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A review on inputs and outputs in determining the efficiency of universities of medical sciences by data envelopment analysis method

Mohammad M. Mojahedian[1], Aeen Mohammadi[2], Mohammad Abdollahi[3], Abbas Kebriaeezadeh[4], Mohammad Sharifzadeh[5], Shadi Asadzandi[6], Shekoufeh Nikfar*[4]

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Abstract

Background: Increasing the number of students in universities, simultaneously limiting allocation of funds to them, and maintaining the highest efficiency level in education and research are of paramount importance. There are several methods to assess the efficiency of universities, and one of the most widely used of which is data envelopment analysis (DEA). The aim of this study was to determine the input and output criteria to evaluate the efficiency of universities of medical sciences through review-related articles using the DEA method.

Methods: The time limit for retrieving articles was considered from the beginning of the publication of the first paper in this field until the end of 2017. The data were retrieved from Web of Science, Scopus, Ovid, ProQuest, Science Direct, and PubMed using advanced searches. Inclusion criteria were as follow: relevancy of the articles to the purpose of the research, availability of the articles' full-text, articles published to the end of 2017, and articles published in English.

Results: The most inputs used in the literature to determine university efficiency were number of academic staffs, budget and costs, number of students, number of nonacademic staffs, spaces, and equipment and student's entrance scores. Also, the most outputs used in the literature to determine university efficiency were number of graduates, publications, incomes, number of students, and student's scores.

Conclusion: This study showed that a large number of researchers have focused on measuring and comparing the efficiency of universities to improve efficiency, reduce costs, and manage the resources. Efficiency analysis by DEA allows the policymakers to define and develop policies and guidelines to improve their performances.

Keywords: Education, Efficiency, Data envelopment analysis, Inputs, Outputs

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Introduction

Education is an important factor in human life and evidence suggests that it is directly related to the economic growth of a country (1, 2). Because of the social benefits of education, one of the ways to finance education cost has always been the public funding of countries. However, due to the high demand for public funding, optimum use

Corresponding author: *Dr Shekoufeh Nikfar, nikfar_sh@tums.ac.ir*

1. Department of Pharmacoeconomics and Pharmaceutical Administration, Faculty of Pharmacy, Tehran University of Medical Sciences, Tehran, Iran
2. Department of eLearning in Medical Education, Virtual School, Tehran University of Medical Sciences, Tehran, Iran
3. Department of Toxicology and Pharmacology, Faculty of Pharmacy and Pharmaceutical Sciences Research Center, Tehran University of Medical Sciences, Tehran, Iran
4. Department of Pharmacoeconomics and Pharmaceutical Administration, Faculty of Pharmacy and Pharmaceutical Management and Economics Research Center, Tehran University of Medical Sciences, Tehran, Iran
5. Department of Pharmacology and Toxicology, Faculty of Pharmacy, Tehran University of Medical Sciences, Tehran, Iran
6. Research Department, Virtual School, Tehran University of Medical Sciences, Tehran, Iran

↑What is "already known" in this topic:
By increasing the number of university students and limited funds allocated to universities, maintaining the efficiency of universities resources is necessary. Data envelopment analysis (DEA) method is one of the most widely used methods to evaluate efficiency of universities.

→What this article adds:
To evaluate efficiency via DEA method, selecting outputs and inputs plays an important role. Results of this study determine most inputs and outputs that can be used to evaluate the efficiency of universities of medical sciences.

of the public resources allocated to education is highly important. By increasing the number of university students and limited funds allocated to universities, maintaining the highest level of performance and using universities' resources efficiently is of high importance. Therefore, understanding the efficiency of universities plays an important role in allocating funds to academic units. Also, one of the most important issues related to university management is determining the relative efficiency of units (3).

Generally, efficiency means using minimum resources to produce the highest output and product. More broadly, efficiency can be defined by doing the right things. Organizational efficiency should be continuously measured by making plans for improvement, providing information about organizational performances, and guiding the university toward its goals. Therefore, in recent years, a large number of researchers have focused on measuring and comparing the efficiency of decision-making units to improve efficiency, reduce costs, and manage resources and their subunits. Efficiency analysis allows universities' policymakers to define policies and guidelines to improve their performances (4).

