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Implementation of Music in the Perioperative Standard Care of Colorectal Surgery: A Cost-Effectiveness Analysis

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ABSTRACT

Introduction: Randomized controlled trials and meta-analyses have provided evidence of the positive effects of perioperative music interventions on pain, anxiety, and stress. However, the cost-effectiveness is unknown. The objective of this study was to analyze the cost-effectiveness of the implementation of a music intervention in the perioperative care of patients undergoing colorectal surgery.
Methods: A post hoc analysis was performed on patients included in the Implementation of Music Intervention in the PeRiOperatiVe standard care study: a clinical implementation study comparing the effects of perioperative music interventions (post-implementation group, $N = 50$) to standard care in colorectal surgery (pre-implementation group, $N = 50$). Main outcomes analyzed were postoperative pain scores and healthcare costs. Propensity score matching with inverse probability weighting was applied. Incremental costs and cumulative pain score differences were estimated using bootstrap analysis with 1000 replications.
Results: Median age of the entire patient population was 62.5. Mean sum of postoperative pain scores on postoperative days 0 to 3 was 9.8 (range 0-40) (95% confidence interval [CI] 8.3-11.4) and 9.9 (95% CI; 7.0-12.9) in the pre- and post-implementation group, respectively ($P = 0.970$). The total costs were not significantly different between the pre- and post-implementation group in the entire group (€7000 versus €8,070, mean difference of €1070 (bootstrap 95% CI - €1190 - €3336), $P = 0.353$). Incremental costs were €1288 and €5030 (intention-to-treat and per protocol analysis, respectively) per clinically relevant decrease in pain during postoperative day 0-3.

Trial registration: ID NL8071 (www.clinicaltrialregister.nl).
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Conclusions: The implementation of music intervention does not lead to a significant difference in costs. These results can aid clinicians considering the implementation of perioperative music.

Introduction

Even though perioperative use of analgesics is often necessary, the commonly used pharmaceutical analgesics can also result in undesirable side effects. These can be mild, such as nausea and fatigue, or more severe, such as poor recovery, higher risk for delirium, more reinterventions, and possible drug dependency.[1-3] The opioid crisis is partly due to the wide use of these drugs in the perioperative phase.[4,5] When addressing this issue of unwanted side effects, healthcare professionals should be introspective of their prescription behavior and look for possible improvements in routine clinical care.[6] Moreover, the costs of pharmaceutical analgesics have been rising over the past decades.[7,8] Therefore, cost-effective nonpharmacological interventions are needed to avoid those adverse effects and increasing costs.

A promising new form of a nonpharmaceutical, pain-reducing intervention that might answer that call is music. Listening to prerecorded music, from here on referred to as "music intervention," has been shown to effectively reduce pain, stress, and anxiety.[9,10] Specifically, the application of music interventions in the perioperative phase has been shown to significantly reduce postoperative stress response, anxiety, pain, and postoperative opioid use in clinical trials.[11-15]

Music intervention is considered inexpensive and thought to carry negligible risks. However, there seems to be a paucity of evidence regarding the cost-effectiveness of music intervention. To the best of our knowledge, Chlan *et al*. (2018) is the only published report that describes the costs of music intervention in an intensive care setting where mechanically ventilated patients were exposed to music.[16] The economic evaluation concluded that the implementation of music intervention with preferred prerecorded music can reduce costs and is free of adverse side effects.[16] More research on the cost-effectiveness of music interventions in different patient populations, conducted in routine clinical practice, can help close the literature gap and shed a light on the effects of music intervention on pain and other healthcare outcomes and related costs when implemented in the standard of care. Furthermore, healthcare insurance companies routinely require cost-effectiveness analyses to be performed before reimbursements of an intervention are considered.

Therefore, the aim of this study was to assess the cost-effectiveness of the implementation of music intervention in addition to the usual care on the cumulative pain scores of postoperative days (PODs) 0 to 3. We hypothesized that the implementation of music intervention would be cost-effective, due to savings from a reduction of postoperative opioid and benzodiazepine costs as a result a reduction of postoperative pain outweighing the costs of the intervention. The Implementation of Music Intervention in the PeRiOperatiVe standard care (IMPROVE) study, which this post hoc study is based upon, examined the effect of music interventions and patient undergoing surgery for inflammatory bowel disease or colorectal cancer.[17] These are patient groups that have been shown to have higher anxiety rates than the general population and might benefit from music interventions.[18,19] Furthermore, the enhanced recovery after surgery (ERAS) protocols for colorectal resections are mostly the same in each group and are well integrated in clinical practice, limiting the heterogeneity of treatments.

