Journal of Biostatistics and Epidemiology

J Biostat Epidemiol. 2024;10(4): 396-405

DOI: https://doi.org/10.18502/jbe.v10i4.18521

Original Article

Clustering Undergraduate Students Based on Their Self-Esteem and Academic Achievement via the K-Means Approach

Zahra Ghafari[1], Elaheh Sanjari[2], Sousan Raeisi[1], Hadi Raeisi Shahraki[3*]

[1]Student Research Committee, Shahrekord University of Medical Sciences, Shahrekord, Iran.
[2]Student's Scientific Research Center, Tehran University of Medical Sciences, Tehran, Iran.
[3]Department of Epidemiology and Biostatistics, Faculty of Health, Shahrekord University of Medical Sciences, Shahrekord, Iran.

ARTICLE INFO

Received 23.05.2024
Revised 13.07.2024
Accepted 26.07.2024
Published 15.12.2024

Key words:
Self-esteem;
Academic achievement;
Academic performance;
K-means clustering;
Students

ABSTRACT

Introduction: Self-esteem is one of the key foundations of human personality and is known as an important component in mental health and social psychology. Students with high self-esteem tend to be more engaged and persistent in areas of achievement. This study was devoted to cluster undergraduate students of Shahrekord University of Medical Sciences based on their self-esteem and academic achievement.
Methods: The multi-stage cluster sampling method (three faculties and three departments in each) was used to select 260 undergraduate students from various fields in 2022. The data collection tool included a background information checklist, a 10-item self-esteem questionnaire, and a 39-item academic achievement questionnaire. The elbow method was used to estimate the number of optimal clusters. The NbClust package in R 4.2.1 software was used for clustering analysis based on the k-means approach.
Results: In this study, out of 260 participating students, 176 (67.7%) were girls and 84 (32.3%) were boys. The overall mean ± standard deviation of academic achievement was 105.2 ± 10.3. There is a positive and significant correlation (r = 0.44) between academic achievement and self-esteem (P-value <0.001). The optimal number of clusters was estimated as four based on the elbow method. Self-esteem in cluster number 1 with 35 students was at the lowest level at -2.6±2.9. The academic achievement was significantly different among the obtained clusters (P<0.001). Cluster number 4 with 48 students had less academic progress with 94.0 ± 6.1 than the other three clusters.
Conclusion: Based on the obtained findings, performing effective interventions for promoting self-esteem and academic achievement seems necessary.

Introduction

Self-esteem is a person's self-satisfaction, responsibility toward himself and others, and sense of worth.[1,2] Self-esteem refers to a person's subjective evaluation of himself as a person. Self-esteem usually shows a person's overall constructive evaluation. Global (general) self-esteem refers to how we feel about ourselves in general, including how we feel about ourselves

*.Corresponding Author: raeisi.shahraki_hadi@yahoo.com

Copyright © 2024 Tehran University of Medical Sciences. Published by Tehran University of Medical Sciences.
This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International license (https://creativecommons.org/licenses/by-nc/4.0/). Noncommercial uses of the work are permitted, provided the original work is properly cited.

in all different areas of life.[1, 3] Self-esteem is one of the key foundations of human personality and is known as an important component in mental health and social psychology.[4, 5] The competence aspect of self-esteem refers to a person's sense of efficiency and capability.[6] Branden believes that self-esteem is the ability to see oneself as capable of coping with life's critical challenges and worthy of happiness. Reasoner defines self-esteem as an experience to face trials and consider oneself to be happy.[6] Being aware of your weaknesses and abilities, accepting yourself for what is more valuable, taking responsibility, affirming yourself, responding to your needs, having a goal, and choosing ways to achieve it are all examples of having good self-esteem.[7]

