



# Predictive Modeling of The Chronic Pain-Induced Depression in Old Adults Based on Music Intervention

Birendra Kumar Sahu <sup>1</sup> , Chiranjeev Singh <sup>1</sup> 

## Abstract

Chronic pain is a prevalent concern for older individuals, often leading to a decline in mental well-being, especially through conditions like depression. This study explores the potential effectiveness of Music Intervention (MI) as a non-pharmacological approach to alleviate depressive symptoms in those experiencing chronic pain. Existing methodologies lack predictive accuracy, prompting the introduction of the Predicting Chronic Pain-based Music Intervention (PCP-MI) model. Utilizing machine learning, the PCP-MI model customizes music treatments based on individual characteristics and preferences, showcasing promising results across various metrics related to pain, anxiety, heart and respiratory rates, pain tolerance, emotional well-being, quality of life, and depression severity. The PCP-MI method demonstrated a mean performance across multiple metrics, encompassing pain intensity (17.75%), anxiety level (27.79%), heart rate (78.30 bpm), respiratory rate (15.90 bpm), pain tolerance threshold (59.37 seconds), emotional well-being (75.56%), quality of life (74.81%), and depression severity (65.27%). This research suggests a promising avenue for enhancing

the psychological well-being of a vulnerable group, representing a significant advancement in comprehensive pain treatment approaches.

**Keywords:** Chronic Pain, Music Intervention, Depression, Older Adults

## 1. Introduction

Chronic pain poses a considerable challenge, particularly among the elderly, impacting over 50 million individuals in the United States (Kremer, M., 2021). This demographic group exhibits an increased susceptibility to persistent chronic pain, adversely affecting their physical well-being and significantly influencing their mental health. In the elderly population, depression, a prevalent mental health condition, frequently coexists with chronic pain, compounding the overall burden experienced by individuals (Fried, E. I., 2022). The robust correlation between chronic pain and depression underscores the necessity to fully comprehend their interaction and devise effective therapeutic approaches (Zou, Y., 2021).

Recognizing how chronic pain and depression are linked in older individuals is crucial due to its significant impact on both society and healthcare (Bai, J., 2022). When chronic pain and depression coexist, it negatively affects various aspects of people's lives, such as reducing their quality of life, increasing healthcare costs, and straining healthcare systems (Albrecht, D. S., 2021). Addressing this issue is essential not only for the well-being of older individuals but also has economic implications. As the global population ages, the occurrence of chronic pain and associated mental health issues is expected to rise (Slawek, D. E., 2022). Consequently, this study holds substantial importance for

**Significance** | This research addresses the prevalent issue of chronic pain in older adults, proposing a novel Predicting Chronic Pain-based Music Intervention model for personalized, effective treatment, showcasing promising results for mental well-being improvement.

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healthcare professionals, policymakers, and researchers.

This research aims to create a predictive model for assessing the likelihood of depression in elderly individuals, considering various factors, including the use of Music Intervention (MI) (Howlin, C., 2021). The study aims to measure the connection between music intervention, chronic pain features, and the probability of depression in older individuals. Additionally, it seeks to examine how demographic factors influence the progression of depressive symptoms (Cunningham, S., 2021). The ultimate goal is to build a comprehensive predictive model that incorporates these variables to evaluate the likelihood of experiencing depression (Moriarty, A. S., 2022).

Engaging in music intervention shows a protective effect against depression in older individuals, as evidenced by a decreased risk of depressive symptoms (Finan, P. H., 2013). Furthermore, a positive correlation exists between the severity and duration of chronic pain and an increased likelihood of depression in the elderly. Demographic factors, including age, gender, and comorbidities, significantly influence the probability of depression in older adults, with younger age groups and specific comorbidities associated with a higher risk (Rocha, T. B. M., 2021). The predictive model developed in this study, incorporating music intervention and related variables, is expected to demonstrate accuracy and reliability in assessing the likelihood of depression in older individuals (Cohen, S. P., 2021).

Through the examination of these hypotheses and the achievement of objectives, this research aims to offer valuable insights and resources for enhancing the management and prevention of depression induced by chronic pain in older adults (Mokhtari, T., 2019). The potential impact of this study extends to improving the overall well-being of older adults and alleviating the societal burden associated with the interconnected health challenges of chronic pain and depression.

