before, during, and after ambulation

(Table 1 continues on next page)

	Number of participants		Control groups	Procedure	General anaesthetic?	Music type	Patient choice?	Timing of delivery	Duration of music
	Intervention	Control							
(Continued from previous page)									
Gravesen and Sommer (2013)	40	35	Routine care	Laparascopic cholecystectomy	Yes	Soft music	No	Preoperative, intraoperative, and postoperative	Until patient discharge
Guerrero et al (2012)	54	47	Routine care	MVA abortion	No	Patient choice	Yes	Intraoperative	Duration of procedure
Harikumar et al (2006)	38	40	No music, headphones	Colonoscopy	No	Various	Yes	Intraoperative	Duration of procedure
Hook et al (2008)	51	51	Routine care	General abdominal	Yes	Various	Yes	Postoperative	8×30 min
Iblher et al (2011)	25 (early postoperative music); 24 (late postoperative music)	25 (no music, headphones, early postoperatively); 27 (no music, headphones, late postoperatively); 25 (routine care)	No music, headphones early postoperatively; no music, headphones late postoperatively; routine care	Open cardiac surgery	Yes	Baroque	No	Postoperative	60 min
Ikonomidou et al (2004)	29	26	White noise, headphones	Lap sterilisation	Yes	Pan flute music	No	Preoperative and postoperative	30 min
Jafari et al (2012)	30	30	No music, headphones	CABG or valve repair	Yes	60–80 bpm	Yes	Preoperative and postoperative	30 min
Jimenez-Jimenez et al (2013)	20	20	Routine care	Varicose vein surgery	No	Classical	No	Intraoperative	Duration of procedure
Johnson (2012)	43	43	No music, headphones	Gynaecological surgery	Varies	Various	Yes	Preoperative	Not specified
Kliempt (1999)	25 (music); 25 (hemisync)	26	No music, headphones	General surgery	Yes	Classical	No	Intraoperative	Duration of procedure
Lee et al (2002)	55 (music and PCA)	55	Routine care and PCA	Colonoscopy	No	Various	Yes	Intraoperative	Duration of procedure
Lepage et al (2001)	25	25	Routine care	Ambulatory surgery	No	Various	Yes	Preoperative and postoperative	Not specified
Li et al (2011)	60	60	Routine care	Breast surgery	Yes	Patient choice	Yes	Postoperative	30 min twice daily
Li et al (2012)	30	30	Relaxation	LSCS	No	Chinese classical	Yes	Preoperative	30 min
López-Cepero Andrada et al (2004)	63	55	Routine care	Colonoscopy	No	Classical	No	Preoperative and intraoperative	Duration of procedure
Maeyama et al (2009)	29	29	Routine care	Various	No	Classical	No	Intraoperative	Duration of procedure
McCaffrey and Locsin (2006)	62	62	Routine care	Lower limb orthopaedic	Yes	Various	Yes	Postoperative	Minimum 4 h daily
Migneault et al (2004)	15	15	No music, headphones	Open gynaecological	Yes	Various	Yes	Intraoperative	Duration of procedure
Mullooly et al (1988)	14	14	Routine care	Hysterectomy	Yes	Instrumental	No	Postoperative	10 min
Nilsson et al (2001)	30 (music); 31 (music and therapeutic suggestion)	34	Sound of operating room	Hysterectomy	Yes	Soothing	No	Intraoperative	Duration of procedure
Nilsson et al (2003a)	62 (music); 57 (music and therapeutic suggestion)	63	Blank tape, headphones	Hernia or varicose vein surgery	Yes	Soft instrumental	No	Postoperative	Patient requests cessation
Nilsson et al (2003b)	51 (intraoperative music, postoperative white noise); 1 (postoperative music, intraoperative white noise)	49	White noise	Hernia or varicose vein surgery	Yes	Instrumental	No	Intraoperative	Duration of procedure and 1 h after procedure

(Table 1 continues on next page)

