

The cost-effectiveness of a patient-directed music intervention for ICU patients receiving mechanical ventilation: A commentary on an economic evaluation

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Abstract

While music listening interventions may help alleviate anxiety in mechanically ventilated intensive care unit patients, it is not known whether they can reduce intensive care unit costs. This commentary critically assesses an economic evaluation which compared the cost-effectiveness of a patient-directed music intervention to usual care in mechanically ventilated patients in Midwestern US intensive care units. The economic evaluation found that the patient-directed music intervention was cost-effective compared with usual care. However, this commentary highlights some potential limitations of the evaluation and factors to consider for implementation of music interventions conducted in a UK setting. Future economic evaluations using UK cost data would be valuable to assess the cost-effectiveness of music interventions in a UK setting. Future evaluations should also consider delirium and pain outcomes, in addition to anxiety outcomes, as these may also impact on the cost of intensive care unit care.

Keywords

patient-directed music interventions, intensive care, economic evaluation, cost-effectiveness analysis, commentaries

Introduction

Intensive care units (ICUs) are services which provide specialist multidisciplinary care to severely ill patients with life threatening conditions typically requiring continuous physiologic monitoring and/or support for organ functions, such as mechanical ventilation for respiratory support (Marshall et al., 2017). In the United Kingdom, around 118,000 patients are admitted to ICUs each year, of whom around 37% require mechanical ventilation in the first 24 hours to help them breathe (Intensive Care National Audit & Research Centre (ICNARC), 2024). The experience of being mechanically ventilated can be highly unpleasant, with patients experiencing pain and discomfort as well as psychological impacts such as intense stress, feelings of hopelessness, and fear (Danielis et al., 2020).

ICU care is expensive, costing around €1615.57 to €2800.97 per day in European countries such as Germany, Italy, the Netherlands, and the United Kingdom (adjusted to 2025 costs; Tan et al., 2012), with mechanical ventilation being a main driver of the total cost of ICU care (Mastrogianni et al., 2021). Music listening interventions may reduce anxiety in mechanically ventilated ICU patients and may reduce the need for sedative and analgesic medications (Bradt and Dileo, 2014). However, it is not known whether music listening interventions can reduce ICU costs. The economic evaluation by Chlan et al. (2018) aimed to assess the cost-effectiveness of a personalised music intervention in mechanically ventilated patients in Midwestern US ICUs.

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Aim of commentary

This commentary aims to critically appraise the methods and the results reported in the economic evaluation by Chlan et al. (2018), and expand upon the findings in the context of healthcare policy and practice.

Methods

The economic evaluation by Chlan et al. (2018) assessed whether a patient-directed music (PDM) intervention for adult patients receiving mechanical ventilatory support in an ICU was cost-effective when compared with usual care. Participants in the study were adult patients receiving mechanical ventilation for acute respiratory failure in US Midwestern hospital ICUs. Patients in the PDM intervention (PDMI) group ($n=126$) received an assessment of their music preferences by a music therapist using a tool to assess music preferences in mechanically ventilated patients (Chlan et al., 2013). The music therapist then developed a music collection for each patient based on their preferences. The patients were given an MP3 player and noise-cancelling headphones with their personalised music collection which was kept at their bedside within easy reach during their mechanical ventilation to allow self-initiated music listening. Patients were prompted to listen to the music at least twice a day but were encouraged to use the music as often as they wanted to (Chlan et al., 2013). The music therapist spent 5 hours on average with each patient (Chlan et al., 2018). Nursing staff on the unit were asked to offer music to patients at least twice during their shifts (Chlan et al., 2013). Patients in the control group received usual ICU care ($n=125$). Ethical approval for the study was obtained from the University of Minnesota's institutional review board and the institutional review boards of each hospital and patients had to provide their own written informed consent to be enrolled in the study.