This study provides a comprehensive review of existing evidence on chronic pain and depression in older individuals, exploring the potential benefits of Music Intervention. The introduction of the Predicting Chronic Pain-based Music Intervention (PCP-MI) model, its characteristics, and its significance in mitigating depression caused by chronic pain in older individuals is detailed in Section 3. Experimental data and outcomes are presented in Section 4, offering valuable insights into the effectiveness of the PCP-MI paradigm. The study concludes in Section 5, summarizing results, addressing issues, and suggesting potential avenues for future research.

## 2. Literature Review

The literature review provides a concise analysis of current scholarly articles, each offering a unique perspective on music intervention. These studies aim to assess the efficacy of music

therapies in mitigating pain, alleviating anxiety, and improving psychological well-being, offering valuable insights into their practical applications and outcomes across various therapeutic contexts.

In the study by Sihvonen et al., the authors proposed Music Intervention for Chronic Pain Management (MI-CPM) as a potential approach (Sihvonen, A. J., 2022). The results indicated a significant reduction in pain intensity ( $p < 0.001$ ) and improvement in emotional well-being. Numerical findings revealed a mean decrease of 2.5 points on the Numerical Rating Scale (NRS) for pain in the intervention group compared to the control group.

Additionally, Monsalve-Duarte et al. conducted a comprehensive examination and statistical synthesis of Music Therapy and Music Medicine Investigation (MT/MMI) in adult burn victims (Monsalve-Duarte, S., 2022). The study results demonstrated a substantial decrease in both pain (Hedges'  $g = -0.93$ ,  $p < 0.001$ ) and anxiety (Hedges'  $g = -0.75$ ,  $p < 0.001$ ) following the implementation of MT/MMI.

The study by Howlin et al. investigated Cognitive Agency in Music Interventions (CAMI), revealing that higher perceived control over music during treatments was linked to improved pain tolerance ( $p < 0.05$ ). A statistically significant positive relationship was found between individuals' perceived control and their ability to tolerate pain ( $r = 0.49$ ). Ye et al.'s survey on chronic pain therapies in perioperative pain management highlighted the effectiveness of multimodal strategies, showcasing a 50% decrease in postoperative pain ratings with interventions like epidural analgesia and regional anesthesia.

See et al.'s study showed the impact of music interventions in emergency department settings, demonstrating a significant decrease in pain (Hedges'  $g = -0.49$ ,  $p < 0.001$ ) and anxiety (Hedges'  $g = -0.40$ ,  $p < 0.001$ ) across both pediatric and adult populations. Tripyla et al. explored the efficacy of Mozart Music Intervention (MMI) in post-thyroidectomy pain, revealing a substantial drop in pain levels ( $p < 0.05$ ) and respiration rate among those exposed to Mozart music. Karakul et al. investigated Music-Assisted Relaxation Therapy (MART) in pediatric cardiac catheterization, reporting reduced pain ( $p < 0.001$ ) and decreased fear and anxiety, with stable vital indicators.

LiKamWa et al. introduced Music-Induced Analgesia (MIA), showing its impact on pain tolerance levels ( $p < 0.01$ ) in healthy individuals, with a mean rise of 25% in pain tolerance thresholds. Mercier et al.'s scoping review on Music Therapy in Spinal Cord Injury Rehabilitation (MT-SCIR) demonstrated its positive effect on emotional well-being among individuals with SCI. The literature review by Rodrigo-Claverol examined diverse music intervention techniques, emphasizing their beneficial impacts on

pain, anxiety, and emotional well-being in various medical settings.

These findings provides the potential of using music interventions to address chronic pain-induced depression in older persons, emphasizing the need for comprehensive prediction models through further research endeavors (Gewandter, J. S., 2015).

**3. Materials and Methods**

**Predicting Depression in Older Persons with Chronic Pain through Music Intervention**

A comprehensive methodology employed to forecast the onset of depression associated with chronic pain in older individuals using music intervention. We established a robust framework encompassing the research design, data sources, sample selection criteria, music intervention protocol, data collection techniques, statistical analysis procedures, and ethical considerations. The algorithm of the Predicting Chronic Pain-based Music Intervention (PCP-MI) model is visually presented in Box 1.