	Number of participants		Control groups	Procedure	General anaesthetic?	Music type	Patient choice?	Timing of delivery	Duration of music
	Intervention	Control							
(Continued from previous page)									
Nilsson et al (2005)	25 (intraoperative music); 25 (postoperative music)	25	No music, headphones	Hernia repair	Yes	Relaxing	No	Intraoperative and postoperative	Duration of the procedure
Nilsson (2009a)	121	119	Routine care	Coronary angiography	No	Relaxing	No	Intraoperative	Duration of procedure
Nilsson (2009b)	28	30	Bed rest	Open CABG or valve replacement	Yes	Relaxing	No	Postoperative	30 min and 30 min rest
Nilsson et al (2009)	20	20	Routine care	Open CABG or valve replacement	Yes	Relaxing	No	Postoperative	30 min
Nilsson (2012)	34	34	Routine care	Coronary angiography	No	Musicure	No	Intraoperative	Duration of procedure
Ovayolu et al (2006)	30	30	Routine care	Colonoscopy	No	Turkish classical	No	Preoperative and intraoperative	30 min
Palakanis et al (1994)	25	25	Routine care	Sigmoidoscopy	No	Various	Yes	Intraoperative	Duration of procedure
Reza et al (2007)	50	50	White noise, headphones	Elective caesarean section	Yes	Spanish guitar	No	Intraoperative	Duration of procedure
Salmore and Nelson (1999)	15 (OGD); 15 colonoscopy	33	Routine care	OGD and colonoscopy	No	Relaxing	No	Preoperative and intraoperative	Duration of procedure
Sen et al (2009)	30	30	No music, headphones	Urological procedures	No	Patient choice	Yes	Intraoperative	Duration of procedure
Sen et al (2010)	35	35	Routine care	Pfannenstiel LSCS	Yes	Patient choice	Yes	Postoperative	1 h
Sendelbach et al (2006)	50	36	Bed rest	Cardiac surgery	Yes	Easy listening	Yes	Postoperative	20 min twice daily for 3 days
Shabanloei et al (2010)	50	50	Routine care	Bone marrow biopsy	No	Relaxing	No	Intraoperative	Duration of procedure
Simcock et al (2008)	15	15	White noise, headphones	Knee arthroplasty	No	Patient choice	Yes	Intraoperative	Duration of procedure
Smolen et al (2002)	16	16	Routine care	Colonoscopy	No	Patient's own	Yes	Preoperative and intraoperative	Duration of procedure
Szmuk et al (2008)	20	20	No music, headphones	Laparascopic hernia repair or cholecystectomy	Yes	Various	Yes	Intraoperative	Duration of procedure
Taylor-Piliae and Chair (2002)	15	15	Information about procedure	Cardiac catheterisation	No	Patient choice	Yes	Preoperative	15–20 min
Triller (2006)	93	107	Routine care	Bronchoscopy	No	Relaxation	No	Intraoperative	Duration of procedure
Tsivian et al (2012)	31	28	Routine care	Prostate biopsy	No	Classical	No	Intraoperative	Duration of procedure
Twiss et al (2006)	42	44	Routine care	CABG or valve surgery	Yes	Prescriptive	Yes	Intraoperative and postoperative	Duration of procedure and 3 days after procedure
Vachiramon et al (2013)	50	50	Routine care	Mohs surgery	No	Patient choice	Yes	Preoperative and intraoperative	Duration of procedure
Voss et al (2004)	20	21	Talking to staff	Open heart surgery	Yes	Sedative	Yes	Postoperative	30 min
Weeks and Nilsson (2011)	30 (music—loudspeaker); 34 (music pillow)	34	Routine care	Coronary angiogram or PCI	No	Musicure	No	Intraoperative	Duration of procedure
Wu et al (2013)	26	14	Routine care	Hand surgery	No	Patient choice	Yes	Preoperative and intraoperative	Not stated

(Table 1 continues on next page)

	Number of participants		Control groups	Procedure	General anaesthetic?	Music type	Patient choice?	Timing of delivery	Duration of music
	Intervention	Control							
(Continued from previous page)									
Wu et al (2012)	13	13	Routine care	Termination of pregnancy	No	Patient choice	Yes	Intraoperative	Duration of procedure
Yeo et al (2013)	35	35	No music, headphones	Cystoscopy	No	Classical	No	Intraoperative	Duration of procedure
Zengin et al (2013)	50	50	Routine care	Catheter placement	No	Turkish classical	No	Intraoperative	Duration of procedure
Zhang et al (2005)	55	55	No music, headphones	Hysterectomy	Yes	Calming	Yes	Intraoperative	Duration of procedure
Zimmerman et al (1996)	32 (music); 32 (music and video)	32	Routine care and rest	CABG	Yes	Patient choice	Yes	Postoperative	30 min

CABG=coronary artery bypass graft. PCI=percutaneous coronary intervention. Hemisync=a patented process used to create audio patterns designed to evoke effects on the brain. MVA=manual vacuum aspiration. bpm=beats per minute. PCA=patient-controlled analgesia. LSCS=lower segment Caesarean section. OGD=oesophagogastro-duodenoscopy. References are listed in the appendix.

