Efficiency of Iranian Hospitals before and after Health Sector Evolution Plan: A systematic Review and Meta-Analysis Study

Saeed Amini
Arak University of Medical Sciences https://orcid.org/0000-0003-1512-245X
Behzad Karami Matin
Kermanshah University of Medical Sciences
Zohreh Anbari
Arak University of Medical Sciences
Javad Nazari
Arak University of Medical Sciences
Yahya Salimi
Kermanshah University of Medical Sciences
Mohammadreza Amiresmaili
Kerman University of Medical Sciences
Ali Kazemi Karyani (alikazemi.k20@gmail.com)
https://orcid.org/0000-0002-4448-9317

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Abstract

Background Aging, chronic diseases, development of expensive and advanced technologies has increased hospitals costs which have necessitated their efficiency in utilization of resources. This systematic review and meta-analysis study has assessed the efficiency of Iran hospitals before and after 2011 Health Sector Evolution Plan (HSEP).

Methods Internal and external databases were searched using specified keywords without considering time limitations. The retrieved articles were entered to EndNote considering inclusion and exclusion criteria and the final analysis was performed after removing duplicates. Heterogeneity between the studies was assessed using Q and I2 tests. Forest plot with 95% Confidence Interval (CI) used to calculate different types of efficiency. The data were analyzed using STATA 14.

Results Random pooled estimation of hospitals technical, managerial and scale efficiencies were 0.84 (95%CI = 0.78, 0.52), 0.9 (95% CI= 0.85,0.94) and 0.88 (95%CI= 0.84, 0.91), respectively. Sub-group analysis on the basis of study year (before and after HSEP in 2011) indicated that random pool estimation of technical (0.86), managerial (0.91) and scale (0.90) efficiencies of Iran hospitals for 2011 and before were better than technical (0.78), managerial (0.86) and scale (0.74) efficiencies after 2011. Conclusion Type of hospitals' ownership was effective on hospitals efficiency. However, HSEP has not improved hospitals efficiency, so that it is necessary to future national plans consider all aspects.

Background

Hospitals have an undeniable role in providing healthcare services to the society but their increasing costs have become to an important challenge for many countries. In other words, utilization of technologies and new methods of diagnosis and treatment of diseases and also increasing elderlies, increasing chronic diseases, increasing demands for healthcare services and specialists and hospitals errors have increased health system costs [1, 2]. Because of these issues and problems, hospitals are always encountered with human and financial resources' constraints which have necessitated efficiency in consuming the resources more than ever [3].

The efficiency concept has been created from the combination of technical and allocative efficiencies. Technical efficiency mean using the lowest amount of inputs to produce a specified amount of the outputs or using a specified amount of inputs to produce more outputs. Allocative efficiency mean using the correct amount of inputs in terms of their prices to produce a specified amount of outputs. Technical efficiency, on the other hand, is created my multiplying scale efficiency and managerial efficiency. Scale efficiency is the ability of an organization unit to perform in or near the most profitable scale to prevent the loss in the resources. Lastly, managerial efficiency means hard working, correct policy making, application of correct number of employees and correct combination of production factors [4].

One of the most widely used methods in assessment of different Decision Making Units (DMUs) such as hospitals and other organizations in terms of the components of efficiency (id est. technical, scale and managerial efficiency) is Data Envelopment Analysis (DEA) method. It is possible, through this method, to create a logical framework to distribute human and financial resources between different wards and sections of studied organizations [5]. DEA method as a non-parametric programming technique has been used from the mid of 1980 to measure DMUs efficiency [6]. In other words, linear and multiple programming models are used in this method to assess the relative efficiency of a field, section, unit or an organization, as a DMU, using multiple input and output indices [7].

Numerous studies have assessed the efficiency of hospitals efficiency using DEA method. These studies can be divided into 4 categories. In the first category, the efficiency of university, teaching and public hospitals, as the main providers of healthcare and therapeutic services, has been assessed such as studies by Kalhor et al. [8] and Nabi-lou et al. [9]. In the second category, the efficiency of private hospitals has been studied and their efficiency has been compared with the first category hospitals [10, 11]. The third category includes studies on hospitals affiliated with special entities such as Social Security Organization [12, 13] and Armed Forces [14]. The last category measures the efficiency of hospital wards such as

radiology [15], dentistry [4], Intensive Care Unit [16], Emergency [17] departments. Because the recent category has studied wards of hospitals not the hospitals as an entity and also have not assessed the technical, managerial and scale efficiency of hospitals wholly, so this category was excluded from the current study.

Although many studies have assessed the efficiency of hospitals using DEA method in Iran, but there is no systematic review and meta-analysis study in this regard to present the final situation of Iran hospitals efficiency. By determining technical, managerial and scale efficiency of Iran hospitals, policy makers and planners can improve hospitals efficiency through improving distribution and consumption of resources.

The extensive review of the literature by the authors of current study have resulted in 4 systematic review and meta-analysis studies on Iran hospital efficiency using DEA method. The first study has assessed the studies in terms of provinces which they have been performed, being input or output oriented, and being fixed or variable return to scale [18]. The researchers in another two systematic and meta-analyzing studies have discussed the methods used to assess hospitals efficiency [19, 20]. The last study has stated only a number about hospitals efficiency and does not mentioned the efficiency sub dimensions namely scale, managerial and technical efficiency [21]. By attention that any of before systematic review and meta-analysis studies have not assessed the main issue namely the hospitals efficiency status separately for its dimensions, so the current study assesses technical, managerial and scale efficiency of hospitals through Systematic review and meta-analysis.

Methods

Search strategy

The foreign databases of Institute for Scientific Information (ISI), PubMed, Scopus, Google Scholar and Persian databases of Scientific Information Database (SID), Magiran and Barakat were searched using the combination of “efficiency”, “hospital” “data envelopment analysis”, “DEA” and “Iran” keywords in 2018. The references of the retrieved articles were searched to increase the study credibility and precision.

Inclusion and exclusion criteria

All published Persian and English languages articles about hospital efficiency with score between 8–12 were entered the study without considering time limit. If several formats of a research were published (such as book, article, report and so on), only one of them were entered to the study. The input-oriented studies were entered to the study. Short reports, letter to editors or editorial comments, one study but in two languages, studies on health care facilities other than hospitals and studies on internal parts of hospitals were removed from the study. Two researchers assessed and extracted data from the studies independently and the third researcher resolved disagreements if there was any one.

Data collection

A researcher made checklist used to extract the studies data including the first author name, year of data collection, place of study, language, sample size, the score of technical, managerial and scale efficiency. Another checklist designed previously which its credibility is approved by numerous studies was used to assesses the studies quality [19, 21].This checklist includes 12 questions regarding the study aim, method, data collection, sample size and study population. Each question has the score between 0–1 and the score for each study is calculated by summing the scores of questions. So that the studies with scores between 8–12 were entered to the final analysis. The study protocol was approved by the Ethical Committee of

Kerman University of Medical Sciences.