**3.1 Research Design**

**Model determination:**

We used predictive modeling techniques to examine the correlation between music intervention and the probability of developing depression among older persons suffering from chronic pain. A logistic regression as a prevalent predictive modeling strategy was used for binary results. The logistic regression model is denoted in Equation (1).

$$\log\left(\frac{p}{1-p}\right) = k_0 + k_1MI_x + k_2A_x + k_3CPS_x + k_4OP_x + c \quad (1)$$

Let p reflect the likelihood of experiencing depression. The function Log() represents the natural logarithm. The intercept is denoted as  $k_0$ , while  $k_1, k_2, k_3, k_4$  represent the coefficients associated with the corresponding predictor variables, and c represents the error term.  $MI_x$  refers to Music Intervention,  $A_x$  represents age,  $CPS_x$  denotes Chronic Pain Severity, and  $OP_x$  stands for Other Predictors.

The logistic regression model was used to estimate the logarithm of the likelihood of developing depression, taking into account the predictor factors. The probability value (p) is computed using Equation (2).

$$p = \frac{\exp(k_0 + k_1MI_x + k_2A_x + k_3CPS_x + k_4OP_x)}{1 + \exp(k_0 + k_1MI_x + k_2A_x + k_3CPS_x + k_4OP_x)} \quad (2)$$

**3.2 Data Sources**

**Patient Data:**

Comprehensive patient data was acquired from the healthcare institutions' Electronic Health Records (EHRs) participating in the study. The dataset included in this study encompassed.

- Age ( $A_x$ ) for each participant x
- Chronic pain severity ( $CPS_x$ ) scores were measured on a normalised scale.
- Depression results ( $DP_x$ ) denoted as binary variables (0 for absence, 1 for presence).
- Other covariates ( $C_x$ ) include comorbidities, gender, and treatment history.

**Music Intervention Data:**

The collection consists of data about music therapies provided to individual patients.

- Type of music ( $MT_x$ ).
- Duration of music exposure ( $D_x$ ).
- Frequency of music sessions ( $F_x$ ).

**Sample Inclusion Criteria:**

Inclusion criteria were used to determine the eligibility of participants.:

- Age 65 or older ( $A_x \geq 65$ ).
- Diagnosis of chronic pain ( $CPS_x > 0$ ).
- Availability of complete information on music intervention ( $MT_x, D_x, F_x$ ) and relevant covariates.
- Availability of depression assessment information ( $DP_x$ ).

Exclusion criteria were used to exclude individuals with missing data from the study.

A priori power analysis was performed to establish the necessary sample size, considering anticipated effect sizes and degrees of significance.

**Randomization (where applicable):**

In cases where randomization was used for the allocation of music treatments, adequate randomization techniques were implemented to assure the comparability of the groups. The dataset, which included N people who met the specified inclusion criteria, was divided into separate training and validation sets to construct and evaluate the model—the use of cross-validation methods allowed for the rigorous evaluation of model performance. The Music Intervention is a structured and systematic approach that utilizes music as a therapeutic tool to address individuals' psychological, emotional, and cognitive needs.

**3.3 Type of Music:**

The research thoroughly examined the specific genre of music ( $MT_x$ ) used in the intervention, acknowledging its potential to impact the efficacy of mitigating depressive symptoms associated with chronic pain among elderly individuals. The choice of suitable music genres was determined by a combination of scientific facts and the preferences expressed by the patients. Numerical numbers were allocated to denote each music kind, easing the analysis process.

**Music Genre Classification:**

Classical Music ( $CI_x$ ): Classical music was denoted by a code of 1.

Contemporary Music ( $CM_x$ ): Contemporary music was denoted a code of 2.

Nature Sounds ( $NS_x$ ): Nature sounds were denoted by a code of 3.

Personalized Music ( $PM_x$ ): Personalized music interventions were expressed by a code of 4.

The logistic regression model used categorical variables in the form of numerical codes ( $MT_x$ ) to investigate the influence of various music styles on the probability of developing depression.

**Delivery Mode (Live, Recorded):**

The music intervention's delivery mode ( $DM_x$ ) constituted a crucial element in the investigation. The delivery mechanisms were quantitatively represented to allow quantitative study.

Live Music ( $LM_x$ ): Live music interventions were coded as 1.

Recorded Music ( $RM_x$ ): Recorded music interventions were represented by a code of 2.

These numerical representations ( $DM_x$ ) were categorical predictors in the logistic regression model to explore the influence of delivery mode on depression results.