Table 1: **Study characteristics**

measured more than 4 h after surgery (–0·76 [–1·19 to –0·33]; figure 3). The appendix contains individual subgroup meta-analyses.

When patients were allowed to choose the music (from personal choice or from a playlist) we noted a slightly increased but non-significant reduction in pain, compared with when patients had no choice (figure 3). Similarly, with patient choice, we recorded a small but non-significant reduction in analgesia use compared with when patients had no choice of music (figure 3). However, we recorded a slight but non-significant increase in anxiety when patients had a choice of music compared with when they had no choice (figure 3).

Pain seemed to be reduced most when music was played preoperatively (SMD –1·28 [–2·03 to –0·54]), then intraoperatively (–0·89 [–1·20 to –0·57]), and then postoperatively (–0·71 [–1·03 to –0·39]). We noted a similar pattern with analgesia use and anxiety. Analgesia use was reduced when music was played preoperatively (–0·43 [–0·67 to –0·20]), compared with intraoperatively (–0·41 [–0·70 to –0·12]), and postoperatively (–0·27 [–0·45 to –0·09]). Anxiety was likewise reduced when music was used preoperatively (–1·12 [–2·05 to –0·19]), compared with intraoperatively (–0·83 [–1·19 to –0·47]), and postoperatively (–0·50 [–0·96 to –0·04]).

Music reduced pain, even when given under general anaesthetic, but the intervention had an increased effect on pain when patients were conscious (SMD –1·05 [95% CI –1·45 to –0·64]) compared with under general anaesthetic (–0·49 [–0·74 to –0·25]). Similarly, music reduced analgesia use when given intraoperatively under general anaesthetic (SMD –0·58 [95% CI –1·05 to –0·11]) but had an increased effect when patients were conscious (–0·26 [–0·44 to –0·07]), and a similar effect was recorded for anxiety (–0·91 [–1·33 to –0·48] for music given under general anaesthetic *vs* –0·48 [–0·91 to –0·05] when patients were conscious).

None of the included studies reported side-effects. However, some studies reported that they ensured that the low volume at which music was delivered enabled communication with medical teams.

Discussion

Our systematic review and meta-analysis suggests that music played in the perioperative setting can reduce postoperative pain, anxiety, and analgesia needs, and improve patient satisfaction. However, we identified no difference in length of stay, although few studies measured it. None of the studies investigated effects of music on infections, wound healing rates, or costs.

We used wide inclusion criteria to make results more generalisable to clinical practice. One could argue that we should not have combined very heterogeneous studies because of clinical differences. For example, is meta-analysis of studies that used different analgesics worthwhile? Strong pain tends to be alleviated with strong analgesia, whereas mild pain responds to mild analgesia. Therefore, relative reduction in pain is of interest. We made the pragmatic decision that to combine all studies reporting analgesia use would be more useful clinically than to group specific types of analgesics. This decision was extended to other aspects of clinical heterogeneity such as age groups, types of interventions, and whether the intervention was done awake or under general anaesthesia. Measures of heterogeneity in the meta-analyses suggested a large amount of statistical heterogeneity in the main analyses for pain, analgesia use, and anxiety. To mitigate this effect, we used random-effects meta-analyses, although this approach only partly removes effects of heterogeneity.[24] Nevertheless, we considered that to combine data would provide a more clinically useful result than to include a small number of homogeneous studies. Because we combined clinically heterogeneous studies, we cannot be sure whether music applies equally to all clinical scenarios. However, we