Methods

Study design

This economic evaluation was performed as post hoc analysis of the IMPROVE study, single-center prospective pre- and post-implementation cohort study executed in a regional hospital in the Netherlands between December 11, 2019, and February 24, 2022.[17] Full details of the study design can be found in the study protocol.[17] In summary, a nonblinded, prospective pre-post implementation study was performed with two groups where 50 patients were included before implementation of perioperative medicine (control group/pretest) and 50 patients were included after perioperative music was implemented by researchers at the hospital (intervention group/posttest). The study intervention consisted of (1) listening preoperatively to preferred music for at least 60 min daily, (2) listening intraoperatively to music during the entire procedure, and (3) listening postoperatively to music for at least 60 min per day. Music played intraoperatively was not audible for the operating staff. The pre- and post-implementation groups were completely independent. The time frame included the length of in-hospital stay up to 90 days postoperatively. The study was powered to assess the impact of implementing music intervention on postoperative pain. Patients and staff were aware of intervention allocation and patients were approached for informed consent by the treating physician and member of the research team. As part of the study, healthcare providers and patients were also invited to answer a survey about their attitude toward music implementation in clinical practice. The IMPROVE study was waived by the local Medical Research Ethics Committee (no. MEC-2019-0563) and registered at the "National Trial Register" (www.clinicaltrialregister.nl, ID NL8071). This economic evaluation was performed from a healthcare perspective, following Dutch guidelines.[20,21]

Participants

Patients were eligible if they (1) were aged 18 years and older, (2) planned for an elective colorectal surgical procedure for inflammatory bowel disease or colorectal cancer admitted to the gastrointestinal surgery ward, and (3) had provided written informed consent. Patients were excluded if they suffered severe hearing impairment causing problems with verbal communication, were unable or unwilling to receive the music intervention, or had insufficient comprehension of the Dutch or English language.

Outcomes

The primary results of the IMPROVE study have been published elsewhere.[22] The effect measure "pain" was reported three times daily using a 100 mm visual analog scale (VAS) converted to 0 to 10 points, with a higher score representing more pain. In order to only include pain scores in the cost-effectiveness analysis (CEA) that were related to the initial surgery, the cumulative (Σ) postoperative pain scores of POD 0 to 3 were used. Missing data were not imputed.

Perioperative in-hospital healthcare consumption was recorded in extensive detail using digital case report forms and complemented with healthcare consumption assumptions based on the widely implemented ERAS protocol, which is used in the IJsselland Hospital (Supplementary Table 1). In-hospital healthcare consumption included hospitalization, surgery, medication (including analgesics), treatment of complications, and the music intervention. Reference costs per unit of healthcare resources were derived from the Dutch Manual for costing in economic evaluations where possible (Supplementary Table 2)[23]; from the Nederlandse Zorgautoriteit (Dutch Healthcare Authority); or the College voor Zorgverzekeringen (Healthcare Insurance Board) (Supplementary Table 2).[24,25] Medication costs were based on standard costs per unit in the Netherlands (Supplementary Table 3).[25,26] The costs of the intervention were calculated from multiple sources (Supplementary Table 4).[27] Due to incomplete and heterogeneous reporting of complications and specifically their treatments, assumptions were made regarding the standard treatment of those complications based on national guidelines, local protocols, and scientific literature wherever necessary. Reference prices for the year 2022 (€) were used or adjusted to 2022 (€) prices with the national consumer price index.[28] Total costs for the pre- and post-implementation strategies were calculated by multiplying the frequency of resource use by the unit prices per cost category. The exchange rate was €1 = US$1.07.[29]

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences, version 25 (SPSS, Chicago, Ill. USA). Differences in outcomes between pre- and post-implementation groups were analyzed using parametric tests (unpaired Student's t-test) for normally distributed data and presented as means (standard deviation) and nonparametric tests (Mann−Whitney *U* test and chi-squared/Fisher's exact tests) for non-normally distributed data and presented as median ($P_{25} - P_{75}$). For the pairwise comparison of the mean costs, bootstrap 95% confidence intervals (CIs) were computed based on 1000 replications. Since the time frame was hospitalization up to 90 days postoperatively, no discounting was required.