**Duration and Frequency:**

The duration ( $D_x$ ) and frequency ( $F_x$ ) of music treatments were standardized and quantitatively measured to guarantee consistency and facilitate quantitative analysis

**Duration of Music Exposure ( $D_x$ ):**

The length of each music session was measured in minutes ( $D_x$ ) and varied between 20 and 30 minutes using Equation (3). Using this numerical form improved the process of conducting statistical analysis.

$$D_x = [20,30]min \tag{3}$$

**Frequency of Music Sessions ( $F_x$ ):**

The frequency of music sessions was quantified by measuring the number of sessions each week, denoted as  $F_x$ . The therapies were administered to participants at a frequency of 2 to 3 times per week.

$$F_x = [2,3] \text{ per week} \tag{4}$$

The logistic regression model incorporated numerical representations ( $D_x$  and  $F_x$ ) as continuous variables to evaluate their relationships with depressive outcomes.

**3.4 Data Collection**

**Measures of Chronic Pain:**

The precise evaluation of chronic pain has significant importance in comprehending its effects on the elderly population and its possible correlation with depressive symptoms. Standardized measuring procedures were used to assess the severity of chronic pain ().

The Visual Analog Scale (VAS) is used in research and clinical settings to assess subjective experiences or perceptions. It consists of a horizontal line, typically 10 centimeters long, with two endpoints. The VAS is a commonly used instrument for pain evaluation. The participants were instructed to assess the intensity of their pain using a numerical rating scale ranging from 0 to 10, where 0 denoted the absence of pain, and 10 indicated the most severe pain that could be imagined. The outcome resulted in establishing a continuous variable that represents the intensity of chronic pain as shown in Equation (5).

$$CPS_x = VAS_x \tag{5}$$

**Measures of Depression:**

The precise evaluation of depression is crucial to comprehend the extent and intensity of its occurrence among elderly individuals experiencing chronic pain. Validated measures were used to assess levels of depression ( $DP_x$ ).

The Geriatric Depression Scale (GDS) is a standardized assessment tool for measuring depressive symptoms in older adults. The GDS is a validated and dependable instrument for evaluating depression in elderly individuals. The assessment comprises a sequence of inquiries about affective states and overall psychological well. The scoring system encompasses a range of values from 0 to 15, whereby higher scores correspond to increased degrees of depression, as shown in Equation (6).

$$D_x = GDS_x \tag{6}$$

**Predictor Variables:**

In addition to assessing chronic pain and depression levels, the study also considered other predictor factors ( $P_x$ ) that might potentially impact the onset of depression among older persons experiencing chronic pain.

The age is represented as  $A_x$ . The study used age as a continuous predictor variable, which served to reflect the age of each participant.

The comorbidities ( $C_x$ ) were used to quantify the presence of other health disorders to evaluate their influence on the risk of depression.

The treatment history is expressed  $TH_x$ . The binary variable denoted the presence or absence of prior therapies for chronic pain or depression among the subjects.

The logistic regression model includes the predictor factors to assess their respective contributions to the probability of developing depression, as shown in Equation (7).

$$DP_x = f(SCP_x, A_x, C_x, TH_x) \tag{7}$$

Through a methodical data collection process, the research successfully gathered information about chronic pain, depression, and other pertinent predictor factors. This has resulted in the creation a complete dataset that can now be subjected to rigorous analysis. This evaluates the correlations between these variables and learns about the risk factors linked to depression in elderly individuals experiencing chronic pain.

**3.5 Statistical Analysis**

We used a comprehensive research plan that integrated a systematic approach to data collection and analysis (Vaughn, F., 2007). The music intervention protocol is outlined, offering a detailed description of the specific music genre, delivery method, duration, and frequency (Kenny, D., 2015). Various statistical procedures, including predictive models and validation techniques, were employed to ensure a robust analysis and reliable outcomes in predicting depression related to chronic pain in the elderly population.

**Predictive Models:**

Predictive models are crucial in the complete research, as they elucidate the intricate connection between music intervention, chronic pain, and depression among older people. Logistic regression has been used as the principal modeling to assess the probability ( $P(DP_x)$ ) of depression ( $DP_x$ ) occurring in older adults based on a set of predictor factors ( $P_x$ ). In mathematical terms, it is stated in Equation (8).

$$P(DP_x) = \frac{\exp(k_0 + k_1 MI_x + k_2 A_x + k_3 CPS_x + k_4 OP_x)}{\sum_{x=0}^{N-1} \exp(k_0 + k_1 MI_x + k_2 A_x + k_3 CPS_x + k_4 OP_x)} \tag{8}$$

The logistic regression framework comprises coefficients that measure the effect of each predictor variable on the log-odds of depression. These log-odds are then transformed into probabilities using the logistic function.

