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by Nokky Farra Fazria

Submission date: 02-Aug-2022 03:05PM (UTC+0800)
Submission ID: 1878016415
File name: Bukti_C.13.pdf (351.5K)
Word count: 7745
Character count: 41338

Unnes Journal of Public Health 10 (1) (2021)

Unnes Journal of Public Health

http://journal.unnes.ac.id/sju/index.php/ujph

A Literature review on the Identification of Variables for Measuring Hospital Efficiency in the Data Envelopment Analysis (DEA)

Nokky Farra Fazria[1] ✉, Inge Dhamayanti[2,3]

[1]Departement of Health Administration and Policy, Faculty of Public Health, Universitas Airlangga
[2]Center for Patient Safety Research, Universitas Airlangga
[3]School of Psychology and Public Health, La Trobe University

Article Info

Article History:
Submitted April 2020
Accepted August 2020
Published January 2021

Keywords:
Efficiency, Data Envelopment Analysis (DEA), Health, Hospitals

DOI
https://doi.org/10.15294/ujph.v0i0.34141

Abstract

The selection of input and output variables usually pose a problem when carrying out efficiency assessment in hospitals. Data Envelopment Analysis (DEA) is an instrument that is used to calculate the efficiency of a hospital using some inputs and outputs. Therefore, this study aims to identify the most frequently used hospital inputs and outputs from an existing paper,, in order to assist the hospital management staffs in choosing the relevant variables that can represent available inputs, are easily accessible, and need improvement. It was conducted using keywords such as "hospital efficiency" and "DEA for hospital" to search for peer-reviewed journals in the PubMed and Open Knowledge Maps from the year 2014-2020. From, the 586 articles, 54 samples were obtained from the about 5-3504 hospitals which were analyzed from 23 countries. The results showed that, the five most used inputs were the number of beds, medical personnel, non-medical staff, medical technician staff and operational costs, while the most used outputs were number of inpatients, surgeries, emergency visits, outpatient service, and days of inpatients. These variables are often used for accessing the efficiency of hospitals in the DEA application.

INTRODUCTION

Resources of hospital are demanded to fulfil what patient wants. But in the reality, there are many hospital have not the same resources of each other so that makes inefficient resources of each hospital (Abdurachman et al., 2019). Efficiecy assesment in hospital are rarely conducted like the other sector because of resources setting and limited control of outputs (Shettian, 2017). Beside that, raising efficiency are needed especially for health care in a low or medium human development index countries. One of health care efficiency assessment problem is on methodological step (Vivekanantham et al., 2014). Efficiency is a condition when existing resources could make an usefull result. Hospital efficiency is about a hospital capacity to make a qualified result such as a well treated patient and have recovered discharged patient by using resources such as medical staff, non-medical staff, and finance. While unefficiency is a sign of low quality services which could affect a late treatment even an addition therapy (OECD, 2019). There are two type of efficiency, the first one is technical efficiency by combining or reducing input at certain level and economic efficiency by setting hospital finance (Samudro & Pratama, 2018).

✉ Correspondence Address:
Kampus C Universitas Airlangga, Surabaya, Indonesia
E-mail: nokky.farra.fazria-2016@fkm.unair.ac.id

Open Access
pISSN 2252-6781
eISSN 2548-7604

There is a most used efficiency assessment method called Data Envelopment Analysis (DEA). A. Charnes, W. W. Cooper and Rhodes are the first who introduced DEA to public (1978)

(Samudro & Pratama, 2018). DEA can be used in DEAP 2.1 (Tim Coelli Inc.) and to knowing its interpretation can be used SPSS (SPSS Inc., USA) and Frontier Analyst fourth version (Banxia Software Ltd, UK). There are some important term form DEA (Soares et al., 2017): Decision-Making Unit (DMU) is a main unit which efficiency is analyzed. In the case of hospital efficiency assessment, the DMU is hospital; Input is an available resources in the DMU; Output is an impact or result of the process of running the DMU; The efficiency score is a calculated value as a result of an efficiency assessment. The value often on a scale of 0 to 1, with means 0 is the minimum and 1 is the maximum value of efficiency.

The proper use of DEA can be used as a reference for considering DMU resources, as long as the used data could represent the DMU process and could be compared with othe DMU (Kang & Kaipornsak, 2014). Lack of information about relevant factors from variables makes it difficult to calculate hospital efficiency, therefore it is important to consider the selection of appropriate and effective inputs and outputs (Hsiao et al., 2018) and even become a source of hospital evaluation (Omrani et al., 2018) . This study aims to identify the most used input and ouput in calculating hospital efficiency using DEA. This study purposes to guide hospital management staff to find the relevant hospital input and output so that the efficiency assessment will be easier, right on target representing the available resources and it can be seen which part which need more attention to evaluate the hospital. This study also describe the form of each variable that can be generated in DEA.