Data analysis

Efficiency types were considered as a proportion in this study. Therefore, the numerator was the sum of technical, managerial and efficiency scores and the denominator was the number of study hospitals. Heterogeneity between the studies was assessed using Q and I^2 tests. P-value lower than 0.05 for Q-test and I^2higher than 50% were considered as the measure of studies' heterogeneity. Because the studies were heterogeneous, Random Effect Model was used to estimate hospitals efficiency. Forest plot with 95% Confidence Interval (CI) used to calculate different types of efficiency. Egger and Begg tests used to assess publication bias. In order to assess the effect of 2011 Iran Health Sector Evolution Plan (HSEP) [22] on hospital efficiency, the studies before and after it were compared. The data were entered to Excel 2016 to be edited and then transmitted and analyzed using STATA v.14.2.

Results

Each one of the scientific databases were searched on the basis of recommended search strategy by the databases themselves using defined keywords. For example, about PubMed database, Twenty-three articles were retrieved after placing search query. Search query used for PubMed was: (((data envelopment analysis) OR DEA) AND hospital) AND Iran))). Among retrieved articles, 9 articles had assessed efficiency in other areas such as radiology units, intensive care units, health centers which were excluded from the study. So, finally 14 articles from PubMed database were entered to the EndNote software. In other databases, after adjusting search query on the basis of the database guide and then removing unrelated retrieved articles through reading titles, abstracts and texts, 25 articles from Scopus, 41 from Google Scholar, 8 from Web of Science, 16 from Barakat, 14 from Magiran and 7 from SID were entered to the EndNote software. After combination of these articles in EndNote software and removing duplicate articles, 47 final articles remained. Also, the assessment of references of these articles resulted in 2 new articles. In this way, 49 articles were entered to the final step of systematic review and meta-analysis (Figure 1). Twelve articles (24.48%) of these were in Persian language and the remaining were in English language.

By attention that some studies have reported the efficiency in several forms or in different scenarios and different inputs were used in them, so we considered them as separated studies. In this regard, studies of Hatam et al., Karimi et al., Salehzade et al., Raeisian et al., Firouzi Jahantigh et al., and Sheikhzadeh et al. each one were considered as 2 separated studies. Studies of Joshan et al. and Asadi et al. Each one were considered as 3 studies and lastly studies of fazeli et al. and Mahfoozpor et al. each one were considered as 4 studies. The average number of hospitals entered to the studies were 17.59 hospitals. The lowest and the highest number of hospitals belonged to the Rezapour et al. with 4 hospitals and Aboulhalaj et al. with 122 hospitals, respectively.

Figure 1

As mentioned before each type of efficiency was entered to the meta-analysis separately, so that 50 studies for technical efficiency, 36 studies for managerial efficiency and 41 studies for scale efficiency had entry requirements to the analysis.

The studies were performed from 1996 to 2016. After performing all steps of study selection, 49 articles were entered to the final phase of the study. The number of hospitals assessed in these articles ranged from 4 to 122. The inputs considered in the studies included number of beds, number of operation rooms, physicians, nurses, support forces and other human resources, costs, education hours, and working days. The outputs were number of surgeries, outpatients, occupancy rate, bed day, admission, inpatients, surgeries, emergencies, bed turnover, mean patient stay, hospital income, bed occupancy rate, SERVQUAL score, number of clinical, Para clinical and outpatient services, number of discharged patients, number of contracted insurances, access to emergency, confront with hospital infections, anesthesia problems, employee consent, active to fixed bed ratio, bed turnover, number of deaths and patient-day. 2 studies had assessed charity hospitals, 4 studies had assessed private hospitals and 5 studies had assessed Social Security Organization (SSO) hospitals. The remaining

studies had assessed the hospitals affiliated with universities of medical sciences belonged to Iran Ministry of Health (Table 1).

Table 1

The results indicated that there is heterogeneity in studies related to technical efficiency (Heterogeneity chi^2 = 156, p<0.001), Managerial efficiency (Heterogeneity chi^2 = 79.58, p<0.001) and scale efficiency (Heterogeneity chi^2 = 67.22, p<0.001). I^2 index in technical and managerial efficiency was higher than 50%, which indicates high heterogeneity between the studies. This index was lower than 50% for scale efficiency.

Study publication error using Egger test indicates that there is publication bias in technical and managerial efficiencies (P<0.001), but there was no publication bias in scale efficiency (p = 0.19). Table 2 indicates the results of Egger's test for 3 types of efficiencies. Begg's test indicated that there is no publication bias in 3 types of efficiencies (P< 0.001).

The results indicated that technical efficiency of Iran hospitals has high variation, so that it ranges from 0.34 in Mahfoozpor et al. study to 1 in Raeisian et al. and Najafi et al. On the basis of

random effects modeling, random pooled estimation of hospitals technical efficiency was 0.84 (95% CI = 0.52, 0.78) (Table 2, Figure 1). The managerial efficiency of Iran hospitals was between 0.59 in Aboulhalaj et al. study and 1 in studies of Joshan et al., Raeisian et al. and Najafi et al. Random pooled estimation of managerial efficiency of Iran hospitals was 0.90 (95% CI = 0.85,0.94) (Table 3, Figure 2). The lowest amount of scale efficiency (0.52) was for Mahfoozpor et al. study and the highest (1) was for Raeisian et al. and Torabipour et al. studies. Random pool estimation of scale efficiency for Iran hospitals was 0.88 (95%CI = 0.84, 0.91) (Table 4, Figure 3). The results of technical, managerial and scale efficiencies are presented in tables 2, 3 and 4, respectively. In addition, the forest plots for technical, managerial and scale efficiencies are presented in figures 1, 2 and 3, respectively.

Table 2

Table 3

Figure 2

Table 4

Figure 3

Sub-group analysis based on study year indicated that random pool estimation of technical efficiency of Iran hospitals for 2011 and before and after 2011 was 0.86 (95% CI = 0.80, 0.91) and 0.78 (95%CI = 0.64, 0.89), respectively. The status of managerial efficiency for 2011 and before was better than after 2011 (Random pool estimation equal to 0.91 compared to 0.86). Random pool estimation of scale efficiency for 2011 and before was 0.90 (95%CI = 0.86, 0.93). This is while random pool estimation of scale efficiency for after 2011 was 0.74 which is lower than it (95%CI = 0.61, 0.86) (Table 5).

Table 5

Discussion

The assessment of hospitals efficiency provides the ground to assess their performance and increase the productivity in using the limited resources. One of the ways assessing the allocated resources to obtain the specified goals is efficiency studies. In summary, efficiency mean the maximum using of the resources to produce goods and services [23].

This is the first systematic review and meta-analysis study regarding assessment the efficiency of Iran hospitals in terms of its sub-categories namely technical, managerial and scale efficiencies. The different methods have been used to assess Iran hospitals efficiency such as DEA, Pabon-Lasso and Stochastic Frontier Analysis (SFA) from the several past decades [21]. In this regard, as this study indicates, DEA method is the most widely applied method to assess hospitals efficiency [19].

Our findings showed that the random pool estimations of technical, managerial and economics of scale efficiency were 0.87, 0.9 and 0.88, respectively. This finding indicates that the resources of the studied hospitals in Iran have been used in an inefficient way. One idea about hospital efficiency is that the expectation from hospitals to work efficiently is far from reality. The reasoning for this claim is the economic theory of firms that declare the hospitals can't work fully efficient because of uncertainty in costs and prices of services that they provide. In summary, lack of information on costs and prices is one of the main factors that have negative affect on hospitals efficiency [24, 25].

Most of the studies were implemented in Tehran province (13 studies). Four studies investigated the efficiency of hospitals across all provinces of Iran. However, some provinces such as Sistan and Baluchistan had no any individual report about the efficiency of hospitals. Therefore, there are an information gap for health policy makers and hospital managers in this field.