Self-esteem attracts the attention of others, whereas low self-esteem can cause distress, anxiety, and anti-social behavior, as well as inhibit will, perseverance, confidence, and desirable academic performance. People with high self-esteem may be more motivated to succeed in a scientific relationship, strive to meet their future goals and expectations, and focus on their strengths rather than their weaknesses.[5, 7] Students with high self-esteem tend to be more engaged and persistent in areas of achievement and exhibit more adaptive cognitive and emotional responses to challenge, which then increases their likelihood of success in school. Students with high self-esteem may spend more time on academic research and homework or think more deeply about an exam question because they feel competent and motivated, resulting in higher test scores.[3]

Academic self-esteem, also known as academic self-concept, how competent a person feels in an academic area may translate directly into higher achievement because the student has higher self-efficacy, which increases confidence in one's ability to complete tasks.[3]

Academic achievement, which is an important aspect of student's life, is commonly regarded as the primary criterion for determining a student's success at university.[8-10] Academic achievement is defined as the extent to which students achieve their educational objectives.[11] Academic achievement known as one of the primary indicator of students' quality of life.[8] Individual factors such as IQ, psychological factors such as hope and self-concept, social factors, and educational factors are all factors that influence academic achievement.[3, 12] Self-esteem judgments can serve as a bridge between "a person's achievements and their goals and aspirations," allowing the individual to respect their achievements and recognize limitations. This self-acceptance may create space for growth and improvement, which leads to further educational progress.[3] Student's academic achievement has a significant impact on their future success.[13] People must use their internal and external abilities to achieve their goals in order to succeed and progress in education. Paying attention to the factors that contribute to students' academic achievement is a step toward long-term development and leads to proper planning to advance educational goals.[5]

So far, no study has focused on clustering of students based on the variables of self-esteem and academic achievement.

In 2023, Sanjari et al conducted a study with the aim of clustering undergraduate students based on academic burnout and satisfaction with the field of study using Medoid clustering. In this study, 400 students of Shahrekord University of Medical Sciences were selected based on the cluster sampling method. The data collection tool included a 15-question academic burnout

questionnaire and a 7-question academic satisfaction questionnaire. The average silhouette index was used to estimate the number of optimal clusters. The NbClust package in R 4.2.1 software was used for clustering analysis based on the k-medoid approach. The mean score of academic satisfaction was 17:70±39:5 and academic burnout was 37:90±27:13. The optimal number of clusters was estimated as two numbers based on the average silhouette index. The first cluster included 221 students and the second cluster included 179 students. The students of the second group had higher academic burnout than the first group.[14]

In 2023, Senjari et al conducted a study with the aim of clustering the economic situation through the division around Medoid and its relationship with common non-communicable diseases. This study was conducted based on the data of the Shahrekord cohort study (SCS). This study investigated nine non-communicable diseases including heart disease, myocardial infarction, diabetes, high blood pressure, stroke, malignancies, chronic lung disease, depression and obesity among 7034 participants aged 35 to 70 from the urban population of Shahrekord (Iran) in commented 2022. Four quantitative variables and four qualitative variables were used to cluster economic status. The NbClust package was used to determine the optimal number of clusters and the K-med package in R software (version 4.2.1) was used for PAM clustering. Descriptive statistics were reported as frequency (%) or median (IQR), and statistical analysis was performed using Chi-square test and Mann-Whitney test in SPSS software (version 19.0). P<0.05 was considered statistically significant. The estimated optimal number was two clusters. The first cluster included people with good economic status and the second cluster included people with average economic status. The findings showed that people with good economic status had significantly higher rates of heart disease (7.2% vs. 5.3%, P<0.001), stroke (1.3% vs. 0.6%, P<0.001), diabetes (12.8% vs. against 9.1 percent). P<0.001), hypertension (21.6% vs. 15.6%, P<0.001), depression (P<0.001), and obesity (P=0.03).[15]

As a result, the aim of this study was to employ the K-mean clustering method to clustering the undergraduate students of Shahrekord University of Medical Sciences (SKUMS), based on their self-esteem and academic achievement.

