

Original Article

# Using Data Mining Algorithm for Assigning Family-Centered Empowerment Model as to Improve the Quality of Life in Cardiac Infarction Patients

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## Abstract

**Introduction:** Today, cardiovascular disease is a major threat to advanced human societies, and is acting as a major cause of disability in many aspects of a patient and family members' lives, including their quality of life. Therefore, the aim of the present study is to provide models for classifying and determining the factors influencing the allocation of family-centered empowerment model to further improve the psychological quality of life of these patients.

**Materials and Methods:** In this study, data from a clinical trial study were used in which 70 patients with myocardial infarction who randomly received a family-centered empowerment pattern and control group. A model of linear mixed effects and then learning algorithms were used to predict the success or failure of the empowerment model.

**Results:** In this study, the decision tree model was able to accurately predict more than 96% of patients (Kappa=0.828, ROC=0.96). Physical functions, walking status, creatinine level, EF level, employment status, gender, stress level and body mass index were identified as the effective factors in assigning a family-centered empowerment pattern (P value <0.05). This process was done through software of SPSS24, SAS9.1 and WEKA 3.6.9

**Conclusion:** The decision tree model was able to correctly classify more than 96% of patients; if a family-centered empowerment model was assigned, this model would improve the psychological dimension of their quality of life.

**Keywords:** Family-Centered Empowerment Model, Quality of Life, Cardiac Infarction, Data Mining, Longitudinal Study

## 1. Introduction

Today, human life, with the increasing growth of science and technology has taken a completely different approach, so that with the density of the population, especially in urban areas, the tendency of people to inappropriate habits has become widespread [1]. One of the consequences of these habits' dispersion is the increasing growth of various diseases. Among non-

communicable diseases, cardiovascular disease is the major cause of death and disability in most countries around the world, and myocardial infarction is one of the most common diagnoses in hospitalized patients in industrialized countries[2]. Myocardial infarction usually occurs due to a sharp decrease or cessation of blood flow in the coronary arteries due to thrombosis caused by advanced atherosclerotic lesions.

The disease affects many aspects of a persons' life and health, leading to limitations in physical activity, psychological distress, disruption of social interactions, increased dependence, and overall negative impact on life quality[3].

According to the world health organization, the life quality is the perception of peoples' living conditions in the form of culture and values that govern society and is in line with the goals, standards expectations and interests of the individual[ 4]. For this reason, it is important to measure the life quality in the healthcare system, which not only have negative effects on social and family life, but also increases the risk of hospitalization and death from heart disease [5]. Although the life quality of these patients is improved in several areas, the most vulnerable ones have been the functional area and then the mental state of patients [6]. Now, given that life quality is a predictor of heart failure consequences, and considering that heart disease can affect the patients and their family members and community, therefore, the involvement of family members as providers of care for patients with this chronic disease, as well as the implementation of empowerment and prevention programs to reduce the complications of this disease seems essential[7].

The concept of empowerment was first introduced in diabetes as a process of discovering and developing one's innate capacity to accept life responsibility due to having knowledge and sufficient resources to make and implement logical decisions, and sufficient experience to evaluate some of the decisions made [8]. The model of family-centered empowerment was defined by Alhani for chronic patterns in Iran, with the aim of empowering the family system to improve health [9]. Therefore, in order to achieve the desired life quality and improve the health of patients, considering the biological differences, various individual and environment factors affect the treatment of patients and their life quality with a great

impact and cause different reactions of people to empowerment model. In the case of improper allocation, this technique may not be 100% effective for all patients and may lead to failure[10].

Therefore, in order to evaluate the effectiveness of treatment and the course of disease, it is necessary to measure the psychological dimension of patients' life quality frequently and over time[11]. These repeated measurements lead to solidarity in the data and cause lack of independence in them. Although the inconsistency of this correlation between the data may not have much effect on the approximation, it will affect the confidence interval and standard deviation as well as statistical tests[12]. Among the methods of data correlation analysis are marginal, mixed and random effects models. However, due to the fact that the mixed models consider more flexible structures than the covariance variance matrix, and the fact that they have no restrictive assumption on the structure of such data, they are more appropriate than other methods. Therefore, by using these methods, it will be possible for each person to make the empowerment pattern effective[13].