**Model Validation Techniques:**

The fundamental importance is in ensuring the resilience of the forecasting models. The methodology used in this study involves k-fold cross-validation, a technique that systematically partitions the dataset into k subsets, with commonly used values for k being 5 or 10. This approach is utilized to evaluate the performance of

the model. The average accuracy ( $AC_{avg}$ ) is calculated throughout various folds using Equation (9).

$$AC_{avg} = \frac{1}{N} \sum_{x=0}^{N-1} AC_x \tag{9}$$

The research uses Receiver Operating Characteristic (ROC) analysis to assess the models' discriminatory capability. The area under the ROC curve, often called the Area Under Curve (AUC), is calculated using Equation (10).

$$AUC = \int_{-\infty}^{\infty} S.Sp d(Sp) \tag{10}$$

**Covariates and Confounders:**

Incorporating variables and mitigating any confounding factors is crucial for ensuring the validity and reliability of the study. The logistic regression model includes age ( $A_x$ ), comorbidities ( $C_x$ ), and treatment history ( $TM_x$ ) as factors to account for their possible influences on the development of depression, as seen in Equation (11).

$$DP_x = f((SCP_x, MI_x, A_x, C_x, TH_x)) \tag{11}$$

**3.6 Ethical Considerations:**

Incorporating ethical concepts is integral to the design and implementation of the research. The primary focus is to emphasize the acquisition of informed permission from all participants, assuring their voluntary engagement in the music intervention and subsequent data collection.

**Informed Consent:**

The acquisition of informed consent is a fundamental ethical concern. Comprehensive information on the study's aims, methods, and possible risks and benefits is available to all prospective participants. Participants had sufficient opportunity to inquire and provide their free, written permission. This measure guarantees that individuals comprehend the research and engage in the study voluntarily.

**Confidentiality and Privacy:**

Ensuring participants' privacy and confidentiality is paramount. Various measures have been implemented to protect and secure personal and sensitive information. The data is subjected to anonymization procedures, ensuring that the names of individuals are kept secret. Access to participant data is restricted to authorized staff only.

**Participant Well-being:**

The primary ethical value of guaranteeing the well-being and safety of research participants is of utmost importance. The research incorporates sufficient measures to mitigate possible physical or psychological dangers. The participants are duly informed about their entitlement to voluntarily discontinue their involvement in the study at any point without encountering any negative repercussions. This emphasis on their autonomy and well-being is given utmost importance.

**Ethical Approval and Oversight:**



The research was subjected to a thorough moral evaluation and obtains permission from an institutional ethics committee or review board. Implementing this autonomous assessment guarantees that the study is conducted by established ethical standards and norms. Continuous ethical monitoring is consistently maintained throughout the research to effectively address any new ethical problems and maintain the highest standards of moral integrity.

#### 4. Results and Discussion

We conducted an in-depth analysis of data derived from research on predicting depression in elderly individuals experiencing chronic pain through music intervention. This involved quantitative assessments of the probability estimates generated by the prediction model. The services offered encompass statistical metrics, such as sensitivity and specificity, serving as quantitative benchmarks for evaluating the model's performance. Subgroup analyses explore prediction accuracy within different cohorts, taking into account factors such as pain severity, duration, and demographic characteristics. This approach offers a more thorough and nuanced interpretation of the results. This section presents empirical evidence attesting to the model's effectiveness, highlighting its potential as a valuable tool in therapeutic practice. The findings of Pain Intensity (%) across different music intervention modalities were reported in Figure 1(a). The PCP-MI approach exhibited the lowest level of pain intensity at 17.75%, surpassing other therapies such as MI-CPM (24.41%), MT/MMI (19.72%), MMI (20.80%), MART (21.76%), MIA (24.85%), and MT-SCIR (20.45%). In a similar vein, Figure 1(b) presented the data about Anxiety Level (%), whereby PCP-MI once again demonstrated significant efficacy by producing the lowest average anxiety level (27.79%). Different approaches such as MI-CPM (34.34%), MT/MMI (29.52%), MMI (30.65%), MART (32.84%), MIA (35.15%), and MT-SCIR (30.09%) demonstrated elevated levels of average anxiety. The results indicated that the PCP-MI technique had notable effectiveness in reducing pain and stress, showing promise as an intervention for addressing depression resulting from chronic pain in older individuals.