Propensity score matching with inverse probability weighting using all baseline variables was applied to reduce the effects of treatment-selection bias or confounding due to unbalanced pre- and post-implementation groups. A dummy variable was added in case of missing data to prevent excessive loss of power due to missing data in one baseline variable. Propensity score matched estimates of costs, cumulative pain scores and their 95% CIs were reported for the main outcomes. A P value < 0.05 (two-sided) was taken as a threshold for statistical significance.

The incremental cost-effectiveness ratio (ICER), comparing pre- and post-implementation groups, was calculated by dividing the difference of the mean total costs by the difference of the cumulative pain score during PODs 0 to 3 and multiplied by the minimal clinically important difference in pain (VAS 1.2 cm; Fig.).[30]

Uncertainty was analyzed using a univariate deterministic sensitivity analysis (± 10 and 20% variation of costs and effects, displayed in a Tornado diagram) and a probabilistic sensitivity analysis (running 1000 Monte-Carlo simulations, displayed in a cost-effectiveness plane [CE-plane]).

Analysis of cost and effectiveness differences and resulting ICER estimates were done both as intention-to-treat (including the entire patient population) as well as per protocol. Only patients who completed the treatment originally allocated and strictly adhered to the study protocol, that is, listened to music >60 min daily preoperatively and postoperatively and during the entire surgical procedure were included. The intervention period started on the day of admission and ended at discharge from hospital. Results were reported following the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Checklist for reporting economic health evaluations.[31]

Results

Patient characteristics and treatment details

Patient characteristics and treatment details are shown in Table 1. 100 participants were included, 50 in each study arm. The median age of the entire patient population was 62.5 ($P_{25} - P_{75}$ 53.5 − 72.0) and did not differ significantly between patient groups (62.5 [$P_{25} - P_{75}$ 48.3 − 72.0] and 63.0 [$P_{25} - P_{75}$ 55.8 − 73.3], P = 0.497, in the pre- and post-implementation group, respectively). Compared to the pre-implementation group, patients in the post-implementation group were more often male (58% versus 38%; P = 0.045) and had had prior surgery more often (n = 30 [88%] versus n = 33 [67%]; P = 0.029). No significant differences were found between the patient groups regarding diagnosis and medical history possibly relevant to experiencing pain. Additional patient characteristics and treatment details are shown in Supplemental Table 5.

After propensity score matching with inverse probability weighting for all baseline covariates (see Table 1 and Supplemental Table 5), the distributions of baseline characteristics in the weighted groups were comparable. Only the percentage of patients with prior surgery differed between the groups (pre-implementation: 59% [95% CI 44- 75%] versus post-implementation: 93% [95% CI 86 - 100%], $P < 0.001$).

A

Incremental cost-effectiveness ratio – entire patient population

$$\textit{ICER entire population} = \frac{\text{Total costs post-implementation} - \text{Total costs pre-implementation}}{\sum \text{POD 0-3 pain scores post-implementation} - \sum \text{POD 0-3 pain scores pre-implementation}} * 1.2$$

$$= \frac{€8.069 - €6{,}996}{10.8 - 9.8} * 1.2 = €1{,}073 * 1.2$$

$$= €1{,}288 \text{ per clinically relevant decrease in pain during POD 0–3}$$

B

Incremental cost-effectiveness ratio – patient population who received the intervention as planned

$$\textit{ICER as planned} = \frac{\text{Total costs post-implementation} - \text{Total costs pre-implementation}}{\sum \text{POD 0-3 pain scores post-implementation} - \sum \text{POD 0-3 pain scores pre-implementation}} * 1.2$$

$$= \frac{€7{,}415 - €6{,}996}{9.9 - 9.8} * 1.2 = €4{,}190 * 1.2$$

$$= €5{,}028 \text{ per clinically relevant decrease in pain during POD 0–3}$$

ICER, incremental cost-effectiveness analysis; POD, postoperative day.

Fig. – Incremental cost-effectiveness ratio. (A) Incremental cost-effectiveness ratio—entire patient population. (B) Incremental cost-effectiveness ratio—patient population who received the intervention as planned.

A total of 11 patients (30%) received the music intervention as initially planned (Supplemental Fig. 1).[22]

Postoperative pain

The Σ POD 0-3 pain scores showed no significant nor clinically relevant differences between the patient groups in both the entire population ($P = 0.343$) as well as the population who had received the intervention as planned ($P = 0.970$; Table 2).