	Pain score reported?	Analgesia use reported?	Anxiety score reported?	Length of stay reported?	Other outcome(s) reported?
Agwu and Okoye (2006)	No	No	Yes, STAI	No	Physiological parameters, HR and BP
Allred et al (2010)	Yes, VAS	No	Yes, VAS	No	No
Angioli et al (2013)	Yes, VAS	No	Yes, STAI	No	No
Argstatter et al (2006)	No	No	Yes, STAI and VAS*	No	Physiological parameters, HR and BP
Ayoub et al (2005)	No	Yes, mg per drug	No	Yes, PACU admission length	No
Bally et al (2003)	Yes, VAS	Yes, mg per drug	Yes, STAI	No	No
Barnason et al (1995)	No	No	Yes, STAI	No	No
Bechtold et al (2006)	Yes, 100 mm VAS*	Yes, mg per drug*	No	No	Procedural time and difficulty, questionnaire
Binns-Turner et al (2011)	Yes, VAS	No	Yes, SAI	No	Physiological parameters, HR and MABP
Blankfield et al (1995)	No	Yes, mg drug given postoperatively	No	Yes, total and ICU total	Depression score and ADLs
Chan et al (2003)	Yes, VAS	No	Yes, STAI	No	No
Chan (2007)	Yes, UCLA universal pain assessment method	No	No	No	No
Chlan et al (2000)	Yes, NRS	No	Yes, STAI	No	No
Colt et al (1999)	No	No	Yes, STAI	No	No
Costa et al (2010)	Yes, VAS	Yes, midazolam requests*	No	No	Patient satisfaction, Likert scale
Cutshall et al (2011)	Yes, VAS*	Yes, mg per drug	Yes, VAS*	No	Patient satisfaction, VAS*
Danhauer et al (2007)	Yes, VAS	No	Yes, STAI	No	No
Ebneshahidi and Mohseni (2008)	Yes, VAS	Yes, mg per drug	Yes, VAS	No	No
Fredriksson et al (2009)	No	No	No	No	Patient wellbeing†, Likert scale
Ghetti (2011)	Yes, NRS	No	No	No	Length of ambulation and patient satisfaction, PANAS
Good (1995)	Yes, PSD	Yes, mg per drug	Yes, STAI	No	No
Good et al (1999)	Yes, VAS	No	No	No	No
Gravesen (2013)	Yes, VAS	No	No	No	No
Guerrero et al (2012)	Yes, VAS	No	Yes, STAI	No	Physiological parameters, HR and BP
Harikumar et al (2006)	Yes, VAS	Yes, midazolam requests	No	Yes, recovery time	No
Hook et al (2008)	Yes, VAS PSD	Yes, morphine equi-analgesic dose	Yes, STAI and VAS†	No	No
Iblher et al (2011)	Yes, ANP	Yes, mg per drug	No	No	No
Ikonomidou et al (2004)	Yes, VAS	Yes, mg per drug	No	No	Patient wellbeing, VAS
Jafari et al (2012)	Yes, NRS	No	No	No	No
Jimenez-Jimenez et al (2013)	No	No	Yes, VAS	No	No
Johnson et al (2012)	No	No	Yes, STAI	Yes, time spent in PACU*	No
Kliempt et al (1999)	No	Yes, mg per drug	No	No	No
Lee et al (2002)	Yes, VAS	Yes, PCA use and requests	No	Yes, recovery time†	Patient satisfaction, VAS
Lepage et al (2001)	No	Yes, midazolam requests	Yes, STAI and VAS	No	No
Li et al (2011)	Yes, VAS, PRI, and PPI	No	No	No	No
Li et al (2012)	Yes, VAS	No	Yes, Zung self-rated score	No	No
López-Cepero Andrada et al (2004)	No	No	Yes, SAI and TAI*	No	No
Maeyama et al (2009)	No	Yes, mg per drug	Yes, STAI-SA	No	No
McCaffrey and Locsin (2006)	Yes, VAS	Yes, mg per drug	No	No	Patient satisfaction, NRS

(Table 2 continues on next page)