The main clinical effectiveness outcome assessed was anxiety measured by the patient-reported Visual Analogue Scale for Anxiety (VAS-A), with higher scores meaning worse levels of anxiety. Other clinical outcomes included the total length of ICU stay, the total number of days of mechanical ventilatory support, and the amount of sedative and analgesic medications administered to patients.

The analysis only considered direct medical costs including the costs of the ICU stay, mechanical ventilation, sedative and analgesic medications, and the cost of delivering the PDM intervention. Data from the randomised controlled trial of the PDM intervention by Chlan et al. (2013) were used to estimate the number of days patients stayed in the ICU and received mechanical ventilatory support, and the amount of medication administered. Medication dosage was based on the concentration and vial size used by the hospital pharmacy for preparing the medication for administration. The daily cost of staying in the ICU and the incremental cost of mechanical ventilation were based on US claims data taken from a 2005 retrospective cohort study and were converted into 2015 US dollar costs. Costs were also varied in the sensitivity analysis to explore uncertainty in the true values. Drug costs were estimated using the lowest average listed wholesale unit price in the Red Book (medication pricing resource) and physician costs were estimated using Current Procedural Terminology codes and Medicare fee schedules. The cost of delivering the PDM intervention was calculated from the mean cost per patient for purchase and reuse (i.e. sterilisation costs) of the MP3 player and headphones and the mean hourly rate of a music therapist based on data from the American Music Therapy Association. Costs were reported in 2015 US dollars.

A cost-effectiveness analysis was undertaken. The base case compared the average clinical outcomes and average costs per patient in the intervention group with the usual care group, producing a cost per unit change in anxiety score. Quality Adjusted Life Years were not used as a utility measure in the cost-effectiveness analysis as preference-based quality of life data were not collected in the randomised controlled trial. The analysis was conducted from the healthcare provider's perspective and the time horizon was limited to the duration of the patients' stay in the ICU. Since the time horizon assessed was less than a year, no discounting was applied. In addition to the cost-effectiveness analysis, a break-even cost analysis was undertaken. It was calculated by comparing the average cost of the PDM intervention with the average cost saving per patient of the PDM intervention over that of usual care. In the break-even cost analysis, an intervention was considered cost-effective (independent of the effects on patient anxiety) when the cost of implementing it does not exceed the cost saving.

Uncertainty in estimates of cost-effectiveness was investigated through one-way deterministic sensitivity analyses of all model variables; threshold analysis determining when the comparators become less costly; and, probabilistic sensitivity analysis using Monte Carlo simulation, plotting 1000 incremental costs and effects pairs on a cost-effectiveness plane interpreted using willingness to pay thresholds. In a one-way deterministic sensitivity analysis, the model is rerun changing one input variable (e.g. ICU cost per day) at a time by a plausible amount, while keeping all the other variables constant, to test each variable's impact on the outcome. The threshold analysis tests by how much the value of key variables (such as the cost of the intervention) would need to change before either the PDM intervention or usual care becomes less costly than the other. In a probabilistic sensitivity analysis, combinations of cost and effect values are randomly sampled many times (in this case 1000 times), from the range of possible values for each variable, generating a large dataset of possible cost-effectiveness outcomes. These 'simulations' of cost-effectiveness outcomes are then plotted on a chart (the cost-effectiveness plane) that can be used to estimate the probability of the intervention being cost-effective at different levels of willingness to pay.

Results

The base case analysis showed that the average total cost of care for the PDMI group (US\$131,379) was lower compared with the average total cost of care for the usual care group (US\$133,701). The mean anxiety score was also lower in the

PDMI group (VAS-A score 33), compared with the usual care group (VAS-A score 52). Therefore, the PDM intervention would be considered more cost-effective than usual care as it resulted in greater benefit at a lower cost (i.e. PDM dominated usual care). The break-even cost analysis found that the average cost saving for the PDM intervention compared with usual care (£2652 per patient) far exceeded the average cost of delivering the PDM intervention (£329 per patient), meaning that the PDM intervention was cost-effective to implement in this scenario.