Methods

In this cross-sectional study, the statistical population includes all the students of Shahrekord University of Medical Sciences (SKUMS) in 2022. A multi-stage cluster sampling method was used and three faculties were chosen via simple random sampling from the list of SKUMS faculties. In the following stage, three departments were chosen at random from each faculty. Finally, the questionnaires were distributed among the students who were willing to participate in the study without any limitation or exclusion criteria.

Rosenberg's self-esteem questionnaire (1965) measures general self-esteem and personal worth. This questionnaire contains 10 questions including five expressions in positive form (1 to 5) and five expressions in negative form (6 to 10). A positive answer to each of the questions 1 to 5 will receive a +1 score. A negative answer to each of the questions 1 to 5 will receive a score of -1. A positive answer to each of the questions 6 to 10 will receive a score of -1. A

positive answer to each of the questions 6 to 10 will receive a +1 score. Algebraic sum of scores represents the score of the questionnaire. A score of +10 indicates very high self-esteem and -10 indicates very low self-esteem.[16] The internal consistency coefficient or Cronbach's alpha for this questionnaire is in the range of 0.77– 0.88 and the validity of the questionnaire has been confirmed using the factor analysis method.

The Wells Academic Achievement Questionnaire (2010) has 39 four-choice questions. The grading method is as follows: totally agree=4, agree=3, disagree=2, totally disagree=1. The reverse items of the questionnaire are 9 to 11, 19, 24, 26 to 31, 36 to 39, that is, a score of 1 is given to completely agree and a score of 4 is given to completely disagree. We add the score of all items together. The score range of the questionnaire will be between 39 and 156. The higher the score, the higher the academic achievement, and the lower the score, the lower the academic achievement.[17]

In the research of Adib-Hajbaghery et al. (2014), the reliability of the questionnaire was measured by Cronbach's alpha method, and the Cronbach's alpha coefficient for the academic success questionnaire was calculated as 0.76.[18]

The reliability of this questionnaire has been calculated through Cronbach's alpha coefficient in a research conducted by Tulliti in Tehran's public universities. The results of the reliability check of the final questionnaire showed that the Cronbach's alpha coefficient calculated for the academic performance questionnaire was reported as 0.7 and for the self-esteem questionnaire as 0.83

Mean±SD and frequency (%) were used to report descriptive statistics for quantitative and qualitative variables respectively. To report correlations between quantitative variables Pearson correlation was used and the association between qualitative variables was investigated using the Chi-square test or Fisher's exact test. Also, independent T-test and one-way analysis of variance were used to compare numerical values in two or more independent groups respectively. Also, the k-means method was used to cluster students.

The k-means clustering method was invented by MacQueen in 1967, where each cluster was represented by its centroid, which corresponds to the mean of the points assigned to the cluster.[19] The goal of the k-means method is to minimize the intra-cluster distance and equivalently, to maximize the inter-cluster distance. To perform k-means clustering, the following steps were implemented:

1- The number of clusters (k) is determined.
2- k observations are randomly selected as the closest primary centers of the clusters. (Initial values of k were considered from 1 to 9).
3- The distance matrix is formed for all the two by two observations.
4- Each observation was assigned to the cluster with the closest distance to its center.
5- The centroid of each cluster was updated.
6- The distance of each observation to the center of all existing clusters was recalculated.

If the distance of each observation to the center of its cluster is less than the distance of that observation to the center of other clusters, the algorithm ends, otherwise we return to the fourth step. To determine the optimal number of clusters, the NbClust package was used in the R software version 4.2.1. In this package, the number of optimal clusters was determined using the elbow method.[19]

Ethical considerations

The purpose of research was explained to all the participants before the sampling procedure and informed consent was signed by all the students. This research was approved by the Ethics Committee of SKUMS (Ethics code: IR.SKUMS.REC. 1398.243).