As the results indicated, most of the researchers tend to perform analyzes through input-oriented method, because the inputs are in the control of hospital managers, so that by creating changes in the inputs can change the rate of outputs to the desired extend. However, it is suggested that private and for-profit hospitals are excluded from this rule, because the managers of these type of hospitals want to maximize the outputs and as a results hospital profits [26].

Human and capital resources such as number of nurses, physicians and number of beds were the main inputs in all included studies. Number of surgeries, outpatient admissions, inpatient admissions bed day and bed occupancy rate were the most frequent outputs that considered in the studies to estimate the efficiency of hospitals. Todays, the management of all resources, especially human resources in health care industry is recognized as vital issue for all healthcare organizations [27]. Furthermore, better management of human resources is associated with higher patient outcomes without significant increase in cost of hospitals [28].

The results indicated that most of hospital efficiency studies suffer from some weak points. So that, the selection of inputs has been performed on the basis of resources review (id est. previous published articles) not consideration of each hospital situation. Also, the inputs were not weighted, so that the resources with high specialty and expenditure receive the same weight as others. Hospital case mix have not been considered in hospital efficiency assessment. This leads to low efficiency assessment in hospitals which have most complicated cases. Lastly, some studies have not considered precisely the data validity and the appropriate ratio of inputs and outputs with the number of hospitals.

The study of Contor VJM and Poh Kl provides some theoretical and methodological limitations of DEA method to capture full view of efficiency of healthcare centers, too [29]. However, with a suitable study design, DEA method is among the most important and most applicable methods in assessment health system efficiency specially hospitals [30].

The results indicated that technical, managerial and scale efficiency of Iran hospitals after performing HSEP have decreased in comparison with before it. On the basis of a study on Turkey hospitals from 2001–2006, which measured the effect of Turkey health sector reform on hospitals efficiency to provide policy implications for policy makers, indicated that this reform has increased the efficiency of public hospitals but the efficiency of private hospitals has decreased [31].

By attention that there was no hospital with full efficiency in the study and increasing trend of health system costs and scarce resources, it is proposed to design and implement a system to monitor efficiency and consumption of resources specially in the hospitals. This can help to identify hospitals with inefficient hospitals and the causes of it. Health policy makers through cost management planning and increasing the outputs can pave the path in this regard.

Conclusions

This study indicated that many number of hospitals are inefficient. This imply that there is considerable room for efficiency improvement for hospitals. Hospital management has a unique role in this regard. Health system reforms in spite of increasing access and utilization of patients to the services, but have not considered efficiency improvement of hospitals. So, health policy makers and hospital managers should design and implement some related programs in order to monitoring and improving the efficiency of hospitals.

Abbreviations

HSEP: Health Sector Evolution Plan; CI: Confidence Interval; DEA: Data Envelopment Analysis, DMUs: Decision Making Units; SSO: Social Security Organization; ISI: Institute for Scientific Information; SID: Scientific Information Database; TUMS: Tehran University of Medical Sciences; IUMS: Iran University of Medical Sciences; SBMU: Shaheed Beheshti University of Medical Sciences; MUI: Isfahan University of Medical Sciences; SSU: Shahid Sadoghi (Yazd) University of Medical Sciences; TUMS: Tehran University of Medical Sciences; MHH: Ministry of Health' hospitals; MUQ: Qom university of Medical Sciences; MUMS: Mashhad University of Medical Sciences; UMSU: Urmia University of Medical Sciences; AJUMS: Ahvaz Jundishapour University of Medical Sciences; TBZMED: Tabriz University of Medical Sciences; UMSHA: Hamedan University of Medical Sciences; GUMS: Guilan University of Medial Sciences; MEDILAM: Ilam University of Medical Sciences; KUMS: Kermanshah University of Medical Sciences; MUK: Kurdistan University of Medical Sciences; LUMS: Lorestan University of Medical Sciences; KMU: Kerman University of Medical Sciences; IAU-ARAK: Islamic Azad University Branch of Arak; SUMS: Shiraz University of Medical Sciences; QUMS: Qazvin University of Medical Sciences.

Declarations

Ethics approval and consent to participate

This systematic review and meta-analysis study is approved by ethical committee of Arak University of Medical Sciences (ethical code number: IR.ARAKMU.REC.1398.044).

Consent for publication

not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

Authors declare that they have no competing interests.

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Authors' contributions

Conception and design of study/review/case series: SA, BKK, AKK. Acquisition of data: SA, MA (CA). Analysis of collected data: AKK, YS, JN, BKK, ZA. Interpretation of data: SA, AKK, YS, JN, ZA, MA. Drafting of paper and/or critical revision: SA, AKK, MA. All the authors have read and approved the manuscript to be submitted to BMC Health Services Research.

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Tables

Table 1. Characteristics of the studies included in the systematic review and meta-analysis

Row	Authors	Years of data collection	Language	Location	Affiliation of hospitals	Number of hospital	Inputs	Outputs	Model of DEA
1	Joshan et al. (1)	2011-12	Persian	Tehran	TUMS	14	N beds, operation room, Physician, nurse and support forces	N surgeries, outpatients patients, bed occupancy rate, bed day and admission-inpatient rate	VRS, Input oriented
2	Joshan et al. (1)	2011-12	Persian	Tehran	IUMS	8	N beds, operation room, physician, nurse and support forces	N surgeries, outpatients patients, bed occupancy rate, bed day and admission-inpatient rate	VRS, Input oriented
3	Joshan et al. (1)	2011-12	Persian	Tehran	SBMU	10	N beds, operation room, physician, nurse and support forces	N surgeries, outpatients patients, bed occupancy rate, bed day and admission-inpatient rate	VRS, Input oriented
4	Sepehrdost et al. (2)	2007-08	Persian	Iran	SSO	28	N medical, nurse and other sources and active beds	N outpatients, inpatients, surgeries, bed turnover	CRS, Input oriented
5	Sepehrdost et al. (2)	2007-08	Persian	Iran	SSO	37	N medical, nurse and other sources and active beds	N outpatients, inpatients, surgeries, bed turnover	CRS, Input oriented
6	Ghaderi et al. (2)	2005-09	Persian	Tehran & Alborz	IUMS	26	N beds, nurses and others	N surgeries, outpatients, hospitalization day, occupied bed day ratios	VRS, Input oriented
7	Karimi et al. (3)	2005-06	Persian	Isfahan	MUI	23	N physicians, nurses and beds	Mean patient stay, bed turnover, bed occupancy, N outpatient and hospital income	VRS, Input oriented
8	Mohammadi Ardakani et al. (4)	2004-06	Persian	Yazd	SSO	12	N physicians, paramedics and active beds	N inpatients and outpatients, occupied bed day	Input and Output oriented
9	Pourreza et al. (5)	1996-98	Persian	Tehran	TUMS	12	N beds, nurses, physicians and others	N outpatients, hospitalization-day, N surgeries	VRS, Input oriented
10	Aboulhalaj et al. (6)	2009	Persian	Iran	MHH	122	N beds, physicians, paramedics and others	Income and admission	VRS, Input oriented
11	Salehzade et al. (7)	2007	Persian	Qom	MUQ & Self-administered	8	N physicians, paramedics and active beds	N outpatient and inpatient	VRS, Input oriented
12	Salehzade et al. (7)	2007	Persian	Qom	MUQ & Self-administered	8	N physicians, paramedics and active beds	N inpatients and outpatients	CRS, input oriented
13	Asadi et al. (8)	2008	Persian	Yazd	SSO	13	Costs, education	SERVQUAL score, ratios,	Input and Output

