1. INTRODUCTION

Organizational structure of health system in Iran including Ministry of Health and Medical Education, Social Security Organization, there Government Hospitals, Private Hospitals (Non-Profit), Private Hospitals (For-Profit) and Private Teaching Hospitals. In Iran, the University of Medical Sciences, play an important role both in medical education and the provision of health services in province level. Also, social Security Organization (SSO) provides medical services to its beneficiaries by their hospitals. Private sector also provides 10-20% of the health care services (1).

In 2000, WHO reported that Iranian health system performance was ranked ninety-three among the other countries (2). One of the reasons of this can be mismanagement of resources (3). In 2014, Iranian health sector evolution plan (HSEP) started by ministry of health. This plan included packages to: increase coverage of basic health insurance, increase quality of care, reduce out-of-pocket (OOP) payments for inpatient services, and increase quality of primary healthcare (4). Healthcare providers’ concerns potentially about the sustainability and efficiency of HSEP in Iran (5).

Low hospital efficiency is one of the most important problems of Iranian health system. Several Iranian’s study has been conducted in hospital efficiency evolution. In most of these studies, the efficiency indicator was reported low (2, 6-13). According to an Iranian’s study, after the implementation of HSEP, the hospital efficiency was better than before (14). The results of studies in some of countries showed that the hospital efficiency was low (15-18). In some study, hospital efficiency was reported high (19-22).

Hospitals are an important economic
enterprise; therefore, measurement of its financial performance is a key action toward improvement of resource management (23, 24). Efficiency means maximum use of resources to generate returns. Two non-parametric and parametric approaches have been introduced to measure the efficiency. Data envelopment analysis (DEA) is an applied and frequent nonparametric technique to measure efficiency of units. By DEA methods can assess inefficient units and reason of the inefficiency (28). Considering the importance of hospital performance measurement, this study aimed to efficiency analyze of public hospitals using DEA technique.

2. METHODS

This is a retrospective panel data study. Seventeen public hospital affiliated with Ahvaz Jundishapur University of Medical Sciences in southwest of Iran (including 9 general hospitals, 4 specialized hospitals, and 4 Multi-specialized hospitals) were assessed using data envelopment analysis (DEA) method.

2.1. Variables and data gathering

Data of 17 hospitals were gathered from 2012 to 2016 using hospital information system and medical record documents based on input and output variables. Input variables included the number of hospital admissions, the number of nurses, and the number of available beds. The output variables included average of length of stay (LOS) and bed turnover interval.

2.2. Efficiency analysis

To evaluate the hospital efficacy indicators including technical, scale, and managerial efficiency the output-based data envelopment analysis approach and the variable returns to scale assumption (VRS) was used. Based on the output-based approach (maximizing the factors of production), to increase efficiency the organization should be increase outputs. In this method, efficiency is ranked between 0-1. If the numerical values were closer to one, the unit was more efficient. The linear relationship between the Maximize production model and efficiency is as follows.

\[
\begin{align*}
\text{Max } & \quad \Phi \\
\text{St. } & \quad (X_i, \Phi Y_i) \in T, \\
\sum_{j=1}^{n} \lambda_j x_{ij} & \leq x_i \quad i = 1, 2, \ldots, m \\
\sum_{j=1}^{n} \lambda_j y_{ij} & \geq \Phi y_i \quad i = 1, 2, \ldots, s \\
\sum_{j=1}^{n} \lambda_j & = 1 \\
\lambda_j & \geq 0 \quad j = 1, 2, \ldots, n
\end{align*}
\]

Decision Making Unit (Tv) is the n foundation (j = 1, 2, 3, ...) With m input xj = {x1j, x2j, x3j, ..., xmj} and S output yj = {y1j, y2j, y3j, ..., ymj}. The purpose of this model is to maximize \( \Phi \) (efficiency) to reach the maximum output level. Deap2.1 software was used to analyze hospital efficiency.