Today, due to the rapid development of technology and a significant increase in the volume of data, significant advances have been made in various fields, including health, safety and medicine [14]; however, the analysis and computational methods of such data have expanded significantly as a major biomedical challenge [15] . On the other hand, advanced data mining techniques have developed rapidly in recent years and now an increasing number of data mining algorithms are used to predict and analyze biomedical data [16]. However, since providing high -quality health services with limited medical resources is a major concern, and given that data mining techniques are commonly used to construct predictive models [17], those models called learning algorithms can be used to evaluate the effectiveness of treatments.

On the other hand, by using statistical data mining tools and available tools, the factors affecting the effectiveness of this pattern and the intensity of the impact of each factor are determined. For example, using different data mining methods, the empowerment model can be predicted.

## 2. Materials and Methods

In this study, the data of 70 patients participating in a randomized clinical trial study designed to investigate the effect of family-centered empowerment model on patients with myocardial infarction were used. The tools used in this study included three general sections (demographic information questionnaire for the patient), clinical (walking test, creatinine level, Ventricular ejection fraction (EF) and (ST) changes) and specific (eight-dimensional tool for life quality). The empowerment model training process is done through 7 group discussion of 45 to 60 minutes according to the physical, mental and psychological conditions of the participants[18]. Independent t-test was used to determine the effect of independent variables in the baseline at the two treatment groups. This study has been approved by research Ethics Committee of Shahid Beheshti University of Medical Sciences (code number: IR.SBMU.REC.1398, 039).

In many medical research studies, it is necessary to measure the response frequently to evaluate the effectiveness of treatments as well as the course of diseases. Indicators related to the psychological dimensions of life quality of patients with myocardial infarction over 8 times (before interventions and 7 sessions during the intervention) were measured. In the current investigation, the statistical mixture model was used since the psychological dimension's index was examined 7 times, and the measures were time-dependent. Predictive variables include three sections: general (demographic information questionnaire), clinical (walking test,

creatinine level, Ejection fraction and ST segment changes) and exclusive (stress, anxiety, social function, Physical function, limitations of physical and social function). The psychological dimension of quality of life was also considered as the response variable. But, in the first stage, the effect of treatment was first discussed, meaning that the two treatment groups were included in the random effects model as predictor variables. This model led to the estimation of correlation between psychological dimensions' indices at different times for each patient. Based on the results of the mixture model, individuals were divided into two distinct groups due to the increase/non-increase of the psychological dimension's index regardless of the type of treatment received. The computation formula of the model is as follows[11]:

$$Y_{ij} = \beta_0 + \alpha_{0i} + (\beta_1 + \alpha_{1i})Z_{1i}T_{ij} + \beta_2T_{ij} + e_{ij}$$

where  $\alpha_{0i}$  and  $\alpha_{1i}$  are the random intercept and slope for subject  $i$ , respectively, and  $e_{ij}$  are random errors. While  $\beta_1$  represents the overall average of the treatment effect over time,  $\alpha_{1i}$  enables us to take into account individual differences. The patients were classified in such a way that the total estimated coefficients of  $\beta_1$  and  $\alpha_{1i}$  of this model were used to evaluate the effect of each of treatment techniques assigned to patients. Because it was expected that for patients receiving optimal treatment, the psychological dimension of life quality would increase over time, patients with a total coefficient of  $\widehat{\beta}_1 + \widehat{\alpha}_{1i} > 0$ , were considered as patients whose family-centered empowerment model led to an improvement in their psychological life quality. (Group 1). For patients with characteristics of  $\widehat{\beta}_1 + \widehat{\alpha}_{1i} < 0$  this pattern did not have a significant effect on improving the psychological dimension of patient's life quality and were considered as (group 0)[10].