There are several methods to evaluate the efficiency of decision-making units, including universities. The data envelopment analysis (DEA), introduced by Charnes et al in 1978, is one of the most widely used methods, which uses multiple inputs and outputs. DEA is a linear and nonparametric method and is used to evaluate the relative efficiency of decision-making units (DMUs). The function of DEA is to evaluate the efficiency by multiple inputs and outputs data from the decision-making units and to evaluate the advantages as much as possible by assigning variable weights to each element of input and output (5). In this method, the best performance is given to a unit that produces the highest output with the lowest input and this unit is then used as the reference to determine the inefficiency of other units (6, 7).

In DEA method, the efficiency of each unit depends on the selected inputs and outputs, which are highly important, as inputs and outputs must reflect appropriate university resources and its specific activities. Also, DEA depends on the study objectives and does not provide guidance for selecting output and input (8, 9).

The aim of this study was to determine the inputs and outputs by reviewing the existing articles that have evaluated the efficiency of universities using the DEA method to evaluate the efficiency of universities of medical sciences. In Iran, universities of medical sciences are supervised by the Ministry of Health, while nonmedical universities are supervised by the Ministry of Science. However, in most countries, medical and nonuniversities of medical sciences are integrated. Therefore, in this study, all articles that evaluated the efficiency of universities were examined. Finally, the most frequently used inputs and outputs to determine the efficiency of universities was reported.

Methods

Data were retrieved from Web of Science (WOS), Scopus, Ovid, ProQuest, Science Direct, and PubMed databases using advanced search to extract and compile all articles related to the performance evaluation of universities using DEA method.

The time limit for retrieving articles was considered from the beginning of the publication of the first paper in this field until the end of 2017. The search process was conducted in November 2018 for 1 month. The keywords were obtained using MeSH terms and limited by expert opinions. The keywords used to retrieve the articles were compiled as follow: efficiency, efficacy, data envelopment analysis, DEA, university(s), college(s), faculty(s), school(s), and academic unit(s).

An example of strategies used in science direct database is as follows:

("efficiency" OR "efficacy") AND ("data envelopment analysis" OR "DEA") AND ("university" OR "universities" OR "college" OR "colleges" OR "faculty" OR "faculties" OR "school" OR "schools" OR "academic unit" OR "academic units").

The criteria for including articles to the study were as follow: relevancy of the articles to the purpose of the research, availability of the articles' full-text, articles published up to the end of 2017, and the articles published in English.

Exclusion criteria were the lack of access to the text of the articles, unrelated subject area, other formats of the article, non-English articles, and review articles. Endnotes were used to remove similar articles, and if similar studies were found during reviewing the articles, they were removed by the researchers. The elimination and review process, including studying abstracts, and full-text of the articles were performed by 2 individuals separately; then, the results and contradictory items were determined. In cases where there was disagreements, a third person reviewed the article. After the articles were collected, data entered into a table containing the title of the article, inputs, and outputs. It was also found that the university's efficiency with respect to education and research was examined separately.

Results

The results of the reviewing process and selecting articles in terms of entry and exit criteria are summarized in Flowchart 1.

Table 1 presents the list of the most inputs used in the literature to determine efficiency of universities.

Also, Table 2 shows the list of the most outputs used in the literature to determine efficiency of universities.

The list of most inputs and outputs used in the literature to determine efficiency of universities is presented in Table 3.

Discussion

This study showed that in some studies, the efficiency of universities in the fields of education and research has been studied separately (36, 41, 42, 48, 53, 69, 76, 87, 88, 101, 104, 106, 118, 126).