2.3. Regression model

To evaluate the effect of variables influencing the hospital efficiency, Beta Regression analysis was used. Beta regression can be conducted with the betareg function in the betareg package (Cribari-Neto and Zeileis, 2010). With this function, the dependent variable varies between 0 and 1, but no observation can equal exactly zero or exactly one. The model assumes that the data follow a beta distribution (26). For this purpose, the value of 0.999 is equivalent to efficiency=1 and 0.0001 is equivalent to efficiency=0. Independent variables in this model include length of stay, number of available beds and proportion of nurse to total staff. Hospital efficacy is a dependent variable. All computations were carried out using the Beta regression model through the statistical R software.

2.4. Ethical approval

The study was approved by the ethical committee of Ahvaz Jundishapur University of Medical Silences (AJUMS).

3. RESULTS

Table 1 shows the average technical, managerial, and scale efficiency of the hospitals during 2012-2016. According to this table, Efficiency in most hospitals was poor (average efficiency less than 1) over the 5 years period. Also average hospital efficiency showed mean of technical efficiency and managerial efficiency were lower than scale efficiency.

| Hospital | Technical efficiency | Managerial efficiency | Scale efficiency | Operational efficiency* |
|----------|----------------------|-----------------------|-----------------|-------------------------|
| 1        | 0.029                | 0.127                 | 0.229           | 0.128                   |
| 2        | 0.015                | 0.072                 | 0.225           | 0.104                   |
| 3        | 0.035                | 0.047                 | 0.765           | 0.282                   |
| 4        | 0.070                | 0.086                 | 0.818           | 0.325                   |
| 5        | 0.081                | 0.085                 | 0.943           | 0.370                   |
| 6        | 0.050                | 0.110                 | 0.459           | 0.206                   |
| 7        | 0.172                | 0.242                 | 0.731           | 0.382                   |
| 8        | 1                    | 1                     | 1               | 1                       |
| 9        | 0.045                | 0.083                 | 0.660           | 0.263                   |
| 10       | 0.118                | 0.285                 | 0.704           | 0.369                   |
| 11       | 0.047                | 0.069                 | 0.791           | 0.302                   |
| 12       | 0.071                | 0.095                 | 0.776           | 0.314                   |
| 13       | 0.056                | 0.096                 | 0.663           | 0.272                   |
| 14       | 0.061                | 0.068                 | 0.880           | 0.336                   |
| 15       | 0.134                | 0.152                 | 0.878           | 0.388                   |
| 16       | 1                    | 1                     | 1               | 1                       |
| 17       | 0.918                | 1                     | 0.918           | 0.945                   |

Mean 0.23 0.27 0.73 0.41

*the total average of technical, managerial and scale efficiency per hospital

Table 1. The average of technical, managerial and scale efficiency during 2012-2016.

Information about technical, efficiency, and scale efficiencies, and returns to the scale of 17 hospitals were assessed based on the type of activity is depicted in Table 2. The results showed that the mean of technical, managerial, and scale efficiency in the hospitals during 2012-2016 were 0.230, 0.272 and 0.732, respectively. Among the estimated indicators, the scale efficiency of hospital was better. Also, information about the efficiency of hospitals based on their type of activity showed that the mean of technical efficiency in multi-specialized, specialized and general hospitals was 0.032, 0.311, and 0.227; mean of managerial efficiency was 0.089, 0.335, and 0.316; mean of scale efficiency was 0.479, 0.873, and 0.880 respectively. Among the hospitals, specialized hospitals were in a better performance. In addition, the results of the return to scale showed 65% (11 cases), 24% (4 cases) and 12% (2 cases) of hospitals had a decreased return to scale, constant returns to scale and increased return to scale; respectively.