Then in the second stage, according to the grouping obtained from fitting of mixed

model that showed the improvement or non-improvement of psychological dimension of life quality, it was used as the response variable and different predictive algorithms were fitted to the data. At this stage, due to multiplicity of factors affecting the allocation of family-centered empowerment model, the factors that were considered by the expert to be effective in the allocation of treatment and include 3 general sections (patient demographic information questionnaire, clinical (walking test, creatinine level, EF and ST changes) and specific (eight-dimensional too of life quality) was considered as the model predictions. In practice, however, due to the unknown relationship between these factors and the outcome of treatment, linear classification algorithms including (logistic regression, support vector machines (SVM), diagnostic analysis (LDA), and nonlinear include (Decision tree, Random forest, Neural network and non-linear support vector machine) were used to fit the prediction models[10]. Finally, the validity of these models was measured through the ROC sub-level index, leading to the identification of the most appropriate predictive algorithm and through this optimal predictor model, the routes of access to the factors affecting the allocation of family-centered empowerment model as well as the intensity of the impact of each factor, were determined[14].

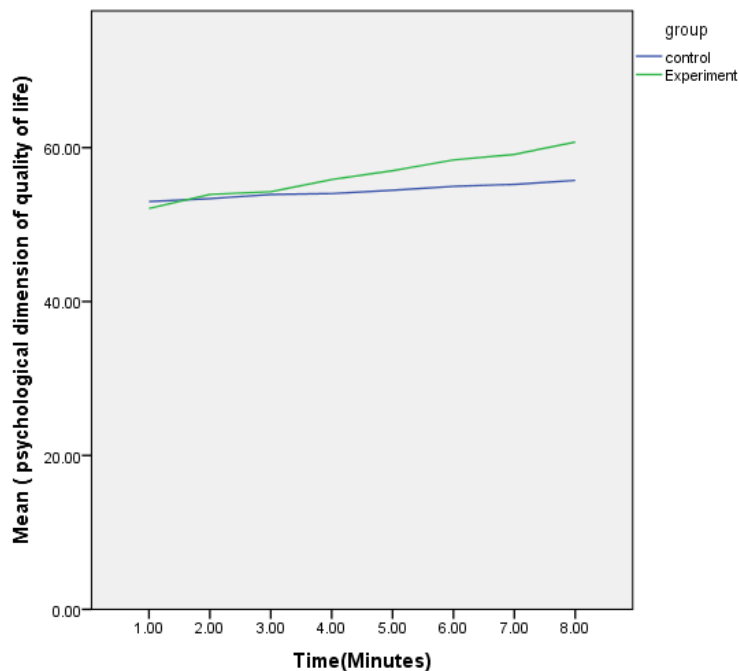
SAS 9.1 and SPSS 23 softwares were used to fit the linear measure of the effectiveness of individual therapy, and WEKA 3.6.9 software was used for modeling learning algorithms to predict optimal treatment. To compare the adjusted forecasting algorithms, the area index below the ROC curve and Kappa coefficient were used and a model was considered as the superior model. First, the model had the lowest estimation error compared to other models, second, the area index below the ROC curve was closer to the number one and had the highest Kappa coefficient. The area below the ROC curve was compared with the number one, and the value ( $P$ -value $<0.05$ ) was considered as a significant level[14].

### 3. Results

The mean age of 70 studied patients in the intervention and control group was 62.03 and 60.09 years respectively, with a deviation of 2.39 and 1.94 years. Prior to the interventions, no significant difference level and 8 dimensions of life quality except for walking and physical activity in the two groups were observed (Table1). The mean psychological dimension of quality of life at 8 times was compared in the two treatment groups, which shows that over time, the psychological dimension of quality of life in the intervention group had improved (Figure 1).

**Table 1.** Comparison of mean and standard deviation of scores of quantitative variables of participants in both experimental and control groups (Baseline)

Variables	Group		P-value
	Experiment	Control	
Age	62.0 $\pm$ 2.39	60.0 $\pm$ 1.94	0.691
BMI	24.7 $\pm$ 0.05	25.0 $\pm$ 0.06	0.717
Ejection fraction	41.7 $\pm$ 1.45	38.8 $\pm$ 1.13	0.120
Creatinine	1.27 $\pm$ 0.05	1.20 $\pm$ 0.06	0.355
Walking condition	618.7 $\pm$ 8.31	655.0 $\pm$ 8.7	0.004
Physical function	52.7 $\pm$ 2.03	43.5 $\pm$ 2.42	0.005
Restrictions on physical function	55.0 $\pm$ 3.91	48.5 $\pm$ 1.09	0.262
Body pain	51.2 $\pm$ 3.59	55.1 $\pm$ 3.09	0.425
Mental health	52.1 $\pm$ 2.05	53.0 $\pm$ 1.91	0.753
Freshness	52.1 $\pm$ 1.94	53.0 $\pm$ 1.75	0.745
Social Performance	54.1 $\pm$ 3.64	54.2 $\pm$ 4.10	0.996
Physical pain	59.6 $\pm$ 4.63	58.2 $\pm$ 4.14	0.182
general health	51.7 $\pm$ 1.75	49.1 $\pm$ 2.13	0.369