							hours, and staff relocation	outpatient, inpatient and emergency patients to physicians score	oriented(input oriented)
14	Askari et al. (9)	2001-08	Persian	Yazd	SSO	13	N active beds, nurses, physicians and others	N inpatient, bed occupancy, surgeries	VRS, Input oriented
15	Ilbeigi et al. (10)	2009	Persian	Mashhad	MUMS	17	N beds, physicians, nurses, Para clinical and support forces	Inpatient-bed day, outpatients and surgeries	VRS_CRS (VRS), Input oriented
16	Rahimi et al. (11)	2009	Persian	W. Azarbaijan	UMSU	23	N beds, physicians and others	Occupied bed-day, outpatient admission	VRS, Input oriented
17	Najarzadeh et al. (12)	2006-10	Persian	Ahvaz	AJUMS	13	N physicians, nurses and beds	Occupied bed day, n surgeries, outpatients, inpatients, mean patient stay	VRS, Input oriented
18	Akbari et al. (13)	2005-08	Persian	Tabriz	TBZMED	20	N physicians and others, beds and hospital costs	N patient admission and surgeries, bed occupancy rate	VRS, Input oriented
19	Azar et al. (14)	2009-11	Persian	Tehran	TUMS	22	N beds, physicians, paramedics and others	N outpatients, emergencies, inpatients and surgeries, bed occupancy rate	VRS, Input oriented
20	Safi Aryan et al. (15)	2009	Persian	Hamadan	UMSHA	16	N beds, physicians, nurses and others	N surgeries and outpatients, bed occupancy rate, mean patient stay, inpatient bed stay	VRS, input oriented
21	Kazemi et al. (16)	2006-08	Persian	East of Iran	Medical Universities, SSO	11	N beds and all employees	Occupied bed day, outpatient admission	VRS, input oriented
22	Raeisian et al. (17)	2007-11	Persian	Ahvaz	AJUMS & SSO, Private & Charity	8	N beds, physicians, nurses and others	N patients and surgeries, bed occupancy rate	VRS, input oriented
23	Raeisian et al. (17)	2007-11	Persian	Ahvaz	AJUMS & SSO, Private & Charity	8	N beds, physicians, nurses and others	N patients and surgeries, bed occupancy rate	VRS, input oriented
24	Mohebifar et al. (18)	2006-10	Persian	Guilan	GUMS	19	N beds, physicians, nurses and others	N outpatients, inpatients, surgeries and inpatients day	VRS, input oriented
25	Fazeli et al. (19)	2009-11	Persian	Ilam	MEDILAM	9	N beds, physicians and others	N clinical, Para clinical and outpatient services	input-oriented
26	Fazeli et al. (19)	2009-13	Persian	Ilam	MEDILAM	9	N beds, physicians and others	N clinical, Para clinical and outpatient services	input-oriented
27	Mahfoozpor et al. (20)	2013-14	Persian	Tehran	SBMU	10	N physicians and nurses	N discharged patients	VRS, input oriented
28	Mahfoozpor et al. (20)	2013-14	Persian	Tehran	SBMU	10	N physicians and nurses	Surgery room function	VRS, input oriented
29	Mahfoozpor	2013-14	Persian	Tehran	SBMU	10	N physicians	N discharged	VRS, input

	et al. (20)						and nurses	patients	oriented
30	Mahfoozpor et al. (20)	2013-14	Persian	Tehran	SBMU	10	N physicians and nurses	Surgery room function	VRS, input oriented
31	Ghasemi et al. (21)	2005-11	Persian	Kermanshah	KUMS	7	N beds, N physicians, nurses and others	N outpatients, inpatients, occupied bed day and surgeries	VRS, input oriented
32	Firouzi et al. (22)	NA	Persian	Tehran	TUMS	40	N beds, physicians, paramedics, some costs	N contracted insurances, access to emergency, confront with hospital infections, anesthesia problems, employee consent, bed occupancy rate, employee to bed ratio	VRS, input oriented
33	Amozadeh et al. (23)	2012, 13, 15	Persian	Mazandaran and Babul	Mazandaran & Babol UMS	21	N beds, physicians, nurses and others	N emergencies, outpatients and surgeries	VRS, input oriented
34	Youzi et al. (24)	2016	Persian	Tehran	TUMS	21	N beds, physicians and nurses	Percent of active beds, bed occupancy rate, mean stay and bed turnover	VRS, input oriented
35	Lotfi et al. (25)	2007-2011	English	Ahvaz	Affiliated and non-affiliated with AJUMS	16	N beds, physicians, nurses and others	Bed occupancy rate, n patients and operations	Input oriented
36	Nabilou et al. (26)	2009-2014	English	Tehran	TUMS	17	N beds, nurses, physicians and others	N outpatient admission, occupied bed days, surgical operations	Input oriented, variable return to scale
37	Rezapour et al. (27)	2009-2012	English	Tehran	IUMS & TUMS	19	Human resources, Capital resources	N inpatients and admissions and inpatient bed occupancy rate	VRS, Input oriented model
38	Torabipour et al. (28)	2007-2010	English	Ahvaz	University, Charity, Private	12	N nurses, beds and physicians	N outpatients and inpatients, mean hospital stay, n major operations	Input oriented
39	Kiadaliri et al. (29)	2006	English	Ahvaz	AJUMS	19	Human resources, n beds	N outpatient and inpatient visits, N surgeries and percentage of occupied beds	VRS, Input oriented model
40	Nabilou et al. (30)	2013-2014	Persian	Urmia	UMSU	23	N nurses, physicians, beds, and others	N discharges, surgeries and bed occupancy percentage	VRS, Input oriented model
41	Rezaei et al. (31)	2007-2011	English	Kurdistan	MUK	12	N beds, nurses, physicians and others	N inpatient admission and occupied bed days	VRS, Input oriented model
42	Goudarzi et al. (32)	2001-07	Persian	Lorestan	LUMS	13	N beds, nurses,	N Outpatient, inpatient and surgeries, bed	VRS, Input oriented model

							physicians and others	day, bed occupancy rate	
43	Askari et al. (33)	2001-11	English	Yazd	SSU	13	N beds, N nurses, physicians, and non-clinical staff	N admission and surgeries, bed occupancy percentage	VRS, Input oriented model
44	Sabermahani et al. (34)	2011	English	Kerman	KMU	13	Full-time physicians and nurses , administrative personnel	N outpatient clients, surgeries and beds per day	VRS, Input oriented model
45	Jahangiri et al. (35)	2011-13	Persian	Arak	IAU-ARAK	31	N day-beds, working days, physicians and other staffs	N admissions, surgeries, child birth, and inpatient-day	CRS, input oriented
46	Najafi et al. (36)	2001-06	Persian	Ardabil	TUMS	10	N beds and physicians	N admission and bed-inpatient	VRS, input oriented
47	Hatam	NA	Persian	Iran	SUMS	18	N beds and all full-time staffs, hospital budget	Bed-day, active to fixed bed, patient mean stay, bed turnover, death, and costs	CRS, Input oriented
48	Rezapour et al.	1998-07	Persian	Qazvin	QUMS	4	N beds, physicians, nurses and others	N discharges, surgeries, admissions, emergencies, bed turnover, patient-day	VRS, input oriented
49	Hadian	2006-11	Persian	Tehran	Iran & Tehran UMS	19	N beds, nurses, physicians an others	N outpatient admission, inpatient day, occupied bed day, surgeries	VRS, input oriented
50	Mehrtak et al.	NA	English	E. Azarbaijan	IUMS	18	N beds, physicians and nurses	N discharges, surgeries, bed occupancy rate	VRS, input oriented