METHOD

This study conducted a literature review method of several articles with inclusion criteria of search keywords such as “hospital efficiency” and “DEA for hospitals”. Selected articles are published articles from peer-reviewed journals from the literature database PubMed and Open Knowledge Maps. The articles that appear are being reviewed from the title which states the elements of the keywords, the language used is English, the year the article was published around 2014-2020, the purpose of the article is to calculate hospital efficiency, the calculation method using DEA application and mentioning the use of input and output for calculation. The exclusion criteria for articles to be analyzed were articles obtained other than the specified keywords and articles that calculated the efficiency of the part of hospital unit. The articles reviewed were not limited to the type of hospital, city or country of origin, the combination of the DEA model used, and the type of efficiency that was calculated. After the relevant articles selected, the variables were collected and calculated by the stake method to see their frequency of used. The results of the literature review will be presented in a table that contains the name of the author of the article, the number of DMU used in the calculation, and the input and output mentioned. The five most used input and five output variables from the relevant article will be discussed further in the results and discussion section.

RESULT AND DISCUSSION

From the search results through the literature database based on keywords and year, the total number of searches was 586 articles. The articles are then reviewed according to the appropriate title and language getting 69 articles. Furthermore, the articles were examined according to their objectives, the method used, the DMU used and the input and output variables mentioned so that there were 51 articles which most relevant to be analyzed in this study. Of the 54 relevant articles, it was found that the number of DMUs was calculated starting from the smallest number DMUs was 5 to the largest number was 3,504 DMUs. The DMUs that are calculated by the DEA in the relevant article come from various types of hospitals such as public hospitals, private hospitals, university hospitals, regional hospitals, veteran hospitals, institutions, and ministry-bound hospitals. The relevant article calculates the DMU of many countries such as Germany, China, Iran, Canada, Brazil, United States, Turkey, Uganda, Bohemia, Greece, Italy, Ethiopia, Taiwan, Norway, Spain, Bangladesh, Poland, Japan, Portugal, South Korea, Saudi Arabia, Malaysia, and Palestine. Technical efficiency, economic efficiency, scale efficiency, managerial efficiency and operational efficiency are the aims in calculating the DEA of the relevant articles. The additional approaches or combinations of DEA calculations used in relevant articles are vary such as the use of Tobit regression, the Malmquist index, integrated K-means clustering, dynamic network DEA, bootstrap DEA, fuzzy DEA, slack-based DEA, window-based, two-level DEA, and the four-tier DEA. Several variables from the results of the review on the application of DEA in hospitals are more clearly shown in Table 1

From Table 1, there are many terms included in the input and output variables. The terms and how many times it has been used shown in Table 2.

Table 1. Literature Review of Hospital Variables in Data Envelopment Analysis (DEA) Application

No	Author(s)	DMU	Variable	
			Input	Output
1	(Büchner et al., 2014)	833 hospitals in German	Full-time equivalent workers Medical supplying cost Other operational supplying cost Staff service price Number of beds	Weighted inpatient cases by length of stay
2	(Chowdhury et al., 2014)	113 acute hospital Ontario, Canada	Staff hours Nursing hours Number of Staffed beds Medical surgical supply cost Non-medical surgical supply cost Total equipment expense	Number of outpatient visits Total number of inpatient days Case-mix adjusted weighted inpatient days Case-mix
3	(Kang & Kaipornsak, 2014)	128 public hospital dan 69 traditional medicine in Inner Mongolia Region, China	Number of beds Number of physicians Number of nurses Area of hospital	Outpatient visits Average of bed days Emergency visits Surgery on inpatients
4	(Cheng et al., 2015)	114 township hospitals in Province of Henan, China	Number of physicians Number of nurses Number of beds	Outpatient and emergency visits Days of inpatient
5	(Gholami et al., 2015)	187 hospitals in United States	Administrative and general direct expenses and salaries Salaries wages and fees payable Total number of full-time employees Sum of total current and total long-term assets Total number of beds	Net patient revenue Total inpatient revenue Total number of admissions Total number of patient days
6	(Li & Dong, 2015)	14 third-grade public general hospitals in Tianjin, China	Number of beds Number of staff	Number of diagnostic visits Number of discharged inpatients
7	(Narcı et al., 2015)	1.103 hospitals di Turki	Number of beds Number of specialist physician Number of general physicians Number of nurses and another employee	Number of inpatients Days of inpatients Number of surgeries Number of outpatient and emergency visits