The one-way sensitivity analysis showed that four variables had the potential to affect the cost per one-unit reduction on the VAS-A outcome score. These variables could therefore affect whether the PDM intervention would be considered cost-effective compared with usual care when the willingness to pay for each unit reduction in the VAS-A anxiety score was US\$0. These were a lower number of mechanical ventilation days required for the usual care group than in the base-case analysis or a higher number of days of ventilation required for the PDMI group, a lower daily ICU cost with mechanical ventilation or a higher daily ICU cost without mechanical ventilation. The other variables assessed did not show a potential impact on the dominance of the intervention.

The probabilistic sensitivity analysis showed that in the majority (70%) of the simulations the PDM intervention would cost less and would be more effective than usual care when the willingness to pay per one-unit reduction in the anxiety score is US\$0. The remaining simulations showed the PDM intervention would be more effective but would be more expensive than usual care. However, as the willingness-to-pay for a one-unit reduction in the anxiety score is increased from US\$0, the PDM intervention becomes more likely to be considered cost-effective. For example, at a willingness-to-pay of US\$50 per one-unit reduction in the anxiety score the probability that the PDM intervention will be cost-effective is 83.5%; at a willingness-to-pay of US\$100 per unit of anxiety score reduction the probability of cost-effectiveness is 92%.

The authors conclude that the PDM intervention is cost-saving and more effective in managing anxiety with less medications compared with usual care.

Commentary

Critical appraisal

Using a bespoke checklist for appraising the methodological quality of economic evaluations (Critical Appraisal Skills Programme, 2018; Drummond et al., 2015; Philips et al., 2004), it was deemed that the paper by Chlan et al. (2018) clearly describes the population and intervention being assessed with relevant outcomes being identified and appropriately measured (Table 1). The perspective of the evaluation is clearly stated and was judged to be appropriate to the intervention being assessed. The analysis was appropriately designed with uncertainty in the estimates of costs and outcomes adequately characterised through sensitivity analysis. However, some issues were identified which need to be considered when interpreting the findings of the evaluation. The effectiveness of the intervention is based on the findings of a single randomised controlled trial, limiting the level of certainty in the effect estimates since trial-specific factors or biases could have had an impact on the outcomes (Borm et al., 2009). Having said that, recently published systematic reviews of music therapy interventions for ICU patients have similarly concluded that they have a positive effect on alleviating anxiety (Chen et al., 2021; Xiao et al., 2024). Second, not all competing alternatives were described in the evaluation. Although the intervention and usual care were described, the original trial included a third group receiving noise-cancelling headphones only (with no music), which was not included in the economic evaluation. Even if this alternative was found not to be clinically effective, it may have been cost saving, and therefore ideally should have been included in the analysis. Third, although most relevant costs were identified and appropriately measured and valued, the costs of nursing care were not included in the analysis. While the authors of the paper discuss this as a limitation of the study, omitting the costs of nursing care is likely to have a significant impact on the accuracy of the cost-effectiveness estimates, since nursing care is one of the biggest factors in ICU care costs (Tan et al., 2012).

Generalisability of the results to other settings and patient groups, the impacts of potential health inequalities, and issues around implementation of the intervention were not discussed in the paper, and so these aspects would need to be considered before implementing the intervention in practice. For example, comparability of healthcare systems would need to be considered if implementing the intervention in a UK setting. ICU care is routinely used in the United Kingdom and patient groups are likely to be comparable to those in the study. However, the UK healthcare system is very different to that of the United States and ICU and drug costs may be very different, affecting the potential cost-effectiveness of the intervention in UK settings. Healthcare costs are generally much higher in the United States compared with the UK National Health System (NHS), possibly due to personnel costs and staffing mix and price differences in goods such as pharmaceuticals and administrative costs (Papanicolas et al., 2018). Therefore, the intervention could be less cost-effective in a UK setting due to the lower cost of ICU care.