**Figure 1.** Comparison of the average psychological dimension of quality of life at 8 times in the two treatment groups

By fitting the random effects model, as expected in patients who have received the

appropriate treatment (regardless of treatment type which assigned), life quality

would increase over time, and calculating these values and comparing them with the number zero allowed us to initialize the patient ( $\widehat{\beta}_1 + \widehat{\alpha}_{1i} > 0$ , was the appropriate treatment for the individual.). Patient ranking through this model showed that in 35 (50%) of patients with myocardial infarction who had received family-centered empowerment pattern or common treatment, the psychological dimension of life quality had improved.

After this separation, the learning algorithms were fitted and compared with each other. Two random forest algorithms and then a decision tree were selected as the most appropriate models. The areas below the ROC curve and Kappa coefficient for these models were calculated respectively (0.96 and 1.0) and (0.82 and 1.0). However, due to the easier interpretation of decision tree, this model was used to allocate treatment which would improve the psychological dimension of patients' life quality (table 2).

**Table 2.** Comparison of linear and nonlinear prediction algorithms.

Type	Methods	Correctly classified instance	Kappa statistic	Roc Area	Mean absolute error
Linear	Logistic regression	68.50	0.371	0.71	0.41
	LDA <sup>a</sup>	56.24	0.117	0.51	0.48
	SVM <sup>b</sup>	55.00	0.092	0.50	0.47
Nonlinear	QDA <sup>c</sup>	57.43	0.152	0.58	0.46
	Neural Network	54.28	0.085	0.50	0.49
	Decision tree	91.42	0.828	0.96	0.13
	Random forest	100.0	1.00	1.00	0.20
	SVM (Radial)	65.70	0.314	0.67	0.34

<sup>a</sup>Linear discriminant analysis , <sup>b</sup>support vector machine , <sup>c</sup>quadratic discriminant analysis .