Tehran University of Medical Sciences= TUMS, Iran University of Medical Sciences= IUMS, Shaheed Beheshti University of Medical Sciences= SBMU, Social Security Organization=SSO, Isfahan University of Medical Sciences= MUI, Yazd University of Medical Sciences= SSU, Tehran University of Medical Sciences= TUMS, Ministry of Health' hospitals= MHH, Qom university of Medical Sciences= MUQ, Mashhad University of Medical Sciences= MUMS, Urmia University of Medical Sciences= UMSU, Ahvaz Jundishapour University of Medical Sciences= AJUMS, Tabriz University of Medical Sciences= TBZMED, Hamedan University of Medical Sciences= UMSHA, Guilan University of Medial Sciences= GUMS, Ilam University of Medical Sciences= MEDILAM, Kermanshah University of Medical Sciences= KUMS, Kurdistan University of Medical Sciences= MUK, Lorestan University of Medical Sciences= LUMS, Kerman University of Medical Sciences= KMU, Islamic Azad University Branch of Arak= IAU-ARAK, Shiraz University of medical sciences= SUMS, Qazvin University of Medical Sciences= QUMS

Table 2. Egger's test for small-study effects to examine the publication bias

		Coefficient	S.E.	P-value	95% confidence Interval	Test of H0: no small-study effects
Technical efficiency	slope	0.56	0.00	0.000	(.40, 0.73)	P = 0.005
	bias	-1.01	0.34	0.005	(0.32, 1.70)	
Managerial efficiency	slope	1.00	0.00008	0.000	(0.99, 1.00)	P = 0.000
	bias	-1.22	0.26	0.000	(-1.76, -0.68)	
Economics of scale efficiency	slope	1.00	0.00009	<0.001	(0.99, 1.00)	P = 0.000
	bias	-1.28	0.19	<0.001	(-1.67, -.0.90)	

Table 2. The results of pool estimation for technical efficiency among Iranian hospitals.

study	authors	estimation	95%confidence Intervals	Weight
1	Joshan et al.	0.93	(0.66,1)	1.99
2	Joshan et al.	0.88	(0.47,1)	1.58
3	Joshan et al.	0.9	(0.55,1)	1.75
4	Sepehrdost et al.	0.86	(0.67,0.96)	2.42
5	Sepehrdost et al.	0.89	(0.75,0.97)	2.55
6	Ghaderi et al.	0.88	(0.7,0.98)	2.38
7	Karimi et al.	0.91	(0.72,0.99)	2.31
8	Alimohammadi Ardakani et al.	0.75	(0.43,0.95)	1.88
9	pourreza et al.	0.92	(0.62,1)	1.88
10	Aboulhalaj et al.	0.43	(0.34,0.53)	2.92
11	Salehzade et al.	0.75	(0.35,0.97)	1.58
12	Salehzade et al.	0.88	(0.47,1)	1.58
13	Asadi et al.	0.92	(0.64,1)	1.94
14	Askari et al.	0.92	(0.64,1)	1.94
15	Ilbeigi et al.	0.76	(0.5,0.93)	2.12
16	Rahimi et al.	0.57	(0.34,0.77)	2.31
17	Najarzadeh et al.	0.69	(0.39,0.91)	1.94
18	Akbari et al.	0.95	(0.75,1)	2.22
19	Azar et al.	0.86	(0.65,0.97)	2.28
20	Safi Aryan et al.	0.88	(0.62,0.98)	2.08
21	Kazemi et al.	0.82	(0.48,0.98)	1.82
22	Raeisian et al.	0.88	(0.47,1)	1.58
23	Raeisian et al.	1	(0.63,1)	1.58
24	Mohebifar et al.	0.89	(0.67,0.99)	2.19
25	fazeli et al.	0.78	(0.4,0.97)	1.67
26	fazeli et al.	0.78	(0.4,0.97)	1.67
27	Mahfoozpor et al	0.4	(0.12,0.74)	1.75
28	Mahfoozpor et al	0.4	(0.12,0.74)	1.75
29	Mahfoozpor et al	0.3	(0.07,0.65)	1.75
30	Mahfoozpor et al	0.5	(0.19,0.81)	1.75
31	Ghasemi et al.	0.86	(0.42,1)	1.49
32	Firouzi Jahantigh et al.	0.93	(0.8,0.98)	2.59
33	Amozadeh et al.	0.9	(0.7,0.99)	2.25
34	Youzi et al.	0.86	(0.64,0.97)	2.25
35	Lotfi et al.	0.88	(0.62,0.98)	2.08
36	Nabilou et al	0.94	(0.71,1)	2.12
37	Rezapour et al.	0.84	(0.6,0.97)	2.19
38	Torabipour et al.	0.92	(0.62,1)	1.88
39	Ahmad Kiadaliri et al.	0.89	(0.67,0.99)	2.19
40	Nabilou et al	0.87	(0.66,0.97)	2.31
41	Rezaei et al	0.83	(0.52,0.98)	1.88
42	Goudarzi et al.	0.92	(0.64,1)	1.94
43	Askari et al.	0.92	(0.64,1)	1.94
44	Sabermahani et al.	0.85	(0.55,0.98)	1.94
45	Jahangiri et al	0.97	(0.83,1)	2.47
46	Najafi et al.	1	(0.69,1)	1.75
47	Hatam	0.89	(0.65,0.99)	2.16
48	Rezapour et al.	0.75	(0.19,0.99)	1.1
49	Hadian	0.95	(0.74,1)	2.19
50	Mehrtak et al.	0.78	(0.52,0.94)	2.16
Random pooled estimation		0.84	(0.78, 0.52)	100
Heterogeneity chi^2 = 156.97 (d.f. = 49) p = 0.000				
I^2 (variation in ES attributable to heterogeneity) = 68.78%				
Estimate of between-study variance Tau^2 = 0.12				

.Table 3. The results of pool estimation for managerial efficiency among Iranian hospitals