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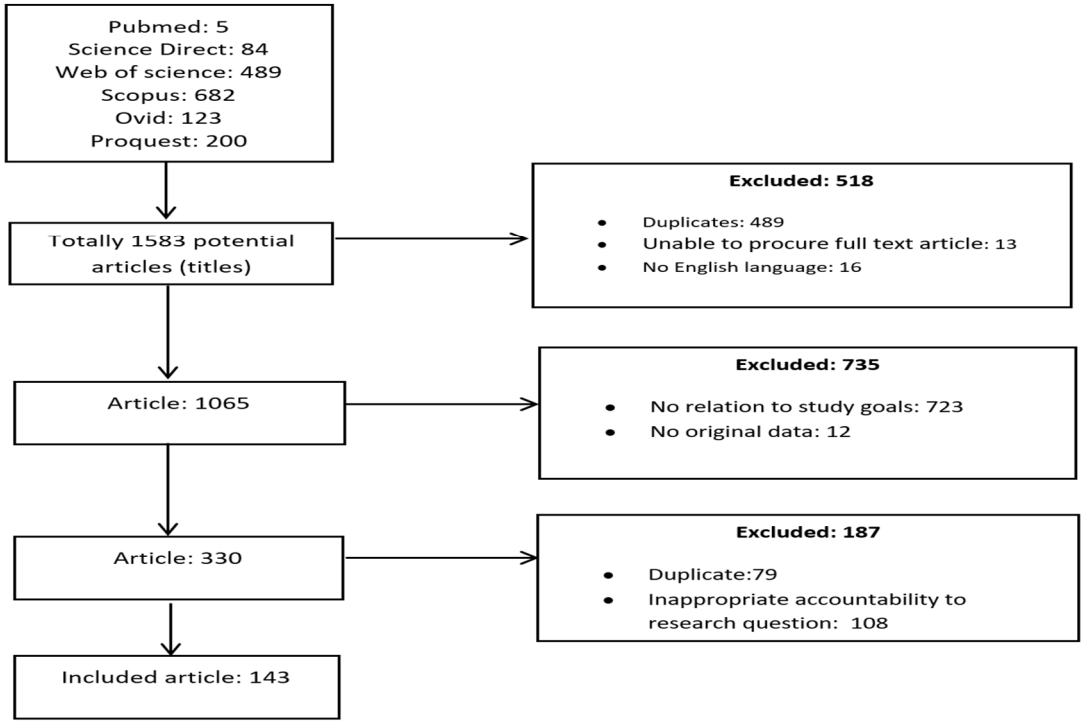

Flowchart 1. The results of the process of reviewing and selecting articles in terms of entry and exit criteria

In the extraction section for inputs for the efficiency section of universities, in 79% of the reviewed papers, the number of academic staffs were considered as one of the inputs, which included some titles such as an academic staff member, academic staffs, faculties, teaching staff, etc. In some of these articles, academic staffs were also classified according to academic rank (43, 66, 102).

Also, in 75% of the articles, the budget and costs were used as one of the inputs with headings like funds, income, financial resources, revenue, budget, expenditure, costs, grants, and spending.

In 35% of the articles, other inputs used to analyze the efficiency were number of students with different titles: total number of students, total enrolment, number of un-

Table 1. List of the most inputs used in the literature to determine efficiency of universities

Title of inputs	Title of inputs used in articles
Number of academic staff	Full-time equivalent faculty (10-12)
	Number of academic staff (9, 13-60)
	Number of professors (61, 62)
	Academic staff full-time equivalent (63)
	Number of fulltime equivalent academic staff (64, 65)
	Full-time academic staff (66, 67)
	Faculties (5, 68-73)
	Total number of full-time professors (62, 74)
	Rate of professors with PhD (62)
	Rate of full-time professors (62)
	Number of academic employees (75)
	The number of residents, fellowships, and faculty members (76)
	Number of faculty members (76-80)
	Number of research assistant position (81)
	Number of professor position (81)
	Number of faculty members with PhD degree (76)
	Number of teaching staff (82-86)
	Professors and Assistant professors (87, 88)
	Other researchers (88)
	Share of faculty with degrees (77)
	Academic Rating (89)
	Ratio between full time academic staff and full-time students (90)
	Research staff (48, 91, 92)
	% of the faculty with doctorates (73, 93)
	Faculty to student ratio (93-96)
	Academic staff per student (97)
	Number of domestic full-time faculty (7, 98)
	Full-time teachers (99)