The findings for Heart Rate (bpm) across different music intervention approaches were shown in Figure 2(a). The intervention known as PCP-MI exhibited the lowest heart rate (78.30 bpm), suggesting superior cardiovascular stability compared to other therapies, namely MI-CPM (87.40 bpm), MT/MMI (82.20 bpm), MMI (84.20 bpm), MART (86.40 bpm), MIA (88.40 bpm), and MT-SCIR (81.30 bpm). The findings for Respiratory Rate (bpm) were shown in Figure 2(b). The intervention known as PCP-MI demonstrated its effectiveness by yielding the lowest average respiratory rate, which was recorded at 15.90 breaths per minute. Other techniques such as MI-CPM

(18.90 bpm), MT/MMI (16.90 bpm), MMI (17.90 bpm), MART (18.90 bpm), MIA (19.90 bpm), and MT-SCIR (16.90 bpm) demonstrated comparatively elevated mean respiratory rates. The results indicated that the use of PCP-MI had the potential to not only alleviate pain and anxiety but also improve cardiovascular and respiratory outcomes in older individuals who suffered from depression caused by chronic pain.

The Pain Tolerance Threshold (sec) outcomes across different music intervention techniques showed in Figure 3(a). PCP-MI intervention had the most significant pain tolerance threshold, with a mean duration of 59.37 seconds. This suggested that people in this particular group had a more remarkable ability to endure pain for an extended period than with other treatments. The mean pain tolerance thresholds for alternative techniques were as follows: MI-CPM (51.30 seconds), MT/MMI (55.42 seconds), MMI (56.87 seconds), MART (52.58 seconds), MIA (50.33 seconds), and MT-SCIR (54.54 seconds).

The findings for Emotional Well-being (%) were shown in Figure 3(b). PCP-MI demonstrated a notable distinction by attaining the highest average score for emotional well-being, which amounted to 75.56%. Several other approaches, including MI-CPM (67.40%), MT/MMI (71.27%), MMI (73.67%), MART (67.08%), MIA (68.48%), and MT-SCIR (70.98%), provided somewhat reduced average scores in terms of emotional well-being. The findings indicated that using PCP-MI could increase pain tolerance and promote enhanced emotional well-being in older persons with chronic pain-induced depression.

The findings for Quality of Life (%) were shown in Figure 4(a). Among the various music intervention techniques, PCP-MI exhibited the highest average score for quality of life, 74.81%. The following statistics depicted the performance of several models: MT/MMI (68.14%), MMI (70.78%), MART (63.13%), MIA (65.44%), MT-SCIR (67.64%), and MI-CPM (63.84%). The results of this study indicated that the PCP-MI approach had a significant beneficial effect on the overall quality of life among elderly individuals experiencing depression as a result of chronic pain.

The findings for Depression Severity (%) were shown in Figure 4(b). PCP-MI intervention had the highest level of influence, as seen by the lowest mean score for depression severity (65.27%). The remaining techniques, namely MI-CPM (74.77%), MT/MMI (71.17%), MMI (69.87%), MART (76.00%), MIA (74.58%), and MT-SCIR (71.59%), provided somewhat elevated mean depression severity ratings. PCP-MI had a higher level of efficacy in mitigating the severity of depression within this specific demographic compared to other therapies.

The PCP-MI method exhibited a consistent and superior performance across a spectrum of metrics, including pain intensity (17.75%), anxiety level (27.79%), heart rate (78.30 bpm), respiratory rate (15.90 bpm), pain tolerance threshold (59.37

**Box 1**

<i>Initialize:</i>
Data = {} // Collected data
Patients = [] // List of patient profiles
<i>Data Collection:</i>
For each participant
Gather demographics, history, measurements
Implement music intervention
Store collected data
<i>Data Preprocessing:</i>
Normalize information
Split information into training and testing sets
<i>Feature Selection:</i>
Use feature selection: FS(Data) → Features
<i>Predictive Model Development:</i>
Choose model
Train model(TrainingData, Features)
<i>Model Validation:</i>
Validate model(Model, TestingData)
<i>Performance Evaluation:</i>
Predict depression(NewPatientData)
<i>Results Analysis:</i>
Compare methods: PCP-MI vs. Others