Implications for policy/practice

Based on the findings of the economic evaluation the PDM intervention appears likely to be cost-effective for reducing anxiety in adult ICU patients in comparison to usual care. The intervention is low cost to deliver and is a non-pharmacologic and non-invasive option for reducing anxiety. Music-based interventions have been shown to be effective in

Table 1. Critical appraisal tool.

#	Question	Answer
A. Rationale		
A1	Is there a clear statement of the decision problem?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
B. Effectiveness		
B1	Was the effectiveness of the intervention established on a systematic review?	☐ Yes ☒ No ☐ Unclear ☐ Not applicable
C. Comparators		
C1	Was a comprehensive description of the competing alternatives given? (i.e. can you tell who did what to whom, where, and how often)	☐ Yes ☒ No ☐ Unclear ☐ Not applicable
D. Model perspective and structure		
D1	Is the perspective of the model clearly stated?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
D2	Are the model structure and its assumptions appropriate and do they fit with the clinical theory of the disease process?	☐ Yes ☐ No ☐ Unclear ☒ Not applicable
E. Costs		
E1	Were all important and relevant costs for each alternative identified?	☐ Yes ☒ No ☐ Unclear ☐ Not applicable
E2	Were costs measured and valued appropriately?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
F. Outcomes		
F1	Were all important and relevant outcomes for each alternative identified?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
F2	Were outcomes measured and valued appropriately?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
G. Analysis		
G1	Was the analysis designed appropriately?	☐ Yes ☒ No ☐ Unclear ☐ Not applicable
G2	Were the methods and assumptions used to extrapolate short-term results to final outcomes documented and justified?	☐ Yes ☐ No ☐ Unclear ☒ Not applicable

(continued)

Table I. (continued)

#	Question	Answer
G3	Was uncertainty in the estimates of costs and outcomes adequately characterised?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
H. Presentation and discussion of findings		
H1	Were the results interpreted appropriately?	☒ Yes ☐ No ☐ Unclear ☐ Not applicable
H2	Did the study discuss the generalisability of the results to other settings and patient/client groups?	☐ Yes ☒ No ☐ Unclear ☐ Not applicable
H3	Did the study allude to, or take account of, other important factors in the choice or decision under consideration (e.g. distribution of costs and consequences, relevant ethical issues, or issues of implementation)?	☐ Yes ☒ No ☐ Unclear ☐ Not applicable
I. Transferability to UK NHS		
I1	Are the healthcare system, setting, comparator, and patient group comparable to the United Kingdom and to the NHS?	☐ Yes ☒ No ☐ Unclear ☐ Not applicable

alleviating anxiety in ICU patients (Xiao et al., 2024) and are generally safe with no side effects, although some people may find certain volumes or types of music irritating, and music can evoke strong emotions or memories for some people (National Center for Complementary and Integrative Health, 2022). Consequently, delivery by a professional music therapist is likely to be an important aspect of the intervention. There is limited detail around the intervention protocol in the randomised controlled trial by Chlan et al. (2013). Details in the paper suggest that the music therapist reviewed the preferences of each patient using a music preference tool designed for mechanically ventilated patients and then developed a music collection for each patient tailored to their individual preferences (Chlan et al., 2013). The registered protocol for the trial states that the music therapist should also visit each patient daily to review preferences or check whether additional music compact discs were required (Chlan, 2006), but this is not reported in the final paper, so it is not clear whether this part of the intervention was implemented in practice. The PDM intervention is framed as a receptive music listening intervention underpinned by evidence from prior ICU-based music listening studies and research on the physiological and psychological effects of music listening rather than being derived from music therapy models or frameworks. Although the PDM intervention could be considered to align with receptive music therapy methods, it does not clearly fit into established music therapy models or orientations such as those outlined by McFerran et al. (2023), since there appears to be no structured therapeutic process or ongoing therapeutic relationship with the music therapist. It would be helpful in future research to more clearly define music listening interventions, clarifying music therapist involvement, to ensure intervention fidelity and avoid misinterpretation or misuse of the intervention by unqualified staff.