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Table 1. Ctd

Title of inputs	Title of inputs used in articles
Number of academic staff	Number of full professors (7, 100, 101)
	Average number of teachers(102)
	% of the faculty with associate professor position or higher (94)
	Academic personnel (103-105)
	Number of teachers (106, 107)
	Number of Full time professors with a doctorate degree (108)
	Number of assistant professors (7, 100)
	Number of lecturers (101, 109)
	Number of full-time academic staff + ½ times the number of part-time academic staff (110, 111)
	Number of associate professors (7, 100, 101)
	Number of full-time equivalent instructors (76, 80, 112)
	Number of lecturers and assistant professors (87)
	Total academic staff (113)
	Number of professors per enrolled students (114)
	Number of Teaching and Research Faculty (115)
	Weighted number of academic staff (57)
	Weight points of professor ranks (116)
Budget and Costs	Revenue (13, 54, 113)
	Grant-in aid for management (5)
	Financial Resources (10, 24, 74)
	Physical Resources (10)
	Staff Expenditure (10)
	Operating costs (14, 15, 35, 48, 117, 118)
	Research funding (16, 45)
	Expenses (21, 58, 109, 119, 120)
	Resources (67)
	Annual operating budget (18)
	Internal research fund (18)
	External research fund (18)
	Annual Educational Expenditure (68, 70)
	Non personnel expenditures (19)
	Total income (19, 60, 72, 121)
	Grants (69)
	Other prime costs + taxes and charges (122)
	Remuneration (122)
	Intramural expenditure (20)
	Weighted tuition (62)
	Labor costs (75)
	Government operating grant (21)
	Staff costs (82, 123)
	Expenditures (7, 12, 26, 31, 36, 37, 43, 44, 66, 105, 110-112, 124, 125)
	Costs (28, 65, 92, 123, 126, 127)
	Public funding (60, 77)
	Financial Rating (128)
	Ratio between expenditure and full-time students (90)
	Operating expenses (7, 38, 40, 50, 51, 78, 106, 129-132)
	Public expenditures (29)
	Annual expenditure (79)
	Academic support expenditures (71, 115)
	Institutional support expenditures (71)
	Instruction expenditures (71)
	Personal expenditures (32)
	Non personal expenditures (32)
	Management expenses (74)
	Government research funding (33)
	Personnel expenses (133)
	Research expenditure (7, 91, 94, 99, 131, 132)
	Annual tuition (134)
	Profit from donations (5)
	Educational and general expenditures per student (93)
	Government budget subsidy (34, 113)
	Total funding per student (97, 135)
	Research grants (36, 104)
	Educational resources (136)
	Services resources (136)
	PhD candidates funding (137)
	Public funds for each institution (102)
	Education and research expenses (5)
	Average monthly costs (138)
	Total administrative costs (139)
	Total financial resources and investment resources (80)
	Funding (56, 140)
	Operating budget (73, 83)
	Total expenditure per student (97)
	Library budget (83)
	General expenditures (141)
	General and administrative expenses (5)
	Other costs than costs for staff (123)

dergraduates, and postgraduates.

The number of nonacademic staffs, with titles as number of nonacademic staff, number of administrative staffs, other personnel, support staff etc., were seen in 29% of the articles; physical space, with titles as floor area, land space, number of room and etc., were observed in 16% of

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Table 1. Ctd

Title of inputs	Title of inputs used in articles
Number of students	Number of students (13, 17, 22, 23, 25, 27, 29, 43, 53-56, 60, 61, 76, 80, 82, 102, 107)
	First joining graduates (11)
	Total enrolment (11, 63)
	Number of bachelor and students (64)
	Number of undergraduate students (39, 44, 46, 52, 67, 71)
	Number of graduate students (67, 71, 87)
	Number of postgraduate students (39, 44, 46, 52, 94, 105, 110, 111)
	Undergraduate enrollment (33, 62, 84)
	Graduate enrollment (33, 62)
	Total number of students enrolled (24, 85, 86)
	Percentage of enrolments who attended a lyceum (25)
	Student to faculty ratio (80, 134)
	Number of licenses to award higher doctorate degrees (34)
	Number of taught course students (36, 48)
	Number of research students (36, 48)
	Number of domestic students (98)
	Number of licenses to award PhD degrees (34)
	Number of international members (98)
	Number of regular students (57, 102)
	Number of active registered students (40)
	Number of admitted postgraduate students (49)
	Entering students (142)
	Full-time equivalent enrollment (131)
	Number of admitted undergraduate students (49)
	The total number of first degree and other undergraduates (105, 110, 111)
	Number of first year enrolled students (57)
	Number of students including regular students (57)
	Number of PhD students (60)
	Full-time students (90)
Number of nonacademic staff	Nonacademic staff (9, 14, 15, 18, 19, 24, 27, 29, 32, 35, 37-40, 42-44, 46, 49, 51, 54, 58)
	Number of other employees (34, 61)
	Full-time equivalents other staff (67)
	Academic support staff (19)
	Full-time equivalent personnel (20)
	Administrative staff (21, 30, 56, 72, 79, 115)
	Technical administrative staff (88, 92)
	Ratio between total number of administrative and technical support personnel and full-time students (90)
	Administrative personnel (145)
	Number of workers (5)
	Support staff (83)
	Nonacademic personnel (130)
	Full-time equivalent nonacademic staff (66)
	Number of nonacademic teaching staff (59) other personnel (104)
	Maintenance and operational personnel (19)
	Management, quality control, and administration staff (19)
Space	Space (14, 121)
	Floor area (15, 45, 50, 99, 103)
	Faculty Area (61)
	Area of classroom (68, 70)
	Area of laboratory (68, 70, 145, 146)
	Land (122)
	Buildings and civil engineering structures (122)
	Number of available places (22)
	Ratio between total space in square meters and full-time students (90)
	Outdoor-indoor area (30)
	Squared feet of construction (74)
	Library collection size (99)
	Area of the buildings (94)
	Room space (41)
	Square feet of facilities (112)
	Number of places (57)
	Work placements(147)
	Usable departmental space (106)
Equipment	Number of available seats (16, 23)
	Total assets (21, 79)
	Property, plant, and equipment (78)
	Costs of equipment (133)
	Value of noncurrent assets (37)
	Library books (45, 94)
	Expenditure on library and computing services (52)
	Equipment (121)
	Equipment expenditure (125)
	Number of seats in lecture halls and in computer laboratories (84)
	Total number of computers per enrolled students (114)
	Capital equipment (115)
	Equipment and facilities cost (127)
	Number of books (106)