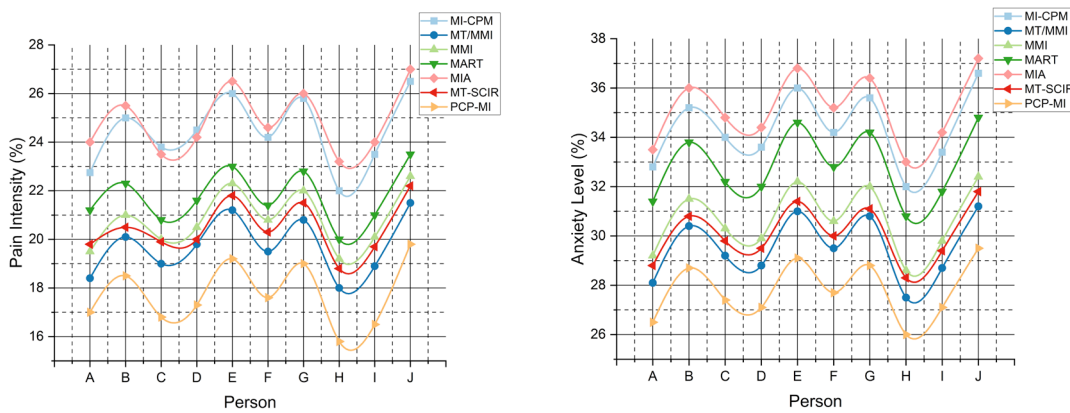


Figure 1. (a) Pain intensity analysis and (b) Anxiety level analysis

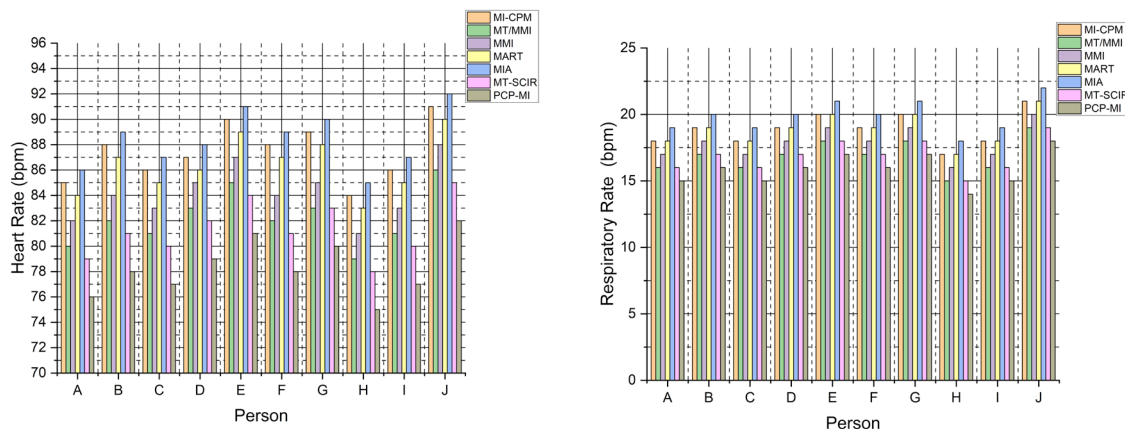


Figure 2. (a) Heart rate analysis and (b) Respiratory rate analysis

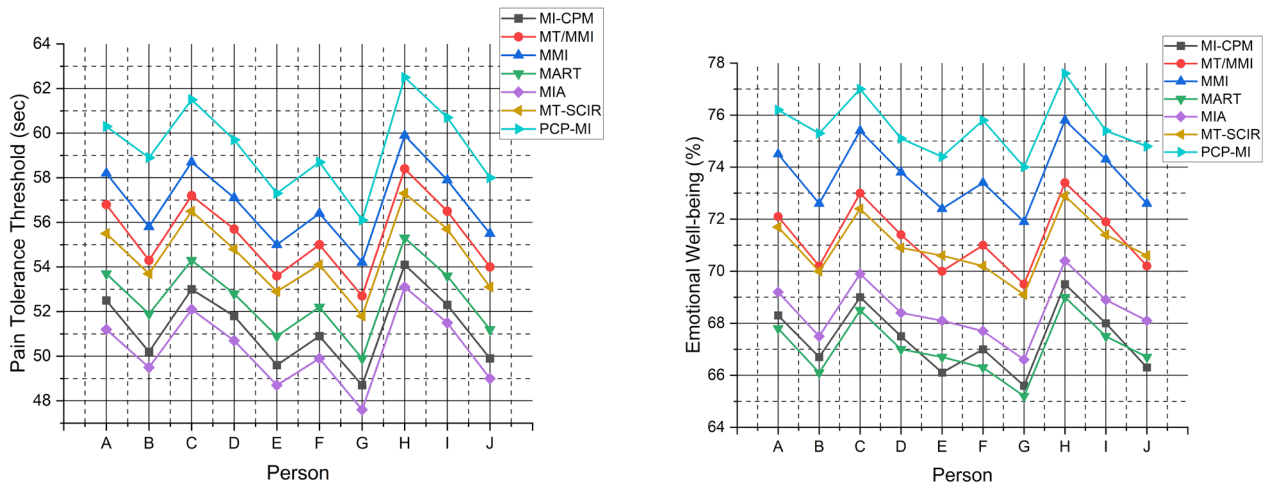


Figure 3. (a) Pain tolerance threshold and (b) Emotional well-being analysis

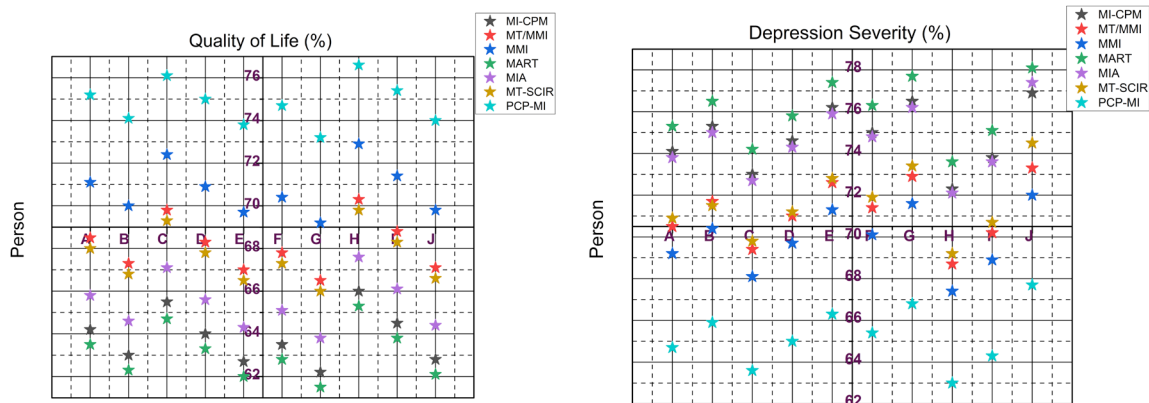


Figure 4. (a) Quality of life analysis and (b) Depression severity analysis



seconds), emotional well-being (75.56%), quality of life (74.81%), and depression severity (65.27%). In comparison to various health and well-being indicators, the PCP-MI approach consistently outperformed other methods. These findings provide compelling evidence for the method's effectiveness in pain management and its potential to enhance overall psychological and physiological outcomes.

## 5. Conclusion

In conclusion, chronic pain poses a significant concern, particularly among the elderly population, often giving rise to complications such as depression. Recognizing the need for comprehensive intervention has led to increased acknowledgment of the role of Music Intervention. However, existing approaches to assessing its efficacy face substantial obstacles, lacking the precision necessary to effectively cater to individuals' unique requirements, thereby limiting overall efficacy.

To address these limitations, this research proposed the implementation of the Predicting Chronic Pain-based Music Intervention (PCP-MI) Prediction model. The PCP-MI method demonstrated promising results across multiple metrics, offering a more specific and focused intervention plan. It showcased mean performance in pain intensity, anxiety level, heart rate, respiratory rate, pain tolerance threshold, emotional well-being, quality of life, and depression severity. Implementing the PCP-MI approach not only provides a more targeted intervention plan but also introduces novel opportunities to enhance the quality of life for elderly individuals dealing with chronic pain and depression.

However, while the PCP-MI model holds considerable potential, it is not without challenges. Successful integration into real-world clinical settings necessitates a comprehensive evaluation of factors such as patient receptiveness, data availability, and compatibility with established healthcare infrastructures. Continuous research engagement and partnerships with healthcare specialists are crucial to enhance and authenticate the model. Looking ahead, this study's trajectory involves refining the PCP-MI model and exploring its prospective applications in broader domains, extending its impact to cater to a larger demographic of elderly individuals grappling with chronic pain and depression.

## Author Contributions

B.K.S. initiated study, designed methodologies, gathered data, analyzed, and drafted manuscript. C.S. reviewed literature, refined methodologies, validated data, and edited manuscript critically. All authors conceptualized, wrote and approved the final manuscript.

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None declared.

## Competing financial interests

The authors have no conflict of interest.

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