Healthcare consumption

Supplemental Table 6 shows the amount and dosage of medication required. Supplemental Table 7 shows all other resources used. Specifically, postoperative use of opioids and benzodiazepines did not differ significantly between pre- and post-implementation groups.

There was no significant difference between the patient groups regarding the standard of care (Supplemental Table 7).

Healthcare costs

Healthcare costs are shown in Table 3. As expected, the intervention costs were significantly higher in the post-implementation group, but the absolute mean difference per person was small (€0 *versus* €14, $P < 0.001$).

The postoperative medication costs were lower in the post-implementation group, however, the difference was not significantly different; €90 (95% CI €66 – €113) versus €67 (95% CI €53 – €82), mean difference of €23, $P = 0.114$, in the pre- and post-implementation population, respectively. This difference was larger but still not significantly different compared with the population who received the intervention as planned; €90 (95% CI €66 – €113) versus €54 (95% CI €53 – €82), mean difference of €36, $P = 0.075$.

The total costs were not significantly different between the pre- and post-implementation group in the entire patient population (€6996 (95% CI €6117 – €7875) versus €8069 (95% CI €5983 - €10,155), mean difference of €1073 (95% CI - €1190 - €3336), $P = 0.353$) nor in the patient population who received the intervention as planned, but the difference in costs was smaller (€6996 (95% CI €6117 – €7875) versus €7415 (95% CI €4496 - €10,334), mean difference of €419 (95% CI - €2629 – €3468), $P = 0.787$). Although not statistically significant, the large difference in total costs observed between the groups is mostly explained by higher costs for complications and hospital length of stay in the post-implementation group (Table 3).

Incremental cost-effectiveness ratio

Cost-effectiveness analyses concerning the entire patient population showed that the total costs and cumulative pain

Table 1 – Patient characteristics and treatment details.

Patient characteristics	N[§]	All (n = 100)	N[§]	Pre-implementation (n = 50)	N[§]	Post-implementation (n = 50)	P value
Female	100	52 (52)	50	31 (62)	50	21 (42)	**0.045**
Age (years)	100	62.5 (53.3–72.0)	50	62.5 (48.3–72.0)	50	63.0 (55.8–73.3)	0.497
Medical history possibly relevant to experience of pain							
Psychiatric[*]	100	6 (6)	50	4 (8)	50	2 (4)	0.400
Chronic pain[†]	100	22 (22)	50	11 (22)	50	11 (22)	>0.999
Prior surgery (any)	83	63 (76)	49	33 (67)	34	30 (88)	**0.029**
Diagnosis	100		50		50		0.615
Colorectal cancer		70 (70)		32 (64)		38 (76)	
Crohn's disease		16 (16)		10 (20)		6 (12)	
Ulcerative colitis		7 (7)		4 (8)		3 (6)	
Other[‡]		7 (7)		4 (8)		3 (6)	

P values <0.05 are shown in boldface.
Data are presented as N (%) or median ($P_{25} - P_{75}$).
ADD = attention deficit disorder; ADHD = attention-deficit/hyperactivity disorder.
[*] Psychiatric history: attention-deficit/hyperactivity disorder (ADHD), attention deficit disorder (ADD), autism, bipolar disease, burn-out, claustrophobia, or depression.
[†] Chronic pain: arthrosis, carpal tunnel syndrome, chronic lower back pain, hernia nuclei pulposi, migraine, neuropathic pain, polyneuropathy, or polymyalgia rheumatica.
[‡] Atonal colon due to Ehlers Danlos syndrome, constipation due to Sjogren's disease, diverticulitis, diverticulosis, or obstructive defecation syndrome.
[§] N represents the number of patients for whom data were available per group.

score were higher in the post-implementation group, resulting in incremental costs of €1288 per clinically relevant decrease in pain during POD 0-3 (Fig. 1A). Cost-effectiveness analyses concerning only patients for whom the intervention was carried out as planned showed that the total costs were higher (€419) and cumulative pain score was lower (0.1) in the post-implementation group, resulting in incremental costs of €5028 per clinically relevant decrease in pain during POD 0-3 (Fig. 1B).