	Pain score reported?	Analgesia use reported?	Anxiety score reported?	Length of stay reported?	Other outcome(s) reported?
(Continued from previous page)					
Migneault et al (2004)	No	Yes mg per drug		No	No
Mullooly et al (1988)	Yes, VAS	No	Yes, Likert scale	No	No
Nilsson et al (2001)	Yes, VAS	Yes, mg per drug	No	Yes, mobilisation time	Patient wellbeing and nausea, five-grade scale
Nilsson et al (2003a)	Yes, VAS	Yes, mg per drug	Yes, STAI	No	No
Nilsson et al (2003b)	Yes, NRS	Yes, mg per drug	Yes, questionnaire†	No	Patient satisfaction*, NRS
Nilsson et al (2005)	Yes, NRS	Yes, mg per drug	Yes, NRS	No	No
Nilsson (2009a)	Yes, NRS	Yes, mg per drug	Yes, STAI	No	No
Nilsson (2009b)	Yes, NRS	Yes, mg per drug		Yes, NRS*	No
Nilsson et al (2009)	No	Yes, mg per drug		No	Relaxation, NRS
Nilsson (2012)	No	Yes, mg per drug		Yes, NRS	Positive sound experience, NRS
Ovayolu et al (2006)	Yes, VAS	Yes, mg per drug		Yes, STAI	Patient satisfaction, VAS
Palakanis et al (1994)	No	No	Yes, STAI*	No	Physiological parameters, HR and MABP
Reza et al (2007)	Yes, VAS	Yes, mg per drug	Yes, VAS	No	Vomiting
Salmore and Nelson (1999)	No	Yes, mg per drug*	No	Yes, recovery time to discharge	No
Sen et al (2009)	No	Yes, mg per drug	No	Yes, recovery	Patient satisfaction, VAS
Sen et al (2010)	Yes, VAS	Yes, mg per drug	No	No	Patient satisfaction, VAS
Sendelbach et al (2006)	Yes, NRS*	Yes, mg per drug	Yes, state personality inventory*	No	No
Shabanloei et al (2010)	Yes, VAS	No	Yes, STAI	No	No
Simcock et al (2008)	Yes, VAS	No	No	No	Patient satisfaction, five-point scale
Smolen et al (2002)	No	Yes, mg per drug	Yes, SAI	No	No
Szmuk et al (2008)	Yes, VAS	No	No	Yes, time to eye opening	No
Taylor-Piliae and Chair (2002)	No	No	Yes, STAI	No	Patient satisfaction, various
Triller (2006)	No	No	No	No	Patient feeling, VAS
Tsivian et al (2012)	Yes, VAS	No	Yes, STAI*	No	No
Twiss et al (2006)	No	No	Yes, STAI	No	No
Vachiramon et al (2013)	No	No	Yes, STAI	No	No
Voss et al (2004)	Yes, VAS	No	Yes, VAS	No	No
Weeks and Nilsson (2011)	No	Yes, mg per drug	Yes, NRS	No	Patient wellbeing†, questionnaire
Wu et al (2013)	No	No	Yes, VAS*	No	No
Wu et al (2012)	Yes, NRS*	No	Yes, NRS*	No	No
Yeo et al (2013)	Yes, VAS	No	Yes, STAI	No	Patient satisfaction, VAS
Zengin et al (2013)	Yes, VAS	No	Yes, STAI	No	No
Zhang et al (2005)	No	No	No	No	Patient satisfaction, VAS
Zimmerman et al (1996)	Yes, NRS	No	No	No	No

STAI=state-trait anxiety inventory. HR=heart rate. BP=blood pressure. VAS=visual analogue scale. SAI=state anxiety inventory. TAI=trait anxiety inventory. MABP=mean arterial blood pressure. ICU=intensive care unit. ADL=activities of daily living. UCLA=University of California at Los Angeles. PACU=post-anaesthesia care unit. PCA=patient-controlled analgesia. NRS=numerical rating scale. PANAS=positive and negative affect schedule. PSD=pain sensation and distress. ANP=anaesthesiological questionnaire for patients after anaesthesia. PRI=pain-rated index. PPI=present pain intensity. *Not included in numerical meta-analysis result because SD was not given. †Not included in data analysis (because of incomplete data or unusable format). References are listed in the appendix.

Table 2: **Outcomes reported**

investigated several clinically relevant subgroup analyses such as general anaesthesia versus no anaesthesia, timing, and choice of music versus no choice, and we did meta-regression. The heterogeneity is unexplained so an individual participant data (IPD) meta-analysis could be the next step.

The largest RCT recruited only 458 participants and assessment of whether a very large trial would generate similar results to this systematic review would be interesting. However, because many small trials showed positive effects of music in patients undergoing surgical procedures, a large trial might not be needed. These