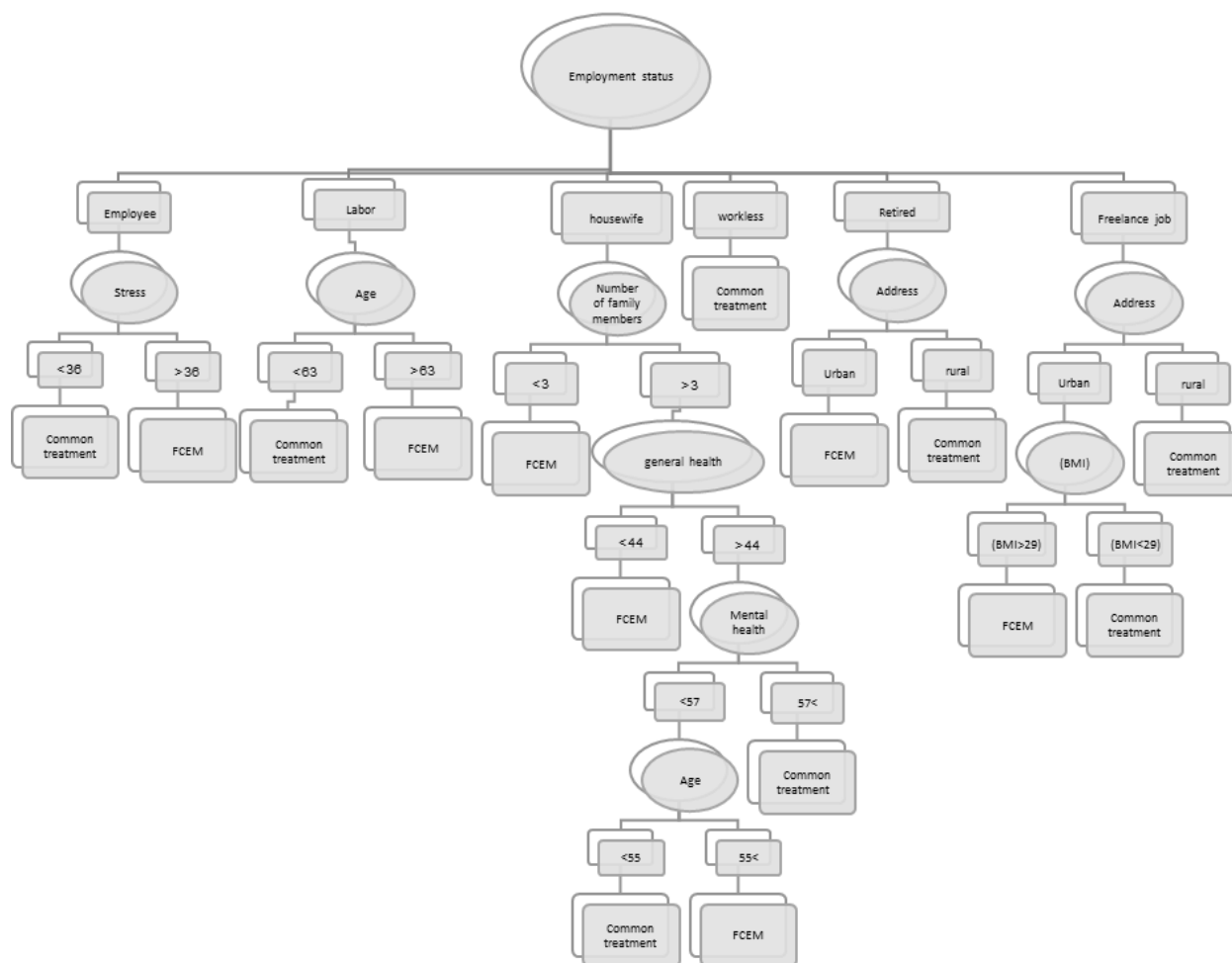
This tree was fitted on the data in tree modes. In the first case, mental variables (stress, anxiety), vitality, social function and mental health) and demographics (employment status, age, gender, body mass index, place of residence, etc...) were considered as predictors. In this case, FCEM improved the psychological dimension of life quality in:

1. Employees with high job stress
2. Workers over the age of 63

3. Housewives with a population of less than 3, as well as housewives with general health less than 52 and if general health benefits more than 52, they had a mental health score less than 57 and at the same time were over 55 years old

4. Retirees who have lived in cities

5. People with freelance jobs have become residents of cities who have been among the obese people in terms of BMI (figure2).