Sensitivity analysis

The uncertainty measured with the probabilistic sensitivity analysis is presented in a scatter plot on the CE-plane by displaying the spread of the ICERs calculated from each random draw (Supplemental Fig. 2). The random draw of 1000 ICERS of the probabalistic sensitivity analysis were wide- and equally spread among all quadrants with the center of the point cloud in the middle of the graph, indicating a relatively small costs and effects difference and large spread in data.

The effect of variation on the base case ICER of clinically relevant input parameters and the most impactful parameters as calculated with the deterministic sensitivity analysis are shown in Tornado diagrams (Supplemental Fig. 3). In both patient populations, the most impactful were the variations in the cumulative pain scores, complication costs, and hospital length of stay costs. The addition of an extra €40 to the intervention costs had a minimal effect on the base case ICER.

Discussion

The current analysis is the first to assess the cost-effectiveness of the implementation of music intervention to the standard of care of colorectal surgery. First and foremost, this analysis shows that the costs of music intervention were

Table 2 – Cumulative pain during postoperative days 0 to 3.

Cumulative pain POD 0-3	N[*]	Pre-implementation (n = 50)	N[*]	Post-implementation (n = 50)	P value
Entire patient population					
Σ POD 0-3	42	9.8 (8.3–11.4)	46	10.8 (9.5–12.2)	0.343
Intervention as planned (preoperative, intraoperative, and postoperative (>60 min) music)					
Σ POD 0-3	42	9.8 (8.3–11.4)	11	9.9 (7.0–12.8)	0.970

Data are shown as the estimated marginal mean (with a 95% confidence interval) adjusted for all baseline covariates.
min = minutes.
[*] N represents the number of patients for whom data were available per group.

Table 3 – Mean healthcare costs (2022; €).

Healthcare costs	N[†]	All (N = 100)	N[†]	Pre-implementation (n = 50)	N[†]	Post-implementation (n = 50)	Mean difference in costs	P value
Entire patient population								
Preoperative costs	100	30 (24–36)	50	29 (20–38)	50	30 (21–38)	−1	0.936
ERAS protocol costs[*]	100	29 (23–36)	50	29 (20–38)	50	30 (21–38)	1	0.938
Medication costs	100	0 (0–0)	50	0 (0–0)	50	0 (0–0)	0	0.705
Intraoperative costs	99	2999 (2775–3223)	49	3076 (2764–3389)	50	2921 (2600–3242)	155	0.497
ERAS protocol costs[*]	100	109 (109–109)	50	109 (109–109)	50	109 (109–109)	0	>0.999
Operating costs (surgeon)	99	262 (238–286)	49	271 (238–304)	50	253 (219–287)	18	0.465
Operating costs (operating room)	100	2598 (2397–2798)	50	2662 (2384–2939)	50	2534 (2245–2822)	88	0.531
Medication costs	100	30 (23–37)	50	35 (22–49)	50	25 (22–28)	10	0.140
Postoperative costs	99	4158 (3199–5117)	49	3795 (3107–4482)	50	4521 (2730–6312)	−726	0.458
ERAS protocol costs[*]	99	77 (73–80)	49	77 (72–81)	50	76 (72–81)	1	0.941
HLOS costs	99	4003 (3049–4956)	49	3628 (2949–4307)	50	4378 (2595–6160)	−750	0.441
Medication costs	100	78 (65–92)	50	90 (66–113)	50	67 (53–82)	23	0.114
Complication costs	100	336 (141–532)	50	91 (21–160)	50	583 (198–967)	−492	**0.014**
Intervention costs	100	7 (6–8)	50	0 (0–0)	50	14 (14–14)	−14	**< 0.001**
Total costs	98	7532 (6401–8664)	48	6996 (6117–7875)	50	8069 (5983–10,155)	−1073	0.353
Intervention as planned (preoperative, intraoperative, and postoperative (>60 min) music)								
Preoperative costs	61	23 (18–28)	50	29 (20–38)	11	16 (11–21)	13	**0.011**
ERAS protocol costs[*]	61	23 (18–28)	50	29 (20–38)	11	16 (11–21)	13	**0.011**
Medication costs	61	0 (0–0)	50	0 (0–0)	11	0 (0–0)	0	0.135
Intraoperative costs	60	3047 (2674–3419)	49	3076 (2764–3389)	11	3017 (2341–3692)	59	0.876
ERAS protocol costs[*]	61	109 (109–109)	50	109 (109–109)	11	109 (109–109)	0	>0.999
Operating costs (surgeon)	60	271 (232–311)	49	271 (238–304)	11	272 (200–344)	−1	0.982
Operating costs (operating room)	61	2635 (2303–2968)	50	2662 (2384–2939)	11	2609 (2004–3214)	53	0.878
Medication costs	61	31 (24–39)	50	35 (22–49)	11	27 (20–33)	8	0.247
Postoperative costs	60	3661 (2824–4499)	49	3795 (3107–4482)	11	3528 (2000–5056)	267	0.755
ERAS protocol costs[*]	60	75 (71–78)	49	77 (72–81)	11	73 (68–78)	4	0.274
HLOS costs	60	3515 (2689–4341)	49	3628 (2949–4307)	11	3401 (1895–4908)	227	0.788
Medication costs	61	72 (52–91)	50	90 (66–113)	11	54 (23–85)	36	0.075
Complication costs	61	465 (-190–1120)	50	91 (21–160)	11	840 (-468–2148)	−749	0.262
Intervention costs	61	3 (1–4)	50	0 (0–0)	11	14 (14–14)	−14	**< 0.001**
Total costs	59	7205 (5681–8730)	48	6996 (6117–7875)	11	7415 (4496–10,334)	−419	0.787