the articles; also, physical amenities, with titles as assets, equipment, physical capital, physical resources and etc., were used as an input in 12% of the articles.

Another input related to analyzing efficiency of universities used in 10% of the articles by the researchers was students' entrance score with titles such as average exam

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Table 1. Ctd

Title of inputs	Title of inputs used in articles
Students score prior to university	Average scores of the entrance exam (15) Weighted universal admission test score (62) Weighted admission high school score (62) Students' education prior to university (148) High school grades (149) Percentage of students with a high score in secondary school (25) First year students' average examination results (77) Admission rating (128) Percentage of students in top quartile of class (128) SAT average or midpoint scores (93) Minimum entrance score (80) Quality of university entrants (143) Mean A-level entry score in the last 3 years (52) Number of first-year enrolled students with a score higher than 0.9 in secondary school (57) Average GMAT score (95) Students' academic results prior to university (150)

Table 2. List of the most outputs used in the literature to determine efficiency of universities

Title of outputs	Title of outputs used in articles
Number of graduates	Number of graduates (5, 11, 13, 14, 17, 18, 21-24, 26, 27, 29, 30, 36, 38, 40, 43, 51, 54, 56-58, 60, 61, 63, 65, 72, 75, 76, 79, 82, 83, 85-87, 92, 98, 102, 107, 109, 115, 117, 122, 124, 126, 136, 142, 144) Number of students graduating (64) Graduate enrollments (119) Number of doctoral graduates (18) Number of graduates of master's and doctoral degrees (76) Number of graduates who received the board degree(76) Graduation rate (36, 48, 90, 93) Number of bachelor/master/PhD graduates (28, 55) Graduates per year (78) Number of master's and doctoral graduates (74) Total graduate students (97) Total PhD degrees awarded (26, 97) Number of graduates from research (36) Number of postgraduate degrees awarded (39, 44) Undergraduate completions (46) Postgraduate completions (46) Number of graduated PhD students (101) Number of undergraduate degrees awarded (39, 44) PhD completions (46) Number of graduates from taught courses (48) Number of graduating undergraduate/ postgraduate diploma/ master's/ doctorate students (49) Number of higher degrees awarded (52) Number of first degree and other undergraduate degrees awarded (71, 110, 111) Total number of graduates within institutional time (84) Number of graduate students per academic year (113) Number of graduated students (101) Number of students graduated by the end of the legal period established to complete the degrees (57) Last year graduates (59) Number of master's students graduated (101) Graduate enrolment in master's level program/ doctoral stream program (7, 132) Total number of first degrees awarded weighted by degree classification (105) Number of higher degrees + total other postgraduate qualifications awarded (111) Number of successful leavers (52) Number of postgraduate degrees conferred (37) Undergraduate and postgraduate qualifications awarded (33) % of regular graduated students (82) Number of undergraduate degrees conferred (37)
Publications	Number of publications (13, 17, 20, 24, 26, 30, 36, 41, 45, 46, 48, 50, 51, 54, 62-65, 75, 77, 91, 94, 100, 106, 109, 113, 119, 127, 130, 141, 144-146) Articles in indexed journals (10) Indexed journals (10, 74) Scopus papers (11) Research publications (12, 16, 66, 73) Number of publications in national and international journals (18) Papers (5, 47, 68, 70) Journal papers (41, 69) Conference papers (69) Total weighted publications (118, 120) Number of written or translated books (76) Numbers of published papers (32, 72, 74, 76) Publication points of nationally visible publications (81) Total number of ISI publications (88) Number of citations (29, 109, 127) Number of scientific articles (29) Journal publications (79) Number of indexed publications per academic staff (31, 94) High quality publications (32)

score, minimum entrance score, mean entry score, etc.