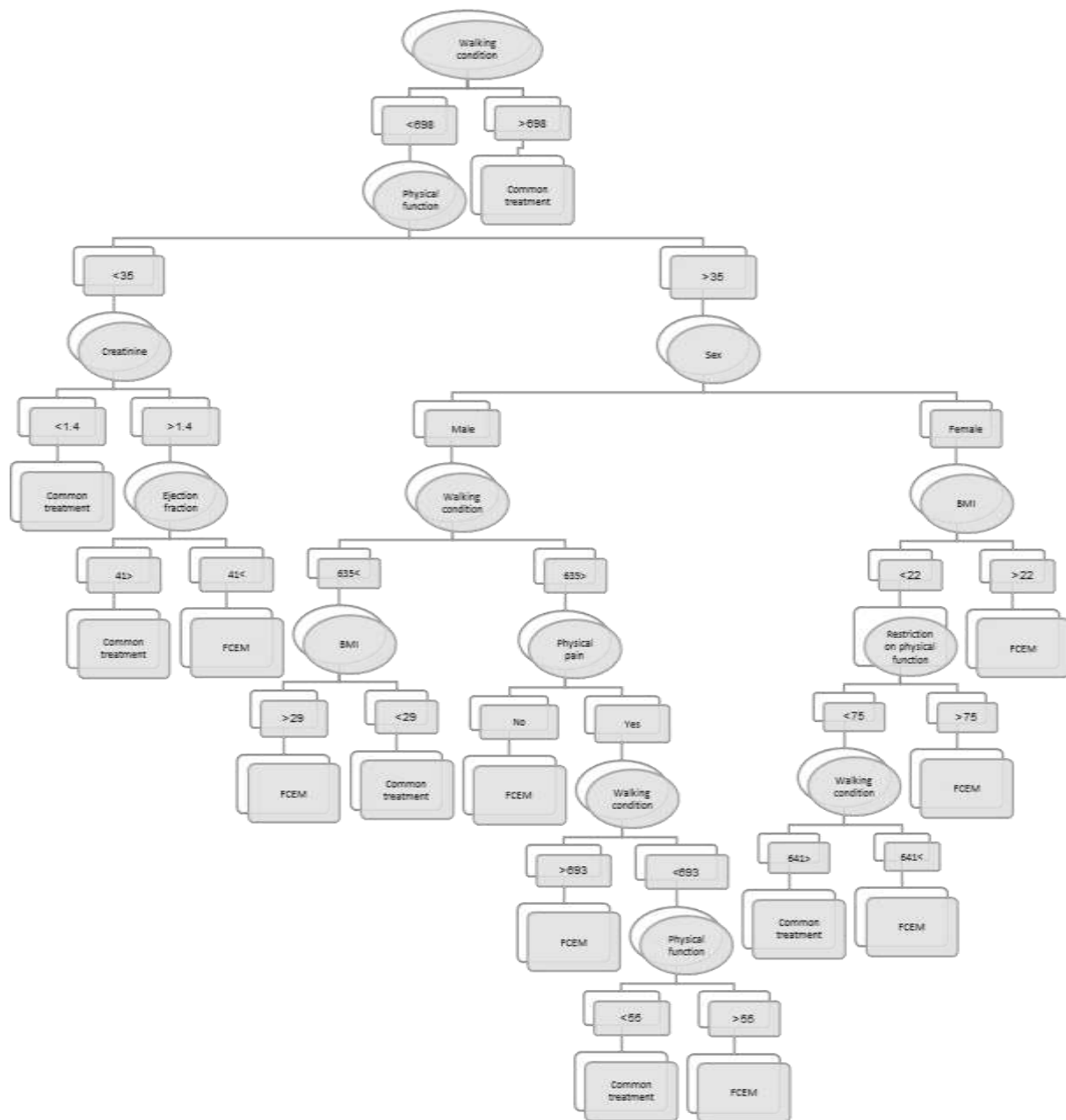
**Figure 2.** Outcomes of decision tree making from effective mental and demographic on allocation of family-centered empowerment model.

In the second case, objective and demographic variables were considered as predictors. In this case, FCEM led to an improvement in the life quality of people, that in all of them the walking condition less than 698, and if should have one of the following conditions:

1. Physical performance less than 35 with creatinine level more than 1.4 and Ejection Fraction more than 41.
2. Having physical activities more than 35 in men while their walking status is less than 635 and BMI less than 29, or if in mentioned, their walking status became more than 635, they would not be in

physical pain, but if physical pain was observed, it would have a walking status of more than 493 and physical activity of more than 55.

3. In case of physical function of more than 35 and female patients, the BMI status should be more than 22 to achieve recovery. If the BMI of these people were less than 22 and the limit were more than 75 due to physical function, the empowerment model would be effective in improving mental health. It could also be useful for people with a performance limit of less than 75 who have walked more than 641 (figure3).



**Figure 3.** Outcomes of decision tree making from effective objective and demographic predicting on allocation of family-centered empowerment model.

And in third case; objective, subjective and demographic variables were considered as predictors at the same time.