The exchange rate was €1 = US$1.07.[29]
P values <0.05 are shown in boldface.
Data are shown as the estimated marginal mean (with a bootstrap 95% confidence interval) adjusted for all baseline covariates. Bold-faced means indicate that the bootstrap 95% confidence interval of the two intervention groups did not overlap ($P < 0.05$).
HLOS = hospital length of stay; min = minutes.
[*] ERAS protocol costs are costs concerning the healthcare consumption based on the ERAS protocol (Supplementary Table 1).
[†] N represents the number of patients for whom data were available per group.

low (i.e., €14 per patient). The study hypothesis that music interventions would be cost-effective due to a reduction in postoperative pain and subsequent reduction in medication usage outweighing the intervention costs could not be confirmed. Postoperative cumulative pain and costs for medication usage were not reduced significantly in the post-implementation, that is, music intervention, group.

The healthcare consumption and associated costs between the groups were almost identical as a methodological assumption was made that all patients followed the same ERAS care pathway, which encompasses most costs. However, the negligible difference could also reflect the small effect of the music intervention on healthcare consumption and costs. There was a trend toward lower postoperative medication costs in the post-implementation group. These calculations included medication consumption after the fifth day of hospitalization. While the majority of the patients were discharged at this point, a number of outlier patients was still hospitalized due to medical complications that are unlikely to be related to music intervention. It appears that the difference in intervention costs and a trend toward a reduction in medication costs were compensated by high costs for longer hospital stay and treatment of (surgical) complications in a subgroup of patients.

Interpretation of the ICER is difficult as the incremental costs of a clinically relevant difference in cumulative pain are not easily comparable to other interventions and cannot be held against a national or international threshold. Moreover, it is difficult to interpret what a clinically relevant difference of 1.2 VAS points spread out over multiple days would imply for an individual patient. Furthermore, analgesics cost-effectiveness is regularly measured with costs per variable measurement of pain, as intuitively, one aims to grasp the additional costs of the intervention on the desired effect (pain) and whether this is justifiable. However, using only the pain score of one POD would fail to assess not only the difference over time but also the within-patient difference, an important element as pain is a subjective measure. The choice made in this study, using cumulative pain scores from POD 0 to 3, offers more insight in changes in pain over a longer period of time and did allow for within-patient comparisons.

The sensitivity analysis showed that complications and hospital length of stay are the largest drivers of the ICER, as these parameters are associated with high costs per unit and the difference in costs had a big impact on the ICER due to the small denominator. Costs of hospital length of stay could be related to the implementation of music intervention, as prolonged pain and anxiety sometimes warrant direct observation. However, we deem it unlikely, and have found no evidence or literature that suggests that severe and often costly complications such as pneumonias and anastomotic leaks are related to music intervention. Hence, we believe it debatable whether these costs unrelated to the expected effects of the music intervention should be included in the CEA. Future researchers can consider narrowing the scope of costs included in the CEA to costs that are reasonably more likely to be influenced by music interventions.