Results

In this study, out of 260 participating students, 176 (67.7%) were girls and 84 (32.3%) were boys. Also, in this study, most of the participants were single (84.2%). The overall mean± tandard deviation of academic achievement was 105.2± 10.3 with a minimum of 69 and a maximum of 136, which showed that the students had mean academic achievement. In this study, the mean academic achievement among students aged 18 to 20 was 107.0±10.3 significantly higher than the other two age groups (P-value=0.04). Other variables have no significant association with academic progress and self-esteem (Table 1).

Table 1. summarizes the comparison of academic achievement and self-esteem across various demographic variables

Subgroup	Number (%)	academic achievement	P-value	self-esteem	P-value
Gender					
Female	176 (67.7)	105.1±9.8	0.79	5.6±4.3	0.52
Male	84 (32.3)	105.5± 11.3		5.9±5.6	
Age					
18-20	90 (34.6)	107.0±10.3	0.04	6.4±3.6	0.11
21-22	113 (43.5)	105.1±10.7		5.5±4.4	
23 and higher	57 (21.9)	102.6±8.8		5.0±4.4	
Marital status					
Single	219 (84.2)	105.0±10.3	0.52	5.7±4.3	0.84
Married	41 (15.8)	106.2±10.1		5.8±3.5	
Ethnicity					
Fars	153 (58.8)	105.7±10.4	0.57	5.9±4.0	0.25
Lor	82 (31.5)	104.7±10.1		5.7±4.3	
Other	25 (9.6)	103.7±10.4		4.4±4.3	
Current residency					
Dormitory	116 (44.6)	105.3±9.8	0.94	5.9±3.7	0.42
With family	144 (55.4)	105.2±10.7		5.5±4.5	
Father education					
Dip or lower	147 (56.5)	104.7±10.5	0.39	5.8±4.3	0.76
higher	113 (43.5)	105.8±10.1		5.6±4.1	
Mother education					
Dip or lower	151 (58.1)	105.4±10.5	0.72	6.0±3.9	0.23
higher	109 (41.9)	104.9±10.1		5.3±4.5	
Own income					
<1	246 (94.6)	105.4±10.4	0.56	5.7±4.2	0.32
1-2	11 (4.2)	102.2±7.7		6.7±2.2	
2-3	3 (1.2)	103.0±11.3		2.7±3.1	
Family income					
<3	54 (20.8)	104.4±10.8	0.31	5.3±4.4	0.24
3-4	108 (41.5)	104.5±9.4		5.4±4.3	
>=4	98 (37.7)	106.5±10.9		6.2±3.9	

The academic achievement was at the highest level for the students of anesthesia with 107.3± 10.8. No significant difference was observed between different fields with academic achievement and self-esteem (Table 2). Also there is a positive and significant correlation (r = 0.44) between academic achievement and self-esteem (P-value <0.001) (Table 2).

Using elbow method, the number of optimal clusters was estimated equal to 4 (Figure 1). Self-esteem in cluster number 1 with 35 students was at the lowest level with -2.6±2.9. Cluster number 4 with 48 students had less academic progress with 94.0 ± 6.1 than the other three clusters (Table 3).

Table 2, the comparison of academic achievement and self-esteem in different major

Major	Number (%)	academic achievement	P-value	self-esteem	P-value
Public health	31 (11.9)	104.7±7.8	0.65	5.2±3.0	0.97
Environmental health	21 (8.1)	102.2±6.5		5.2±4.0	
Anesthesia	37 (14.2)	107.3±10.8		5.2±4.7	
Nursing	50 (19.2)	103.9±10.1		5.9±4.3	
Midwifery	27 (10.4)	106.1±10.8		5.9±4.6	
Surgical technology	34 (13.1)	105.9±12.4		6.1±3.5	
Radiology	28 (10.8)	106.6±10.0		5.8±4.8	
Laboratory sciences	32 (12.3)	104.7±11.8		6.1±4.5	