Figure 1. shows the average changes of technical, mana-
efficiency. Finally, the pseudo R-squared value (model power) shows that 50% of the hospital’s efficiency changes are predictable with independent variables (length of stay and bed size) used in this model. In other words, other independent variables that not used in this model, can also affect the hospital efficiency.

| Independent variable | Beta | Std. Error | Z value | Sig | PR** |
|----------------------|------|------------|---------|-----|------|
| LOS**                | 0.032| 0.011      | 2.707   | 0.006| 0.5053|
| Bed size             | -0.005| 0.001 | -3.184  | 0.001| 0.5053|
| Nurse/ Total staff   | -3.883| 3.453 | -1.125  | 0.26 |      |

Table 3. Multivariate regression analysis of factors effecting hospital efficiency.

4. DISCUSSION

In this study, the nonparametric method of data envelopment analysis (DEA) was used to evaluate the technical, managerial, and scale efficiency of selected public hospitals. The results showed that the mean of technical, managerial, and scale efficiencies in 17 hospitals during 2012-2016 were 0.23 (23% of efficiency), 0.27 (27% of efficiency), and 0.73 (73% of efficiency) respectively, which indicated a poor efficiency level approximately. In other words, based on an output-based approach and assuming a variable return to scale, there is capacity to improve technical efficiency and managerial efficiency in these units without an increase in costs and use of same amount of institutional resources in relation to technical efficiency and managerial efficiency of about 0.75 and scale efficiency of about 0.27. Aboulhallaj et al. performed a similar study with the aim of evaluating the some of the Iranian hospitals. The results showed that the hospitals were better in scale, managerial, and technical efficiency, respectively (27). Also, the results of Chang et al. in China showed that the average technical efficiency of hospitals studied during three years has been increased (28). Comparing the results of Aboulhallaj and Chang with the results of this study indicated that the technical efficiency values were less than the other efficiencies indicators. Since managerial performance impact on the technical efficiency (29).

Also, the result of operational efficiency evaluation showed this indicator in specialized hospitals was higher than general and multi-specialized hospitals. A similar study showed that the mean of efficiency in specialized hospitals was higher than in general hospitals (30). In a research conducted by Aboulhallaj et al. the average technical efficiency and managerial efficiency were the highest in the educational and specialized hospitals, general hospitals, general and educational hospitals, respectively. Also the average scale efficiency has been highest in the general and educational hospitals (31).

In addition, in this study, the results showed that 47% (8 hospitals), 41% (7 hospitals) and 12% (2 hospitals) had decreasing, a constant, and increasing return to scale ratio, respectively. In this case, the study of Safarian et al. (7) and Dargahi et al. (30) showed deferent results. In contrast, comparing the results of this study with the results of Azar et al (32) and Mahfouzpour et al (11) showed that the changes of increasing return to scale in the studied hospital was a relatively similar trend during the period of study. In other words, the frequency of hospitals with a decreasing return to scale has been more, and
these hospitals have not been able to increase their production in proportion to the increase in their financial resources and human resources. In the present study, the changes in the technical, managerial, and scale efficiencies of hospitals before and after the health sector evaluation plan were studied. The changes caused by the implementation of this national plan showed that the average technical and scale efficiency has been reduced and managerial efficiency has been a slight increase. The results of the study by Zhou et al. (20) and Cheng et al. (33) also showed that the efficacy of the hospitals under study has decreased after reform in the their health system. The results Jia et al. (19), Cheng et al. (28) and Mahfouzpour et al. (11) were not consistent with the results of the present study.

In different studies, the effect of different factors has been analyzed on efficiency. Based on the findings of these studies, factors such as modification of managerial practices, use of modern technologies tailored to the cultural, political and social infrastructures, formulation of clinical guidelines to standardize the medical processes in order to reduce medical errors and increase the power of health care buyers (insurance organizations), length of stay, management of hospitals by specialist managers, administrative requirements, full-time hospital physicians, limiting the authority of decision makers in relation to the recruitment of staff in accordance with the needs of the hospital and optimal allocation of beds, conducting economic evaluations and employing more effective clinical interventions, and ultimately, the type of hospitals ownership had an impact on the efficiency of the hospital (7, 10, 13, 34-39). In this study, the length of stay and the number of available beds had impact on the hospital efficiency significantly. By increasing the number of beds the hospitals efficiency decreases. Optimizing the bed size can increase hospital efficiency.