	Method of randomisation	Allocation concealment	Blinding of participants	Blinding of investigators	Blinding of outcome assessment
Agwu and Okoye (2006)	Even/odd wrapped numbers	Not stated	No	Not stated	Not stated
Allred et al (2010)	Sealed envelope system	Yes	No	Not stated	Not stated
Angioli et al (2013)	Computer generated	Not stated	No	No	Not stated
Argstatter et al (2006)	Permuted block randomisation	Not stated	No	No	Not stated
Ayoub et al (2005)	Not stated	No	No	No	Yes
Bally et al (2003)	Randomly generated group numbers	Yes	No	Not stated	Not stated
Barnason et al (1995)	Drawing lots	Not stated	No	Not stated	Not stated
Bechtold et al (2006)	Opaque envelopes music or no music	Yes	Yes	No	No
Binns-Turner et al (2011)	Drawing numbers from bag	Not stated	No	Yes	Yes
Blankfield et al (1995)	Not stated	Not stated	Yes	Yes	Not stated
Chan et al (2003)	Computer generated	Yes	No	No	Not stated
Chan (2007)	Random digit randomiser	Not stated	No	No	No
Chlan et al (2000)	Coin toss	No	No	No	Not stated
Colt et al (1999)	Random number tables	Yes	Yes	Yes	Yes
Costa et al (2010)	Computer generated	Yes	No	Yes	Yes
Cutshall et al (2011)	Randomised using blocks	Yes	No	Not stated	Not stated
Danhauer et al (2007)	Random assignment slip	Not stated	No	Not stated	Not stated
Ebneshahidi and Mohseni (2008)	Not stated	Not stated	No	Not stated	Not stated
Fredriksson et al (2009)	Random envelopes	Not stated	No	Not stated	Not stated
Ghetti (2011)	Random number table	Not stated	No	Yes	Not stated
Good (1995)	Not stated	Not stated	No	Not stated	Not stated
Good et al (1999)	Computer generated	Not stated	No	No	Not stated
Gravesen and Sommer (2013)	Random envelope	No	No	No	Not stated
Guerrero et al (2012)	Random number tables	Yes	No	Not stated	Not stated
Harikumar et al (2006)	Computer generated	Not stated	No	Yes	Not stated
Hook et al (2008)	Random envelopes	Not stated	No	Not stated	Not stated
Iblher et al (2011)	Drawing lots	Not stated	No	No	No
Ikonomidou et al (2004)	Not stated	Yes	No	Yes	Not stated
Jafari et al (2012)	Not stated	Not stated	No	No	Yes
Jimenez-Jimenez et al (2013)	Computer generated	Not stated	No	No	Not stated
Johnson et al (2012)	Not stated	Not stated	No	Not stated	Not stated
Kliempt et al (1999)	Computer generated	Yes	Yes	Yes	Yes
Lee et al (2002)	Computer generated	Not stated	No	Yes	Not stated
Lepage et al (2001)	Not stated	Not stated	No	No	Not stated
Li et al (2011)	Computer generated	Not stated	No	Not stated	No
Li et al (2012)	Computer generated	No	No	No	No
López-Cepero Andrada et al (2004)	Coin toss	No	No	No	Not stated
Maeyama et al (2009)	Not stated	Not stated	No	No	Not stated
McCaffrey and Locsin (2006)	By room availability	Yes	No	No	Not stated
Migneault et al (2004)	Not stated	Not stated	Yes	Yes	Not stated
Mullooly et al (1988)	Not stated	Not stated	No	Not stated	Not stated
Nilsson et al (2001)	Computer generated	Not stated	Yes	Not stated	Not stated
Nilsson et al (2003a)	Computer generated	No	No	No	Not stated
Nilsson et al (2003b)	Computer generated	Not stated	Yes	Not stated	Not stated
Nilsson et al (2005)	Computer generated	Not stated	Yes	Yes	Not stated
Nilsson (2009a)	Computer generated	No	No	No	Not stated
Nilsson (2009b)	Computer generated	Not stated	No	Yes	Yes
Nilsson et al (2009)	Computer generated	Not stated	No	Yes	Yes
Nilsson (2012)	Computer generated	Not stated	No	Not stated	Not stated
Ovayolu et al (2006)	Computer generated random numbers	No	No	No	Not stated

(Table 3 continues on next page)