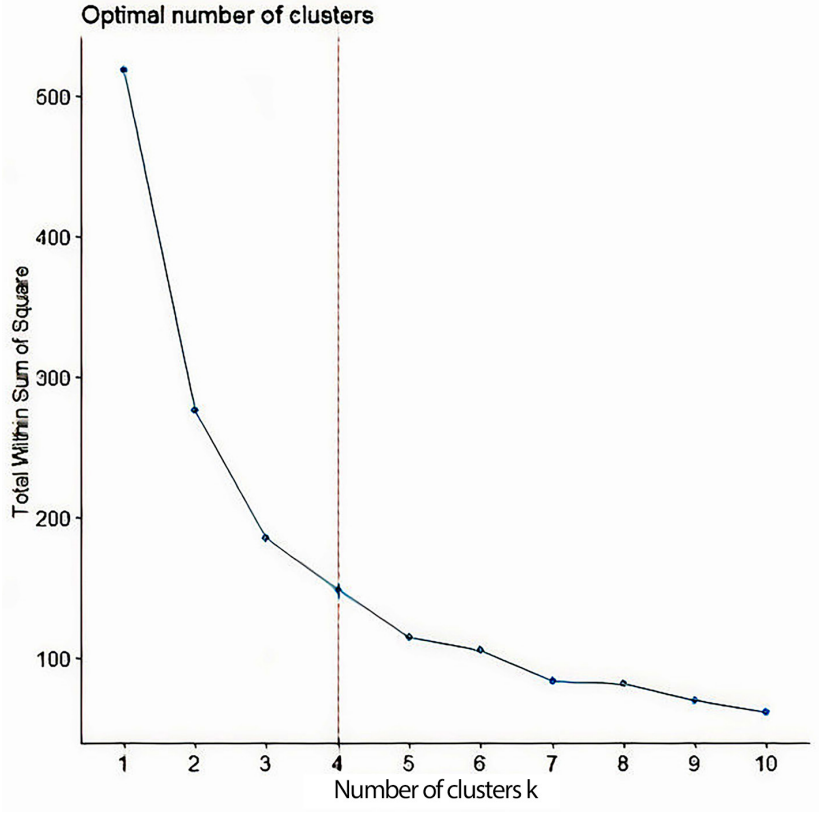


Figure 1. Using the intra-cluster sum of squares index to determine the optimal number of clusters k

Table 3, the comparison of academic achievement and self-esteem in clusters

Cluster	Number of students	academic achievement	P-value	self-esteem	P-value
1	35	95.1± 6.8	<0.001	-2.6± 2.9	<0.001
2	68	118± 5.5		8.0± 2.0	
3	109	105.4± 3.6		7.2± 2.3	
4	48	94.0± 6.1		5.0± 2.6	

Discussion

The purpose of this study was to cluster students based on self-esteem and academic achievement. In this study, there was a positive and significant relationship between self-esteem and academic achievement, which was consistent with some previous studies. In the study of Asakereh et al., which was conducted in 2018 with the purpose of reflective thinking, self-efficacy, self-esteem and academic achievement of Iranian EFL students the sample size in this study was 132 students, including 100 female students and 32 male students, and the sampling method, like our study, was cluster sampling. it was shown that there is a positive and significant relationship between students' self-esteem and academic achievement. It seems that the competencies that students attribute to themselves can be of great importance. Academic achievement of students contributes to their high self-esteem, that is, the more successful students are, the higher self-esteem they have.[20] In line with our study, in Moradi et al.'s study, which was conducted with the aim evaluation of the relationship between self-esteem and academic success in nursing students of Kurdistan University of Medical Sciences, Sanandaj, Iran in 2018, students' self-esteem was in line with their academic achievement. In justification of this matter, it can be said that self-esteem causes academic success by influencing students' self-confidence and self-reliance to carry out activities in the field of study and increasing the motivation to study. Also, self-esteem as one of the most effective factors in increasing academic motivation by influencing students, if it is high, it can increase the motivation to study and academic achievement, and on the other hand, if it is low, it can cause academic demotivation in students.[21] Also, in the study of Guirong Liu et al., which was conducted with the aim effect of self-esteem and parents' psychological control on the relationship between teacher support and chinese migrant children's academic achievement it showed that students with higher self-esteem had higher academic achievement. Students with more self-esteem had more self-confidence to cope with academic assignments and achieve their goals, and progress in the field of study was higher than other students.[22]