Study	authors	estimation	95%confidence Intervals	Weight
1	Joshan et al.	0.93	(0.66,1)	2.71
2	Joshan et al.	1	(0.63,1)	2.01
3	Joshan et al.	0.9	(0.55,1)	2.28
4	Sepehrdost et al.	0.93	(0.76,0.99)	3.59
5	Sepehrdost et al.	0.95	(0.82,0.99)	3.9
6	Ghaderi et al.	0.88	(0.7,0.98)	3.5
7	Karimi et al.	0.96	(0.78,1)	3.35
8	pourreza et al.	0.92	(0.62,1)	2.51
9	Aboulhalaj et al.	0.59	(0.5,0.68)	4.83
10	Askari et al.	0.92	(0.64,1)	2.61
11	Ilbeigi et al.	0.88	(0.64,0.99)	2.96
12	Rahimi et al.	0.74	(0.52,0.9)	3.35
13	Najarzadeh et al.	0.85	(0.55,0.98)	2.61
14	Akbari et al.	0.95	(0.75,1)	3.17
15	Safi Aryan et al.	0.94	(0.7,1)	2.88
16	Kazemi et al.	0.91	(0.59,1)	2.4
17	Raeisian et al.	1	(0.63,1)	2.01
18	Raeisian et al.	1	(0.63,1)	2.01
19	Mohebifar et al.	0.95	(0.74,1)	3.11
20	Mahfoozpor et al	0.6	(0.26,0.88)	2.28
21	Mahfoozpor et al	0.6	(0.26,0.88)	2.28
22	Mahfoozpor et al	0.7	(0.35,0.93)	2.28
23	Mahfoozpor et al	0.8	(0.44,0.97)	2.28
24	Nabilou et al	0.94	(0.71,1)	2.96
25	Rezapour et al.	0.95	(0.74,1)	3.11
26	Torabipour et al.	0.92	(0.62,1)	2.51
27	Ahmad Kiadaliri et al.	0.89	(0.67,0.99)	3.11
28	Nabilou et al	0.91	(0.72,0.99)	3.35
29	Rezaei et al	0.83	(0.52,0.98)	2.51
30	Goudarzi et al.	0.92	(0.64,1)	2.61
31	Askari et al.	0.92	(0.64,1)	2.61
32	Sabermahani et al.	0.92	(0.64,1)	2.61
33	Najafi et al.	1	(0.69,1)	2.28
34	Rezapour et al.	0.75	(0.19,0.99)	1.29
35	Hadian	0.95	(0.74,1)	3.11
36	Mehrtak et al.	0.94	(0.73,1)	3.04
Random pooled estimation		0.9	(0.85,0.94)	100
Heterogeneity chi^2 = 79.58 (d.f. = 35), p =0.000				
I^2 (variation in ES attributable to heterogeneity) = 56.02%				
Estimate of between-study variance Tau^2 = 0.07				
Test of ES=0 : z= 34.96, p = 0.00				

.Table 4. The results of pool estimation for economies of scale efficiency among Iranian hospitals

Study	authors	estimation	95%confidence Intervals	Weight
1	Joshan et al.	0.93	(0.66,1)	2.38
2	Joshan et al.	0.88	(0.47,1)	1.64
3	Joshan et al.	0.9	(0.55,1)	1.91
4	Sepehrdost et al.	0.93	(0.76,0.99)	3.46
5	Sepehrdost et al.	0.95	(0.82,0.99)	3.91
6	Ghaderi et al.	0.96	(0.8,1)	3.34
7	Karimi et al.	0.96	(0.78,1)	3.15
8	pourreza et al.	0.92	(0.62,1)	2.16
9	Aboulhalaj et al.	0.75	(0.66,0.82)	5.44
10	Salehzade et al.	0.88	(0.47,1)	1.64
11	Salehzade et al.	0.88	(0.47,1)	1.64
12	Askari et al.	0.92	(0.64,1)	2.27
13	Ilbeigi et al.	0.82	(0.57,0.96)	2.67
14	Rahimi et al.	0.74	(0.52,0.9)	3.15
15	Najarzadeh et al.	0.77	(0.46,0.95)	2.27
16	Akbari et al.	0.95	(0.75,1)	2.92
17	Safi Aryan et al.	0.94	(0.7,1)	2.58
18	Kazemi et al.	0.91	(0.59,1)	2.04
19	Raeisian et al.	0.88	(0.47,1)	1.64
20	Raeisian et al.	1	(0.63,1)	1.64
21	Mohebifar et al.	0.95	(0.74,1)	2.84
22	fazeli et al.	0.67	(0.3,0.93)	1.78
23	fazeli et al.	0.91	(0.59,1)	2.04
24	Mahfoozpor et al	0.5	(0.19,0.81)	1.91
25	Mahfoozpor et al	0.7	(0.35,0.93)	1.91
26	Mahfoozpor et al	0.5	(0.19,0.81)	1.91
27	Mahfoozpor et al	0.6	(0.26,0.88)	1.91
28	Nabilou et al	0.94	(0.71,1)	2.67
29	Rezapour et al.	0.89	(0.67,0.99)	2.84
30	Torabipour et al.	1	(0.74,1)	2.16
31	Ahmad Kiadaliri et al.	0.95	(0.74,1)	2.84
32	Nabilou et al	0.91	(0.72,0.99)	3.15
33	Rezaei et al	0.92	(0.62,1)	2.16
34	Goudarzi et al.	0.92	(0.64,1)	2.27
35	Askari et al.	0.92	(0.64,1)	2.27
36	Sabermahani et al.	0.85	(0.55,0.98)	2.27
37	Najafi et al.	0.9	(0.55,1)	1.91
38	Hatam	0.5	(0.26,0.74)	2.76
39	Rezapour et al.	0.75	(0.19,0.99)	0.98
40	Hadian	0.95	(0.74,1)	2.84
41	Mehrtak et al.	0.78	(0.52,0.94)	2.76
Random pool estimation		0.88	(0.84, 0.91)	100
Heterogeneity chi^2 = 67.22 (d.f. = 40) p = 0.00				
I^2 (variation in ES attributable to heterogeneity) = 40.5%				
Test of ES=0 : z= 40.93 p = 0.00				

Table 5. The random pool estimation of technical, managerial and economics of scale efficiencies among Iranian hospitals by time of studies.

	subgroup	estimation	95%confidence Intervals	Weight	Test(s) of heterogeneity		Random Test for heterogeneity between sub-groups:
					I^2**	P-value	P-value
Technical efficiency	2011 and before	0.86	(0.80, 0.91)	75.97	66.80%	0.000	0.23
	After 2011	0.78	(0.64, 0.89)	24.03	75.55%	0.000	
Managerial efficiency	2011 and before	0.91	(0.86, 0.95)	77.89	60.74%	0.000	0.27
	After 2011	0.86	(0.75, 0.94)	22.11	39.89%	0.100	
Economics of scale efficiency	2011 and before	0.90	(0.86, 0.93)	83.67	32.79%	0.040	0.01
	After 2011	0.74	(0.61, 0.86)	16.33	35.26%	0.150	