For this study, to investigate the effects of perioperative music, the primary outcome was postoperative pain. However, pain is multifaceted and could be influenced by multiple factors and underlying differences in the patient groups.[32] Music interventions have multidimensional effects that not only affect pain but also positively influence anxiety, stress, sleep quality, and opioid and sedative requirements.[11,12,33] This is also reflected in the implementation study. Postoperative anxiety was significantly lower in the post-implementation group (2.0 [$P_{25} - P_{75}$ 0.5 − 3.0] versus 3.0 [$P_{25} - P_{75}$ 1.0 − 5.8]; $P = 0.02$). Moreover, benzodiazepine use was significantly lower on POD 1 ($P = 0.04$).[22] However, additional cost-effectiveness analyses combining pain as well as anxiety scores as effect measure would be methodologically challenging.

Recently, the development of a Dutch guideline of perioperative music in perioperative standard of care underlines the willingness and interest of physicians to apply music interventions to improve care.[34] This positive attitude is mirrored by participants in music intervention trials that express high levels of satisfaction with the intervention and willingness to receive it again.[14,35] The positive response to music interventions is also reflected in the qualitative data of the primary study indicating that the music intervention is well received by patients and possibly improves well-being.[22] At first, this seems to be contradicted by the low adherence percentages in this study. However, as the qualitative data reveal, patients highly appreciated the music intervention and lack of adherence was attributed to technical issues, more pressing healthcare issues, or uncomfortable headsets. Without directly comparing qualitative to quantitative results, we can observe a positive attitude to music interventions in both kinds of data. These subjective patient-reported outcome measures, such as patient satisfaction, are increasingly studied and implemented in healthcare programs.[36,37] Health insurance companies/third-party payers and hospitals not only have qualitative key performance indices, such as mortality and hospital length of stay, but also aim for patient satisfaction and highly value the perceived well-being of their patients.

This first study on cost-effectiveness of perioperative music interventions fails to demonstrate cost-effectiveness in the ICERs of music intervention compared to standard care when focusing on pain as the only effect outcome. Reasons for this could be a small sample size combined with low adherence in the postoperative period (Supplemental Fig. 1) and the nonrandom study design. However, the absolute costs of music implementation are small, and other studies and meta-analyses have found positive effects of music interventions on pain, stress, and anxiety.[8-10] The results of this study can be taken into account by decision-makers along with the results of previous studies that show intervention effectiveness and high levels of patient satisfaction when deciding on possible implementation or reimbursement of music interventions.

Strengths and limitations

One of the strengths of this economic evaluation is that it is more reflective of real-life practice as clinical data were used for the CEA. Furthermore, the known heterogeneity in baseline characteristics was mostly tackled with propensity score matching, but the influence of prior surgery and disease type is hard to assess with this limited sample. Lastly, both sensitivity analyses allowed for more insight in the effect of uncertainty and variation of clinically relevant input parameters.

However, the results should also be interpreted in the light of several limitations.

The positive impact of music intervention on pain found in earlier studies[10-15] could not be reproduced, for which there are multiple possible reasons. The sample size is relatively small and was powered on a pain reduction of 1.2 cm VAS on day one postoperatively; however, this limitation was mitigated regarding costs by using bootstrapping. The primary study was an implementation study and not a randomized controlled trial. Contextual changes in the hospital during the process of implementation (6 months) cannot be ruled out but are not likely, as the ERAS protocols were not changed during the study period. Lastly, compliance and adherence to the study intervention were low, as only 11 patients could be included in the per protocol analysis.

Conclusions

This economic evaluation is the first of its kind in the assessment of the implementation of music intervention to the standard of care of colorectal surgery. The results indicate that perioperative music implementation does not result in a significant difference in costs. These findings in combination with the proven positive effects of music on pain, stress, and anxiety in other studies can aid clinicians in the decision-making process of whether to implement perioperative music interventions.

Supplementary Materials

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jss.2024.10.052.

Disclosure

The authors have no conflicts of interest to declare.

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Ethics Approval

The IMPROVE study was exempted by the Erasmus MC local medical research ethics committee (No. MEC-2019-0563).

Data Sharing

No additional data are available. Data can be made available upon reasonable request to the corresponding author.

CRediT authorship contribution statement

Saskia H. Van Bergen: Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jorrit G. Verhoeven:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ellaha Kakar:** Writing – review & editing, Investigation, Conceptualization. **Johannes Jeekel:** Writing – review & editing, Supervision, Conceptualization. **Erwin Birnie:** Writing – review & editing, Methodology, Conceptualization. **Markus Klimek:** Writing – review & editing, Supervision, Conceptualization.

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