The followings were also observed to be used as inputs: diversity of teaching materials (148), socioeconomic level of students (148), quality of teaching materials (148),

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Table 2. Ctd

Title of outputs	Title of outputs used in articles
Publications	Number of internationally visible publications (81)
	High quality publications (32)
	International articles (91)
	Domestic articles (91)
	Research index (35)
	Number of journal (136)
	Number of printed books (136)
	Internal printed papers (136)
	External printed papers (136)
	Refereed articles (137)
	Nonrefereed articles (137)
	Refereed articles in Dutch journals (137)
	Nonrefereed articles in Dutch journals (137)
	Number of books (5)
	Impact of research (138)
	Number of articles published in international journals (140)
	Monographs (41)
	Scientific production index (42)
	H-index (146)
	Citation index (45, 146)
	Chapters in books and proceedings(137)
	Score of scientific and publishing activity (143)
	Total value of publication points (53)
	Number of presented papers at international venues (87)
	Virtual impact (73)
	Compilations of educational group (151)
	Number of journals and books published (56)
Income	Research income (14, 15, 40, 42)
	Income (44, 64, 65)
	Doctor/master/bachelor degree Granting (68, 70)
	Income from sales (122)
	Gants (5, 62, 71, 91, 126, 132)
	Income generation excluding government grants (21)
	Fees income (21)
	Amount of expended third party funds (81)
	Total external research funding (24)
	Research grants (27, 31, 51, 79, 92, 101, 105, 144)
	Total revenue (78, 124, 145)
	Public service expenditures (71)
	Quantity of financial support (98)
	Funds (102)
	External research grants and contracts (102)
	Contract research funds (5)
	Profit from business (5)
	Total income from students (139)
	National scientific and educational collaboration expenditures (140)
	Income from research and consultancy (39)
	Total budget for accepted projects (141)
	Number of formative credits (102)
	Loan quantity (129)
	Loan price (129)
	External grants (103, 123)
	Financial funds (41)
	Number of degrees granted at 5 levels (131)
	Total nonadministrative staff costs (139)
	Revenues from national and regional research grants/ international research grants/ orders (146)
	Ratio of nonbudget income to number of students paid (143)
	National competitive grants (12, 46)
	Industry grants (12, 46, 66)
	Grants from science and technology activities (50)
	Number of supported projects (109)
	Income received in funding council grants and research grants and contracts (110-112)
	Revenue from state government (112)
	Total internal and external grants (87)
	Number of research funded (56)
	Public sector grants (12)
	Total sponsored research expenditure (7)
	Average salary and benefits (132)
	Total expenditure (132)
	External grants for research weighted by quality measure (123)
	Project funding (106)
	Number of active grants as a percentage of eligible faculty (7)

number of research centers (76), human resources (24, 145-147), ranking of the university in the previous year (91), average students' qualifications (36), discipline level (99), richness of course contents (152), diversity of accessed multiple teaching channels (152), average students and staffs qualification (48), student contact hour (112), teaching experience of members (147, 151), number of study programs (56), number of collages (59), number of electives (95), provision of work placement (147), and personnel characteristics (150).

Furthermore, in some articles, input factors were expressed as ratios: the ratio between full-time academic staffs, expenditures, number of nonacademic staffs, and total space to full-time students (90); student to faculty