In this case, the first factor influencing the improvement of the psychological dimension of life quality through receiving treatment of family-centered empowerment model, is walking status. SO, FCEM has led

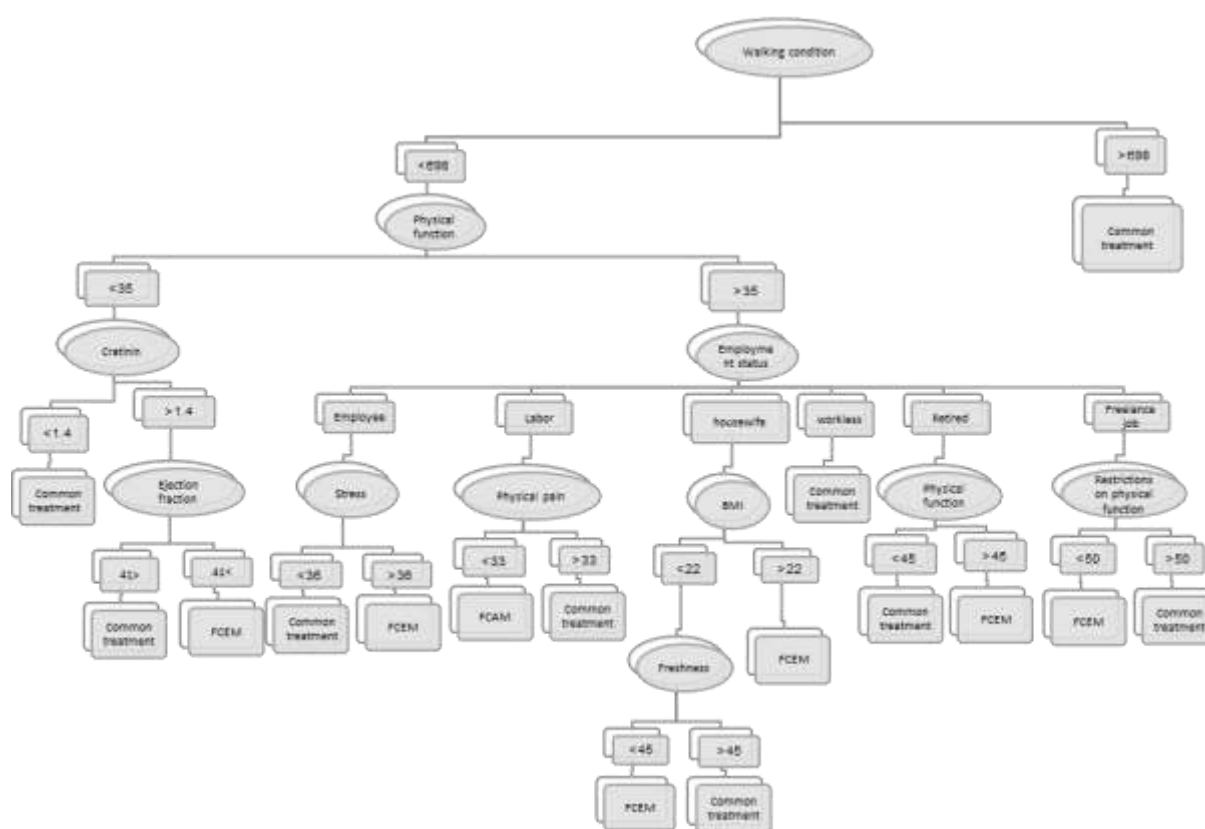
to an improvement in the psychological dimension of people with the following characteristics:

Having a walking status of less than 698 who have less than 35 physical functions, so that at the level of creatinine more than 104, their ejection fraction is more than 41.



In case of walking status of more than 698 and physical function of more than 35, employees with stress level of more than 36, workers who have physical pain of less than 33, housewives with BMI of more than 22, if the BMI is less than 22 for these people and the freshness is less than 45, FCEM can be effective in recovery. This treatment is also suitable for retirees with a physical function of more than 45 and

people with a freelance job who are restricted in movement (figure4). Patient classification based on fitted decision trees in order to predict the impact of the family-centered pattern showed that if this pattern is used properly in 33 patients, psychological dimension of life quality of patients will be improved.



**Figure 4.** Outcomes of decision tree making from effective mental, objective and demographic predicting on allocation of family-centered empowerment model.

#### 4. Discussion

Given the multidimensional impact of chronic disease on family members and the potential role that this center has on the overall lifestyle of the patient and his family, it seems important to examine the life quality of these patients and to have a

plan to empower them in this group of diseases[19]. Hence, it is necessary to try to provide appropriate and talented fields for prevention of disease exacerbation through using the available facilities and conditions. This can provide the conditions for patients

with heart diseases to have a better and more optimal life quality[20].