	Method of randomisation	Allocation concealment	Blinding of participants	Blinding of investigators	Blinding of outcome assessment
(Continued from page)					
Palakanis et al (1994)	Coin toss	Not stated	No	Not stated	Not stated
Reza et al (2007)	Computer generated	Yes	Yes	Yes	Yes
Salmore and Nelson (1999)	Not stated	Not stated	No	No	Not stated
Sen et al (2009)	Computer generated	Not stated	No	No	Not stated
Sen et al (2010)	Computer generated	Not stated	No	No	Not stated
Sendelbach et al (2006)	Coin toss	Not stated	No	Not stated	Not stated
Shabanloei et al (2010)	Random number table	Not stated	No	No	Not stated
Simcock et al (2008)	Sealed envelopes	Yes	Yes	Yes	Not stated
Smolen et al (2002)	Not stated	No	No	No	Not stated
Szmuk et al (2008)	Not stated	Yes	Yes	Yes	Not stated
Taylor-Piliae and Chair (2002)	Drawing slip of paper	Not stated	No	No	No
Triller (2006)	Not stated	Not stated	No	Not stated	Not stated
Tsivian et al (2012)	Adapted coin toss	No	No	No	Not stated
Twiss et al (2006)	Drawing slip of paper	Not stated	No	Not stated	Not stated
Vachiramon et al (2013)	Randomised number table	Not stated	No	No	Not stated
Voss et al (2004)	Varied block size	Yes	No	No	Not stated
Weeks and Nilsson (2011)	Sealed envelopes	Yes	No	No	Not stated
Wu et al (2013)	Concealed envelopes	Yes	No	No	Not stated
Wu et al (2012)	Computer generated	Yes	No	No	Yes
Yeo et al (2013)	Block randomised	No	No	Not stated	Not stated
Zengin et al (2013)	Computer generated	Not stated	No	Not stated	Not stated
Zhang et al (2005)	Computer generated	Not stated	Yes	Not stated	Not stated
Zimmerman et al (1996)	Not stated	Not stated	No	Not stated	Not stated

Table 3: **Study quality**

small RCTs were difficult to find in journals that are not well known, which shows the benefits of systemic reviews and meta-analyses. However, a large RCT would address issues of heterogeneity.

Prediction intervals could have been calculated because they would give a more comprehensive view of potential effects of music in individual settings. However, prediction intervals tend to be wider than 95% CIs and, because of clinical heterogeneity, how calculation of prediction intervals would help to guide individual clinicians on implementation of music is unclear.

We included more studies than have previous systematic reviews. The most comprehensive previous systematic review used a vote-counting approach to summarise results only.[21] Some of the previous systematic reviews investigated only one outcome, such as anxiety or pain, whereas we report all relevant clinical outcomes. We believe that this study is the most comprehensive systematic review and meta-analysis so far for use of music in perioperative settings, including 6902 patients. Our results are similar to those of Cepeda and colleagues[20] for effect size. We identified no side-effects reported in any of the studies, as did a Cochrane review.[25]

The beneficial effects of music on patient wellbeing are consistent with expectations and the public's perception of music. Several potential mechanisms could help to explain effects of music from the patient's and the medical team's perspective. Modern theories of pain suggest that pain experience is affected by physical and psychological factors. Cognitive activities such as listening to music can affect perceived intensity and unpleasantness of pain, enabling patients' sensation of pain to be reduced.[26] Another potential mechanism could be reduced autonomic nervous system activity, such as reduced pulse and respiration rate and decreased blood pressure.[27] For patients undergoing general anaesthesia, some evidence from RCTs suggests that parts of the brain involved in hearing can sometimes be perceptive during general anaesthetic.[28] For about one in 1000 people undergoing general anaesthesia, unwanted intraoperative awareness during anaesthetic is a risk factor for post-traumatic stress.[29] Whether intraoperative music might have prevented this effect by reduction of anxiety is unclear. Whether other distracting stimuli might have a similar effect to music, such as videos or talking books, is unclear. Some experimental evidence shows that distraction with video gaming can reduce experimentally induced pain in adults,[30] but no studies have been done to investigate the effectiveness of talking radio or talking books during surgery in the adult population.

Other primary studies and systematic reviews have shown that medical teams might be more relaxed and attentive[31] when music that they enjoy is playing, but use of music might be inappropriate in some settings. The medical team might be distracted if music is audible from the patient's headphones. Music might impede