5. CONCLUSION

The This study offers DEA technique for evaluating the hospital efficiency. The results showed that hospitals efficiency was the poor generally. Technical efficiency and managerial efficiency rate were lower than scale efficiency. Also, Multi-specialized hospitals had a low efficiency than other hospitals and were in critical conditions considering resource management and economies of scale. Therefore, in order to eliminate mismanagement of resources, it is necessary to improve the efficiency indicators periodically.

Limitation study: In this study, there were some of the limitations. A key limitation of the study was the small sample size. A small sample size may result in many hospitals becoming efficient by default (as a result of not having a comparator from within the small sample). Another important limitation of this study was availability of hospital data. Studied hospitals had not integrated hospital information system; therefore, it could be led to increase error in data gathering and analyzing.

REFERENCES

1. WHO. Health Systems Profile of Islamic Republic of Iran. Regional Health Systems Observatory—EMRO [Internet]. [cited November 24, 2017]. Available from: apps.who.int/medicine-docs/documents/s17294e/s17294e.pdf.
2. Salehzadeh R, Ketabi S. Measuring the efficiency of Qum hospitals with data envelopment analysis and analytic hierarchy process. Director General. 2011; (8)(4): 34-41.
3. Alamtabriz A, Imanipour M. Measuring the Relative Efficiency of Health Care Offered in Hospitals of Shahid Beheshti University of Medical Sciences Using Data Envelopment Analysis (DEA) Technique. Health Information Management. 2011; (8)(3): 315-325.
4. Moradi-Lakeh M, Vosough-Moghaddam A. Health Sector Evolution Plan in Iran; Equity and Sustainability Concerns. International journal of health policy and management. 2015; (4)(10): 637-640.
5. Moradi-Lakeh M, Vosough-Moghaddam A. Health Sector Evolution Plan in Iran; Equity and Sustainability Concerns. International journal of health policy and management. 2015; (4)(10): 637-640.
6. Barouni M, Amirtesmaie1i MR, Shahrvan A, Amini S. The Efficiency Assessment of Dental Units Using Data Envelopment Analysis Approach: The Case of Iran. Iranian journal of public health. 2017; 46(4); 552.
7. Saffarian R, Shahbooei S, Rahmani M, Azar A, Beheshti MA. Performance Evaluation of Provincial Units of Social Security Organization in Indirect Health Services Sector using DEA Performance Assessment of Provincial Units of Social Security Organization in Indirect Health Services Sector using DEA Analysis Approach: The Case of Iran. Iranian journal of public health. 2017; 46(4); 552.
8. Amir MM, Nasiri T, Saadat SH, Abando HA, Ardakan PM. Measuring Efficiency of Knowledge Production in Health Research Centers Using Data Envelopment Analysis (DEA): A Case Study in Iran. Electron Physician. 2016; 8(11): 3266-3271.
9. Emamii F, Mehrohlelani M, Barooni M, Goudarzi R. Measurement of Efficiency of Direct Medical Services Affiliated with Iranian Social Security Organization using Data Envelopment Analysis in 2014. Iranian Journal of Epidemiology. 2017; (12)(5); 32-39.
10. Goudarzi R, Mehdollahian M, Dehnaveh R, Darvishi A. Performance Assessment of Provincial Units of Social Security Organization in Indirect Health Services Sector using DEA Method in 2014. Iranian Journal of Epidemiology. 2017; (12)(5); 65-73.
11. Mahfoozpour S, Pouragh B, Abedi Z, Satarivand S. Assessing efficiency in hospitals of Shahid Beheshti University of Medical Sciences using Data Envelopment Analysis Method. Journal of Health Promotion Management. 2015; (5)(1): 11-20.
12. Azar A, Valipour Khatir M, Moghbel Baeza A, Hasas Veganeh Y. Evaluation of Hospital Efficiency by Data Envelopment Analysis: Tehran University of Medical Sciences: 2009-2011. Journal of Health Administration. 2013; 16(53); 36-46.
13. Goodarzi GR, Imani Nasab MH, Jahan Mehr N, Rostami K, Omid Far R, Mahouti F. Performance Evaluation of Hospitals of Lorestan University of Medical Sciences during 2001-2007. Payesh Health Monitoring. 2012; (11)(3): 309-315.
14. Moradi G, Pirtozi B, Safari H, Emamii Nasab N, Mohammadi