As mentioned, increasing self-efficacy and self-esteem are two important factors in increasing patients' ability to monitor health status. In a clinical trial which was conducted by Vahedian Azimi and co-workers (2008), the effect of family-centered empowerment model on life quality of patients with myocardial infarction was investigated. They found that by using a family-centered empowerment model the life quality of patients with myocardial infarction is improved [9]. In another clinical trial study, Chery (2009) examined patient empowerment and intervention motivation and concluded that providing a set of care goals to empower a patient could be achieved by increasing patient motivation and significantly improving recovery in their life quality.

However, as it is known, most of the studies have examined the effect of different treatment methods on improving patient's life quality, in which several factors can be involved as to the effectiveness of treatment methods. In the present study, it was decided to use demographic, clinical and specific characteristics of patients with myocardial infarction, to identify patterns for optimal allocation of family-centered empowerment model that had the least error and were easy to interpret. Also, the factors affecting the effectiveness of this pattern and impact severity of each factor were identified. The most influential factors identified in the case where demographic and mental variables were considered as predictors, were employment status, amount of stress, age, number of family members, address, body mass index (BMI), mental and general health of each patient.

These factors, when demographic and objective variables were used as predictors in data mining model, including walking status, body function level, blood creatinine level, EF level, gender, physical pain, body mass index, and restriction due to physical function. Finally, considering all three areas

of general, specific and clinical as predictive, effective factors for improving the psychological dimension of patients' life quality includes walking status, job status, creatinine level, EF level, amount of stress, physical pain, limited movement and body mass index. Therefore, according to the level of access to each of general, specific and clinical areas of patients, it is possible to decide on the optimal allocation of family-centered empowerment model, so that it has the highest return for the patient.

Based on the area index below the curve of performance characteristic, the best methods were random forest, decision tree, nonlinear support vector machine, nonlinear diagnostic analysis, linear support vector machine, logistic regression and finally linear diagnostic analysis. The reason for the relative superiority of the random forest algorithm in predicting the correct allocation of family-centered empowerment model should be considered in the learning process, because based on the learning process, all complex nonlinear relationships are learned among independent variables. Therefore, the predictive power of this model will be significantly higher. The most important disadvantages of random forests are the complexity and time consuming nature of calculation method and algorithm; therefore, statistical data software related to data mining should be used for its proper implementation[21].

Decision tree, as a non-parametric method and a powerful tool in data mining, has shown high accuracy in predicting the correct allocation of the family-centered empowerment model[22]. This method, when a high percentage of variables are qualitative, is a good one for data mining[23]. The most important advantage of this method is its very high interpretability due to its tree structure. However, one of the problems with the decision tree method is that at each stage of the implementation of the algorithm, it makes the separation process based on only one decision variable[24].

In this study, the weakest predictive results were related to diagnostic analysis, because it is a parametric method which depends on the acceptance of normality of several variables, and as a result, as long as this acceptance is not estimated, it is not a suitable method for classification purposes. Another problem with diagnostic analysis, such as neural network, is the inability to interpret the coefficients of the diagnostic function[25].

As can be seen from the above discussion, in most researches, all attention has been focused on predicting patients' status as accurately as possible and increasing accuracy, while a very important issue, the validity of algorithms, has been neglected. This issue has received a special attention in the current study[10, 26]. The advantage of the proposed method is that it first measures the effectiveness of individual therapies and uses learning algorithms while making them easier and more practical. However, given that each of these algorithms differs in terms of classification time, interpretation of results[10], computational time, and availability of statistical software, the appropriate algorithm differs according to the relationships of the variables to the response variable. However, among other models, the most suitable model was the random forest algorithm, while here, due to better interpretability and similarity of the results of the decision tree algorithm with the random forest model, this algorithm was used to allocate treatment[10].

## 5. Conclusion

The results of this study manifested that the decision tree model is able to predict accurately more than 96% of patients who, if properly allocated to the family-centered empowerment model, will have improved psychological dimension of their life quality. This model also identifies the factors influencing the allocation of the treatment effect and severity of each factor's effect. However, the results of each learning

can vary according to the variability of the variables.

## Conflict of interest

The authors declare no conflict of interest.

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