** I^2: the variation in ES attributable to heterogeneity

Figures

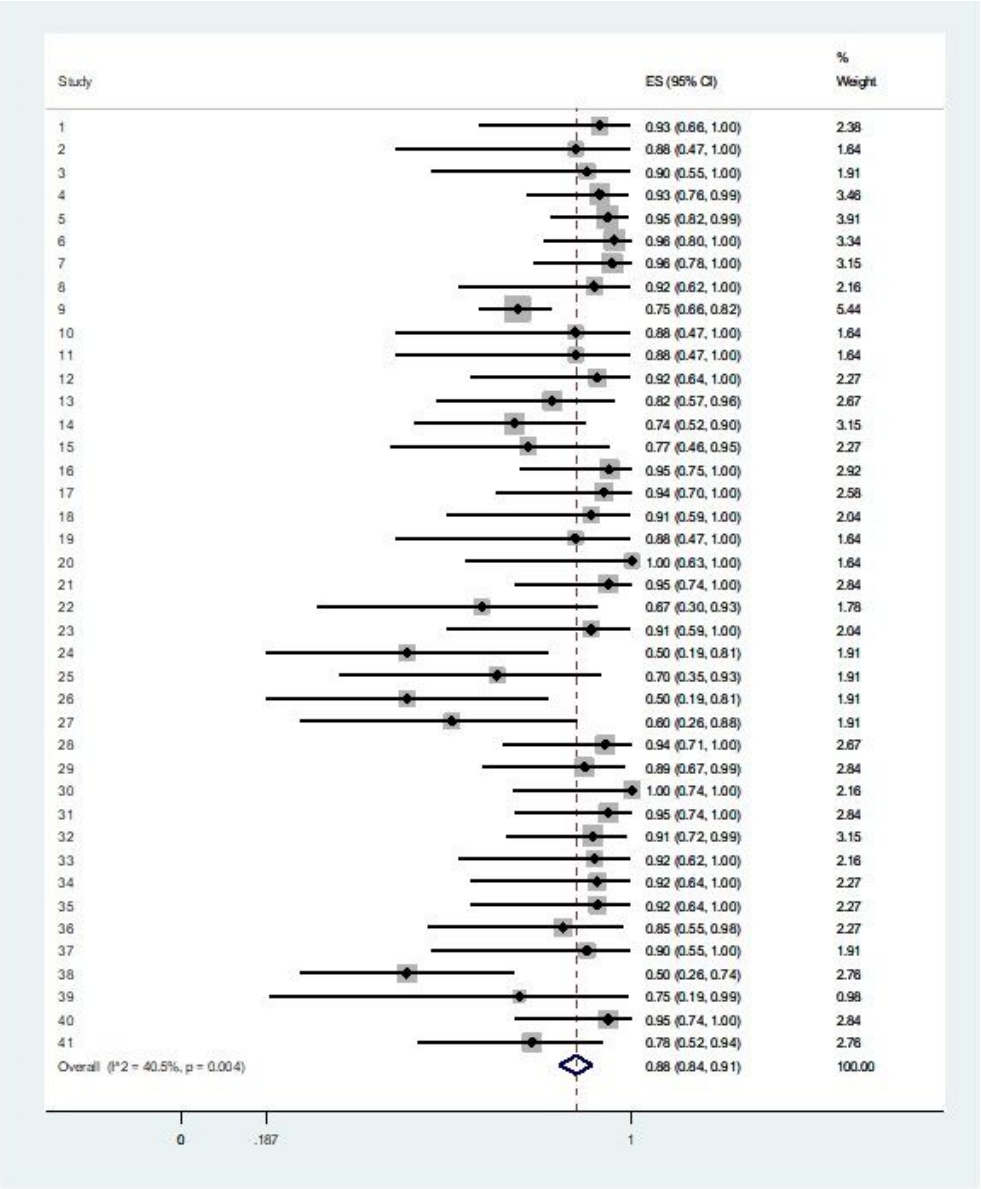

Figure 1

Forest plot of estimates and 95% confidence intervals of the economics of scale efficiency among Iranian hospitals.

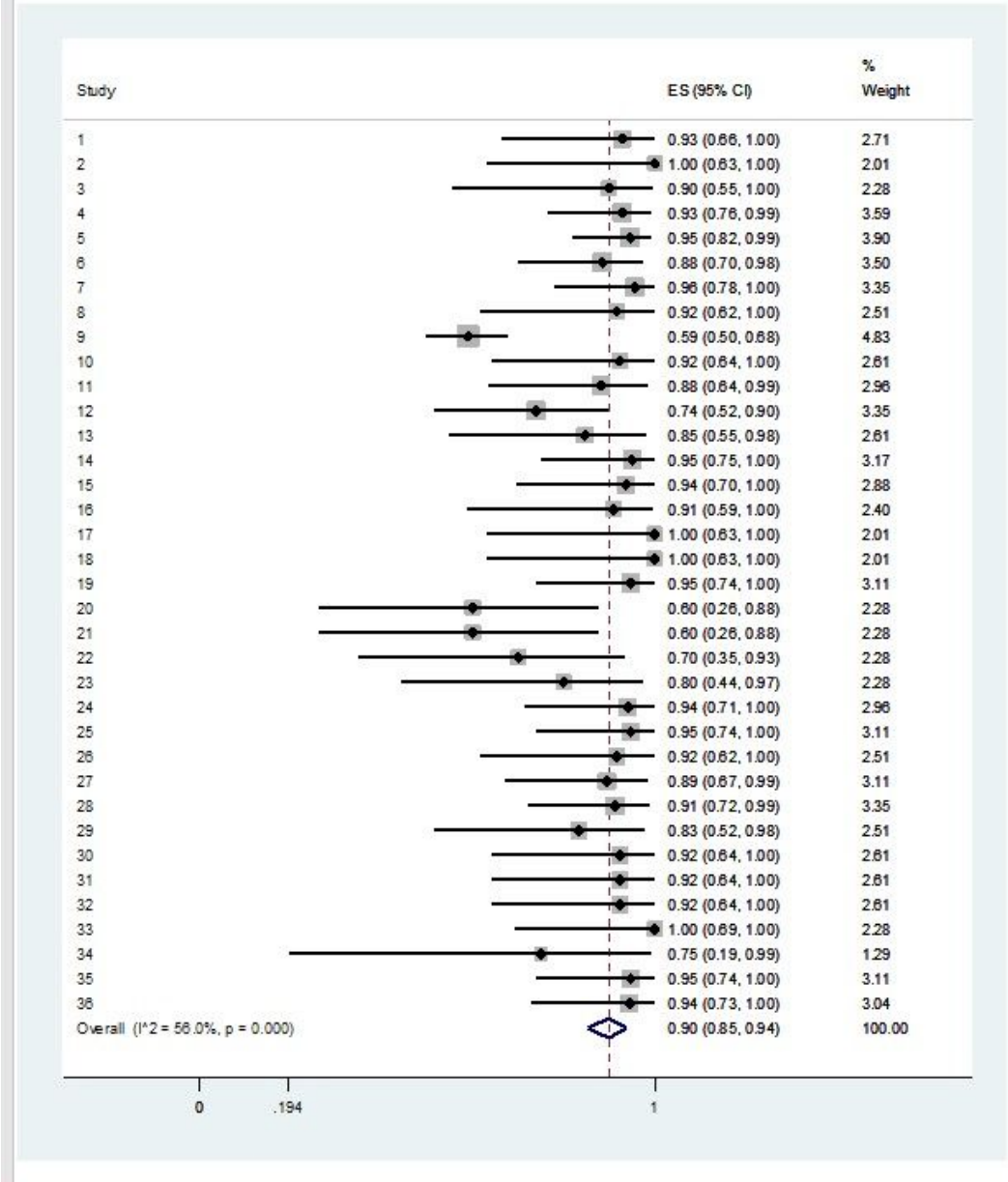

Figure 2

Forest plot of estimates and 95% confidence intervals of the managerial efficiency among Iranian hospitals.