In the study of Itbar Khan et al., which was conducted with the aim Interplay of self-esteem with the academic achievements between male and female secondary school students of 2019, no significant relationship was observed between self-esteem and academic achievement, which was contrary to our study. In justifying these contradictory results, we can mention the difference in the age range of the participants and the sample size of the two studies, 260 versus 480 and the different majors of the students.[6]

Among other findings of this study, there was

no significant relationship between gender and academic achievement. On the other hand, in the study of Jafari et al., which was conducted with the aim Relationship between study habits and academic achievement in students of medical sciences in Kermanshah-Iran of 2019, there was a significant relationship between academic achievement and gender. In justifying these contradictory results, the difference in the age range of the participants and the sample size of 260 to 380 can be mentioned.[23]

The present study has several limitations that require further research. First, this study adopted a cross-sectional design, which leads to limited causal relationships between our variables. Therefore, a longitudinal cross-sectional or experimental design should be adopted in the future to perform a robust analysis of causal relationships. This study was conducted in only one university, so our findings may not be applicable to all Iranian undergraduate medical students. As a result, it is better to conduct a multicenter study with a larger sample size that can be generalized to the Iranian student population.

Conclusion

The findings of this study showed that there is a positive relationship between self-esteem and academic achievement of students. Clustering of students was done using the k-means clustering method and based on the knee method, the optimal number of clusters was 4, with self-esteem in cluster number 1 at the lowest level and academic achievement in cluster number 4 at the lowest level. So in order to improve the self-esteem of students, it is necessary to provide conditions for academic achievement and effective and efficient ways to increase students' academic achievement. It is the duty of students, professors and colleges to help students with such strengths with the aim of improving their self-esteem level in order to achievement academically.

Therefore, it is suggested that in order to improve the academic status of students, special attention should be paid to programs focused on strengthening self-esteem, interest, and the ability to cope with problems in educational and cultural programs for students.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of Interest

The author(s) declare(s) that there are no conflicts of interest regarding the publication of this article.

Funding statement

This work was supported by the Research and Technology Deputy of the Shahrekord University of Medical Sciences, Shahrekord, Iran [grant numbers 5084]

Source of funding

This work was supported by the Research and Technology Deputy of the Shahrekord University of Medical Sciences, Shahrekord, Iran [grant numbers 5084].

Ethical Approval

This research was approved by the Ethics Committee of SKUMS (Ethics code: IR.SKUMS.REC. 1398.243).

Authors' Contribution

Substantial contributions to the conception or design: ZG, HR, substantial contributions to the design and the acquisition: ES, SR, drafting the work: ZG, HR, reviewing work critically for important intellectual content: ES, SR, HR final approval of the version to be published: all of the authors, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: all of the authors.

References

1. Kiviruusu O, Berg N, Huurre T, Aro H, Marttunen M, Haukkala A. Interpersonal conflicts and development of self-esteem from adolescence to mid-adulthood. A 26-year follow-up. PloS one. 2016;11(10):e0164942.

2. Moyano N, Quílez-Robres A, Cortés Pascual A. Self-esteem and motivation for learning in academic achievement: The mediating role of reasoning and verbal fluidity. Sustainability. 2020;12(14):5768.

3. Zheng LR, Atherton OE, Trzesniewski K, Robins RW. Are self-esteem and academic achievement reciprocally related? Findings from a longitudinal study of Mexican-origin youth. Journal of personality. 2020;88(6):1058-74.