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Table 2. Ctd

Title of outputs	Title of outputs used in articles
Number of students	Number of undergraduate students (5, 10, 15, 16, 31, 47, 65, 79, 83, 109, 115, 119, 125, 141) Number of postgraduate students (10, 15, 31, 47, 105, 125) Total number of inactive students (25) Number of students enrolled (14, 35, 59, 78, 88, 124) Number of students (26, 45, 75, 77, 112, 121-123, 126, 133) Number of full-time equivalent students (37, 38, 73, 104, 120) Number of dropout enrolments at the end of the first year (25) Regular students (126) Students with internships (128) Number of bachelor/master/PhD students (28) Number of inactive enrolments (25) Percentage of students studying abroad/ international students/ students with university scholarships/ students with government ministry scholarships (34) Number of postgraduate and undergraduate degrees enrolled (7, 37) Number of degree-seeking international students/ exchange students/ collaborations (140) Average enrolment per class (83) Number of master's and doctoral students (12, 141) Weighted number of full-time students and full-time PhD students (34) Domestic students (45) Foreign students (45) Number of undergraduate completions(66) Number of postgraduate students per academic year (113) Number of students per 10 000 population (135) Number of enrolled full-time students per number of school-leavers who passed the state university entrance exam (135) Number of new students (59) Number of doctorate students per academic year (113) Undergraduate enrolments (9) Postgraduate enrolments (9) Undergraduate enrolment in the sciences or other programs (132) Number of students (127) Number of teaching or research postgraduates (127) Number of PhD students (123) Students enrolled in scientific courses/nonscientific courses (123) Student load (118) Science/ nonscience/ research higher degree/ nonresearch higher degree student load (118) Undergraduate enrolment in the sciences (7)
Students' score	Number of students with exam results in the top quintile (10) Academic results of students (148) Number of top-rank students in the board exam (76) Mean scores of practical board exams and theoretical board exams (76) Degree marks at the end of the first year (149) Average graduates' results (36, 48, 150) Difference between last-year and first-year scores (114) Students grade point averages (151) Students exam score (116) Success rate of undergraduate students (96)

Table 3. Number of most inputs and outputs used in the literature to determine efficiency of universities

Subject	Input/output	Number of articles included
Number of academic staff	Input	113
Budget and costs	Input	107
Number of students	Input	50
Number of nonacademic staff	Input	42
Space	Input	23
Equipment	Input	17
Students score prior to university	Input	14
Number of graduates	Output	75
Publications	Output	69
Income	Output	55
Number of students	Output	50
Students' score	Output	11

ratio (80, 134); educational and general expenditures per student (93); total funding per student (97); academic staffs and total expenditures per student (97); number of professors and computers per enrolled student (114); budget per student (116); faculty to student ratio (95); and average total spending per student (96).

In the section of output variable selection for analyzing efficiency of universities, in 52% of the articles, the number of graduates, and in 48% of the studies, publication, with titles of number of publication, number of articles, number of research papers, citation index and etc., were considered as outputs.

Income, with titles of income, grants, funds, revenue etc., in 38% of all articles, number of students in 35% of the articles, and student's score, with titles such as academic results, the mean score of exam etc., in 8% of the articles were used as one of the outputs.

Some titles, including completion rate (15), volume of contracts (27, 61), patents (41, 56, 68, 70, 98), number of projects (41, 69, 76, 136), students' level of satisfaction (24, 95, 121, 148), number of dissertations (41, 81, 96, 137), students who found jobs (36, 45, 99, 128, 134), papers presented in national and international conferences (76), retention and progress rate (35, 90), number of certificates (71), international collaborations (32, 98, 140), rank of university (32, 80), median starting salaries (45,

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99, 134), freshman retention rate (93), employer preference for hiring alumni (34), number of awards (36), percentage of international students (34, 45, 140), number of intellectual awards (36, 48, 64), number of seminars (136), technology transfer (139), average number of classes taught per department (83), students learning performance (152), number of accredited educational, national program (108), number of infringement and turning over to the committee of peculiar cases (121), employer satisfaction with training of the student (112), employer satisfaction with graduate ability (95, 106), competencies (147), and achievements of students in competitions (106) were outputs used to assess efficiency of universities.

In addition, in some articles, outputs were expressed as ratios, including number of indexed publications per academic staffs (31, 94), average enrolment per class (83), ratio of income to the number of students who paid for education (143), number of graduate/ postgraduate/ doctorate students per academic year (113), and the number of students per number of school leavers (135).

Conclusion

In the reviewed articles, the number of academic staffs, costs, and number of students were the most important inputs; also, number of graduates, publications, and income were the most important outputs used to determine the efficiency of universities via DEA method. Moreover, we suggest the use of these inputs and outputs to evaluate medical universities and the efficiency of their faculties in future studies.

In this study, most of the universities included the faculties of medical sciences. Therefore, these data can also be used to measure the efficiency of universities of medical sciences using DEA method.

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Conflict of Interests

The authors declare that they have no competing interests.

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