Acknowledgment: This study is part of MSc. thesis for Narges Pirani. This work was financially supported by grant: No IR.AJUMS.REC.1396.324 from the vice-chancellor for research affairs of Ahvaz Jundishapur University of medical Sciences. The authors would like to thank all participants in this research.

Conflict of Interest: none declared.
27. Aboulhallaje M, Najafi B, Ahmad Kia Daliri Aa. Measuring the technical efficiency of Iranian Ministry of Health and Medical Education hospitals: 2007. Teb va Tazkiyeh. 2010; 19(3): 49-59.

28. Chang SJ, Hsiao HC, Huang LH, Chang H. Taiwan quality indicator project and hospital productivity growth. Omega. 2011; 39(1): 14-22.

29. Mehregan MR. Ratio analysis in measuring performance. In: soud khah s, editor. Data Envelopment Analysis (Quantitative Model in Organizational Performance Evaluation). Tehran: Publishing Academic Books; 2016: 37-39.

30. Dargahi H, Masoori N, Safdari R, Fazaeli S, Yousefi M. Investigating Productivity Changes in Medical Records Departments of Tehran University of Medical Sciences Hospitals Using Malmquist Index. 2011.

31. Abuhlallaj M, Najafi B, Kia Daliri A, Aghar A. Measuring the Technical Efficiency of of Iranian Ministry of University of Health and Medical Education Hospitals: 2007. Teb va Tazkiyeh. 2010; 19(3): 49-61.

32. Azar A, Andalib Ardakani D, Shahtahmasbi E. Assessment of Relative Efficiency of Country Provinces in Rural Health Sector during the Third Development Plan and Early Years of the Fourth Development. Journal of Health Administration. 2010; 13(39): 65-78.

33. Cheng Z, Cai M, Tao H, He Z, Lin X, Lin H, et al. Efficiency and productivity measurement of rural township hospitals in China: a bootstrapping data envelopment analysis. BMJ open. 2016; 6(11): e011911.

34. Dargahi H, Masuri N, Safdari R, Fazaeli S, Yousefi M. The Efficiency analysis of Medical Records Departments of Tehran University of Medical Sciences Hospitals with Data envelopment analysis (2007-2009). Payavard Salamat. 2010; 4(2): 9-17.

35. Alidadi A, Amerioua A, Sepandi M, Hosseini Shokouh SM, Abedi R, Zibadel L, et al. The Opportunities and Challenges of the Ministry of Health and Medical Education for Improvement of Healthcare System. Health Research Journal. 2016; 1(3): 173-184.

36. Hendrich AL, Lee N. Intra-unit patient transports: time, motion, and cost impact on hospital efficiency. Nursing economics. 2005; 23(4): 157-164.

37. Vaňková I, Vrabková I. The Factors Influencing Economic Efficiency of the Hospital Bed Care in Terms of the Regional Allowance Organizations. Review of Economic Perspectives. 2014: 233.

38. Edwards JN, Silow-Carroll S, Lashbrook A. Achieving efficiency: lessons from four top-performing hospitals. Commonwealth Fund. 2011.

39. Koçkaya G, Koçkaya PD, Özbazgraçık Ö, Obu S. Improving cost-efficiency at a hospital by showing the time-saving effect of using different neuromuscular blockers for short operations. Journal of Pharmaceutical Health Services Research. 2014; 5(1): 61-66.