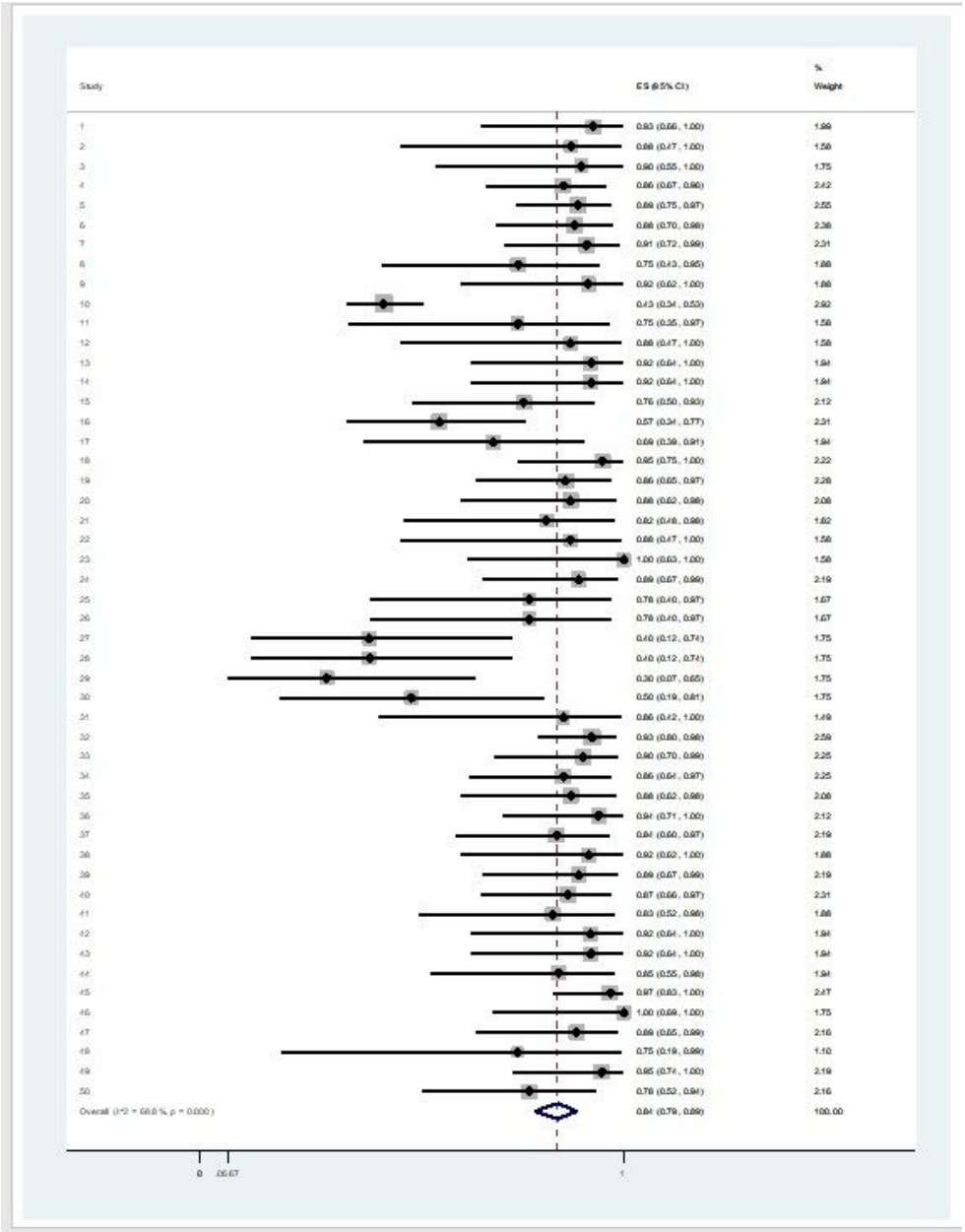

Figure 3

Forest plot of estimates and 95% confidence intervals of the technical efficiency among Iranian hospitals.

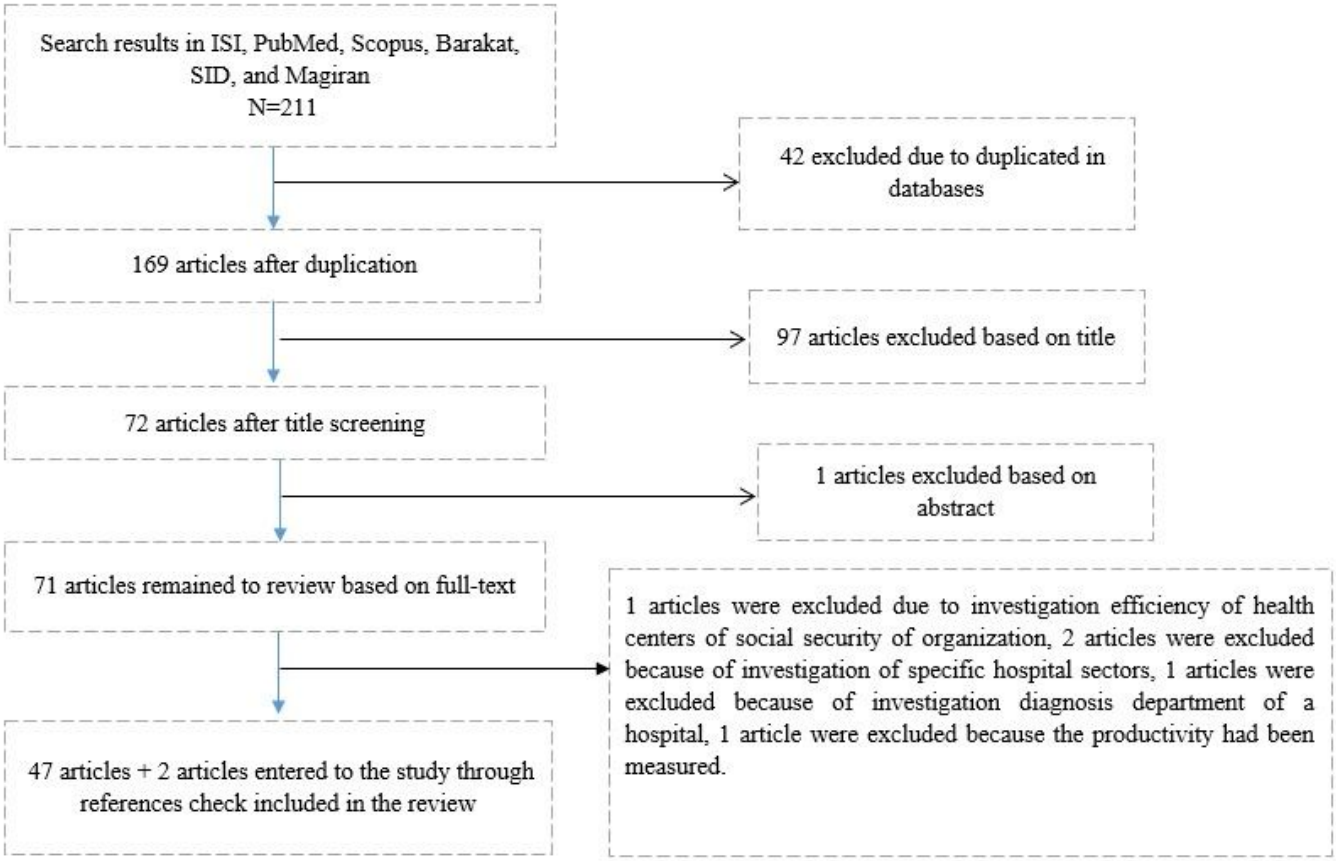

Figure 4

Flow chart of systematic search and studies selection

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