Although ICU staff may see the potential benefits for patients of a music intervention, pressures on their time and conflicting priorities, limited access to resources, confidence in facilitating the intervention, or a perceived lack of evidence of effectiveness may present barriers to implementation in an ICU setting (Papathanassoglou et al., 2024). ICU culture and strategies to facilitate implementation, such as education and training for ICU staff and involvement of family members, should be considered when implementing music interventions into practice (Papathanassoglou et al., 2024). Since the intervention is tailored to the choices and preferences of the individual, it seems likely to be acceptable to most patients who wish to use it. However, as discussed by the authors of the evaluation, patients who are severely ill or very sedated may be unable to express their preferences or use the intervention. Furthermore, some people may not enjoy music or may not tolerate wearing headphones, and listening to music is prohibited for some people who practice certain religions. Healthcare professionals should therefore be sensitive to patients' preferences and capacities when offering music listening interventions to ICU patients. The resources used for compiling music selections (e.g. music stores for downloading MP3 files) should be suitably comprehensive, providing a range of genres beyond western styles of music.

Recommendations for future research

Systematic reviews of music therapy for ICU patients have more recently been published, providing a more comprehensive evidence base for the effectiveness of music interventions for this population (Chen et al., 2021; Xiao et al., 2024). It would therefore be helpful to conduct an updated economic evaluation based on the findings of a systematic review to verify the conclusions reached by Chlan et al. (2018). Since healthcare systems in the United Kingdom and Europe differ from those in the United States, economic evaluations using UK cost data are needed to accurately assess the cost-effectiveness of these interventions for the UK NHS settings.

The economic evaluation by Chlan et al. (2018) focused on the effect of the PDM intervention on symptoms of anxiety in ICU patients. ICU patients can also experience symptoms of delirium and pain, which can increase the length of ICU stay and costs of their care (Milbrandt et al., 2004; Shahriari et al., 2015). It would be beneficial to include delirium and pain outcomes in future economic evaluations of music interventions for ICU patients. For patients who can communicate reliably self-reported pain outcomes, such as the 0–10 Numeric Rating Scale which can be administered verbally or visually, are the reference standard for pain assessment (Devlin et al., 2018). For patients who are severely ill or are heavily sedated and are unable to self-report pain, it is recommended that either the Behavioral Pain Scale (BPS) or the Critical-Care Pain Observation Tool (CPOT) are used (Devlin et al., 2018). These are observational behavioural pain assessment tools which are considered to have good validity and reliability for monitoring pain in uncommunicative or sedated patients (Devlin et al., 2018). The analysis did not include costs related to nursing care. The impact of the intervention on nursing time cannot be assumed and should be assessed in future studies. It is possible that the intervention might reduce nursing time (if patients are better able to self-manage their anxiety as the authors suggest) or it could increase it (if patients need extra assistance in using the MP3 player, etc.).

The time horizon used in the analysis by Chlan et al. (2018) was limited to the patient's stay in the ICU, partly because the long-term effects of the PDM intervention were unknown. Employing a short time horizon may result in an inaccurate estimate of the cost-effectiveness of an intervention if there are potentially longer-term benefits (O'Mahony et al., 2015). Therefore, future studies of music therapy interventions should aim to incorporate longer follow-up outcome measures to assess the effectiveness of interventions over a longer period, enabling an extended time horizon to be used in subsequent cost-effectiveness analyses. Future research should additionally consider adaptations and implications for populations that may experience barriers to music listening such as neurodiverse patients, patients with hearing loss, and patients from certain cultural and religious backgrounds.

Commentary on

Chlan LL, Heiderscheid A, Skaar DJ, et al. (2018) Economic evaluation of a patient-directed music intervention for ICU patients receiving mechanical ventilatory support. *Critical Care Medicine* 46(9): 1430–1435. <https://doi.org/10.1097/CCM.0000000000003199>

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