4. Körük S. The effect of self-esteem on student achievement. The factors effecting student achievement: Meta-analysis of empirical studies. 2017:247-57.

5. SHARAFI L, TAGHIBAYGI M, ALIBAYGI A. The Impact of Self-Esteem and Personal Characteristics on Educational Improvement of Razi University Agriculture Students. 2015.

6. Khan I, Mahmood A, Zaib U. Interplay of self-esteem with the academic achievements between male and female secondary school students. Journal of Human Behavior in the Social Environment. 2019;29(8):971-8.

7. Srivastava A, Mukherjee DS, Jebarajakirthy C. Triggers of aspirational consumption at the base of the pyramid: a qualitative inquiry from Indian context. Journal of Strategic Marketing. 2023;31(1):154-84.

8. Lepp A, Barkley JE, Karpinski AC. The relationship between cell phone use, academic performance, anxiety, and satisfaction with life in college students. Computers in human behavior. 2014;31:343-50.

9. Li J, Han X, Wang W, Sun G, Cheng Z. How social support influences university students' academic achievement and emotional exhaustion: The mediating role of self-esteem. Learning and individual differences. 2018;61:120-6.

10. Xiao JJ, Tang C, Shim S. Acting for happiness: Financial behavior and life satisfaction of college students. Social indicators research. 2009;92:53-68.

11. Batool SS. Academic achievement: Interplay of positive parenting, self-esteem, and academic procrastination. Australian Journal of Psychology. 2020;72(2):174-87.

12. Salmalian Z, Kazemnezhad Leili E. Correlation between self-concept and academic achievement of students. Journal of Holistic Nursing and Midwifery. 2014;24(1):40-7.

13. Minev M, Petrova B, Mineva K, Petkova M, Strebkova R. Self-esteem in adolescents. Trakia Journal of sciences. 2018;16(2):114-8.

14. Sanjari E, Majidian Dehkordi F, Raeisi Shahraki H. Clustering undergraduate students based on academic burnout and satisfaction from the field using partitioning around Medoid. Computational and Mathematical Methods in Medicine. 2023;2023(1):8898939.

15. Sanjari E, Ahmadi A, Raeisi Shahraki H. Clustering the Economic Status via Partitioning around Medoid and Its Association with Common Non-communicable Diseases. Iranian Journal of Medical Sciences. 2024;49(11):699-706.

16. Rosenberg M. Rosenberg self-esteem scale. APA PsycTests. 1965.

17. Welles TL. Analysis of the academic success inventory for college students: construct validity and factor scale invariance. 2010.

18. Adib-Hajbaghery M, Aminolroayaee Yamini E. Assessing academic success and its predictors from the perspective of nursing students in Kashan University of Medical Sciences. Iranian Journal of Medical Education. 2015;15:510-20.

19. Kassambara A. Practical guide to cluster analysis in R: Unsupervised machine learning: Sthda; 2017.

20. Asakereh A, Yousofi N. Reflective thinking, self-efficacy, self-esteem and academic achievement of Iranian EFL students in higher education: Is there a relationship? International Journal of Educational Psychology. 2018;7(1):68-89.

21. Moradi D, Karami M, Ghanei Gheshlagh R, Nemati M, Dehvan F. Evaluation of the relationship between self-esteem and academic success in nursing students of Kurdistan university of medical sciences, Sanandaj, Iran in 2018. Scientific Journal of Nursing, Midwifery and Paramedical Faculty. 2018;4(2):71-8.

22. Liu G, Teng X, Zhu D. Effect of self-esteem and parents' psychological control on the relationship between teacher support and Chinese migrant Children's academic achievement: a moderated mediation. Frontiers in Psychology. 2019;10:2342.

23. Jafari H, Aghaei A, Khatony A. Relationship between study habits and academic achievement in students of medical sciences in Kermanshah-Iran. Advances in Medical Education and Practice. 2019:637-43.