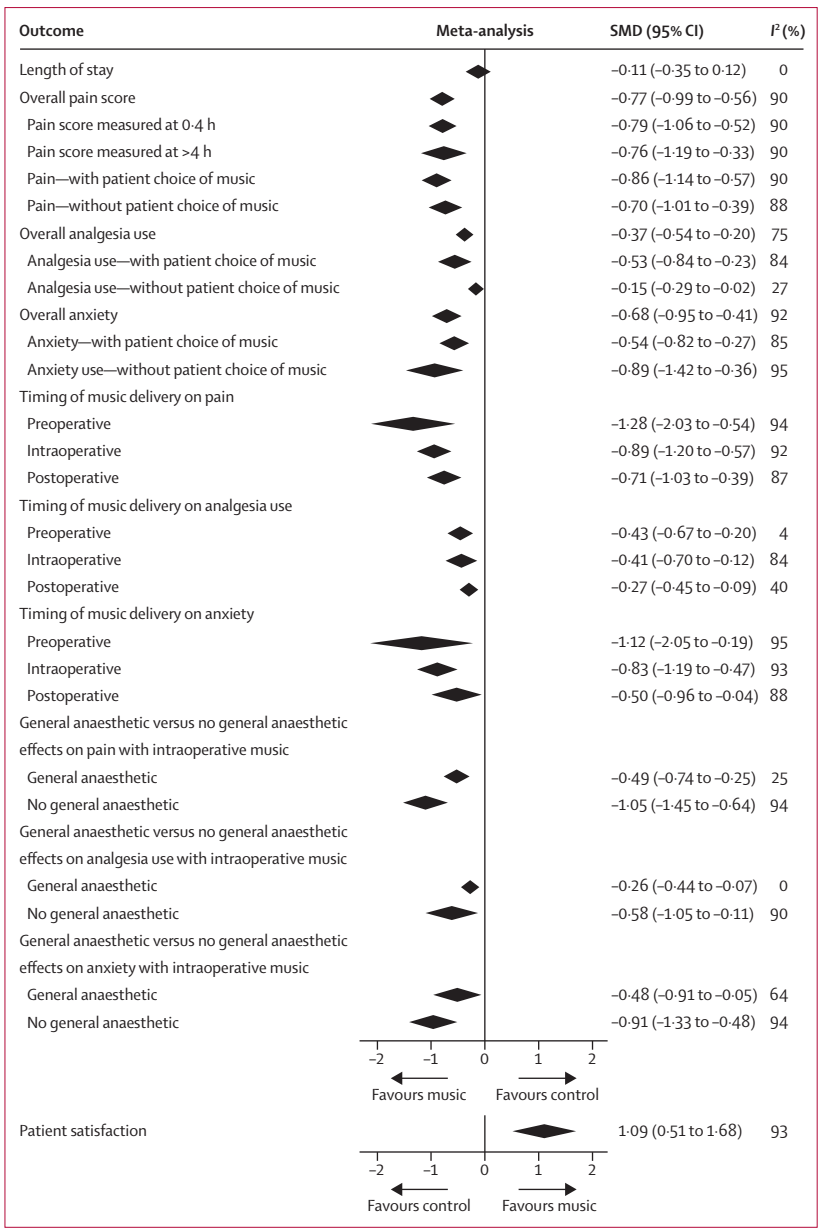

Figure 3: **Summary forest plot**
SMD=standardised mean difference. References listed in the appendix.

communication with patients, especially during an awake procedure. If patients need to be able to communicate with health-care workers, bilateral headphone use might be an obstacle. Music and noise could potentially obstruct other interventions through negatively affecting the surgeon's performance. Therefore, music should not be imposed on the medical team, especially during the procedure. If medical teams intend to introduce music into perioperative settings, care needs to be taken that music does not interfere with communication among the medical team.[32,33]

Music is a non-invasive, safe, and inexpensive intervention that can be delivered easily and successfully in a hospital setting. We believe that sufficient research has been done to show that music should be available to all patients undergoing operative procedures. Patients should be able to choose the type of music they would like to hear, but whether this music should be of their own choice or from a playlist is unclear. However, some patients might prefer for religious reasons to listen to recitations or natural sounds. Timing of music does not make much difference to outcomes so can be adapted to the individual clinical setting and medical team. For example, some medical teams might want to implement intraoperative music, whereas other teams might prefer the patient to listen to their own electronic musical device before the procedure or as soon as they arrive back onto the ward. The appropriate volume for use in different settings is likewise unclear.

Obstacles to implementation in the clinical setting, such as copyright and intellectual property issues, need investigation. On a local scale, patients could be encouraged to listen to music through patient information leaflets and hospital guidelines.

Contributors
EB and CM came up with the research idea. Statistical supervision was provided by CM, and senior clinical input by EB. CM, MH, and JH designed the protocol. MH and JH did searches, study selection, and subgroup analysis. All authors wrote the report.

Declaration of interests
We declare no competing interests.

Acknowledgments
We acknowledge the help of Ewelina Rogozinska with the meta-regression.

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