No	Author(s)	DMU	Variable	
			Input	Output
8	(Rezaee & Karimdadi, 2015)	288 hospitals from 31 Province in Iran	Number of staff Number of medical equipment Number of operational beds	Number of inpatients Number of outpatients Number of patients with special disease Number of operational beds in a month Bed occupancy rate
9	(Xu et al., 2015)	51 tertiary hospital in Beijing, China	Medical personnel Equipment Construction Finance	Economic output Bed occupancy services
10	(Cheng et al., 2016)	48 township hospitals from Xiaogan, Province of Hubei, China	Number of medical personnel Number of medical technicians Number of non-medical staff Number of beds	Number of outpatients and emergency visits Number of inpatients Number of electronic medical record Number of patients with chronic disease
11	(Jiang et al., 2016)	7 pilot group hospitals dan 7 non-pilot group hospitals di Guangxi, China	Number of beds Number of medical staff Hospital expenditure Fixed asset	Person-time outpatient Discharged patients Revenue from health services
12	(Kalhor et al., 2016)Q	25 university hospitals, 19 private hospitals, 10 social security hospitals Tehran, Iran	Number of full-time doctors Number of full-time nurses Number of other medical personnel Number of beds	Days of inpatients Number of outpatients Number of surgeries Average Length of Stay
13	(Lobo et al., 2016)	31 federal public hospital guided by Ministry of Education Brazil	Number of beds Number of equipment Human resources (except doctor)	Outpatient visits weighted by disease seriousness
14	(Mujasi et al., 2016)	17 hospitals in Uganda	Number of beds Number of medical personnel	Days of inpatient Number of outpatients
15	(Papadaki & Stankova, 2016)	5 hospitals part of Central Bohemian Holding and 7 independent hospitals	Operational cost	Number of beds Number of inpatients Bed occupancy days

No	Author(s)	DMU	Variable	
			Input	Output
16	(Samsudin et al., 2016)	25 public hospitals in Kedah, Perlis, Pulau Pinang, Perak, Malaysia	Number of doctors Number of nurses Number of beds	Number of inpatients Number of outpatients Number of surgeries Total services
17	(Ali et al., 2017)	12 hospitals in East Ethiopia	Number of health staff Medicine supplying cost Number of beds	Outpatient visits Days of inpatient Number of surgeries
18	(Anthun et al., 2017)	Somatic hospital which provides emergency service on 1999-2014 in Norway	Operational cost	Elective inpatients and emergency services Day care services Outpatient services
19	(Campanella et al., 2017)	50 public hospitals in Italia	Number of beds Number of doctors Number of nurses	30 days death risk of acute myocardial infarct case 30 days death risk of congestive heart failure case 30 days death risk of pneumonia
20	(Flokou et al., 2017)	107 NHS hospitals in Greek	Beds Doctors Another professional employee	Inpatient cases Number of surgeries Outpatient visits
21	(Guo et al., 2017)	18 hospitals from 7 hospital clusters in Hong Kong, China	Number of Full-Time Equivalents Staff Number of beds Inpatient discharged rate	Days of inpatients Emergency visit Outpatients visit
22	(Jia & Yuan, 2017)	5 high level public hospitals in Shanghai, China	Number of beds Number of staff	Number of outpatients Number of emergency patient Number of discharged patients Average length of stay
23	(Jiang et al., 2017)	1105 hospitals from 31 province in China	Open beds Doctors Nurses Medical technician	Outpatients and emergency visits Days of inpatients
24	(Li et al., 2017)	12 hospitals in Province of Anhui, China	Number of beds Number of nurses Number of beds Total expenditure	Number of emergency visits Inpatient discharged Number of inpatients

No	Author(s)	DMU	Variable	
			Input	Output
25	(Soares et al., 2017)	18 federal hospitals and 3 government hospitals in Brazil	Number of medical and non-medical personnel Yearly revenue Number of beds Average length of stay	Number of outpatient visits Number of inpatients Number of surgeries Number of examinations
26	(Wang et al., 2017)	127 region general hospitals East China, Middle China, and West China	Number of employee (doctors, nurses, technician) Number of active beds	Number of outpatients and emergency visits Days of inpatients
27	(Giancotti et al., 2018)	41 public hospitals in Italia	Number of beds Number of staff	Number of discharged inpatients Days of inpatients Average length of stay
28	(Hsiao et al., 2018)	182 hospitals in Taiwan	Number of beds Human resources Number of physicians Number of nurses Number of other medical personnel	Number of inpatients Number of outpatients Number of emergency visits Inpatients revenue Outpatients revenue
29	(Kiani et al., 2018)	8 hospitals affiliated University of Medical Science Boshehr, Iran	Number of doctors Number of beds Number of nurses	Occupancy rate Number of surgeries Number of discharged patients Admission per bed
30	(Kocisova et al., 2018)	Hospitals from 16 province in Poland	Average length of stay Average costs of care	Average number of patients Share of accredited hospitals Net profit per doctors
31	(Leleu et al., 2018)	1847 hospitals in United States	Case-mix Index Staff Beds	Volume of surgeries Volume of visits 30 days of re-admission rate 30 days of death rate
32	(Miguel et al., 2019)	All general hospital of Health Service Madrid (SERMAS) Spain	Number of doctors Number of beds Goods and services expenditure	Number of discharges Number of outpatient consultations Number of emergency consultations Number of non-admission surgeries

No	Author(s)	DMU	Variable	
			Input	Output
33	(Pirani et al., 2018)	17 general hospital affiliated by University of Medical Science Ahvaz, Iran	Number of admissions Number of nurses Number of available beds	Average length of stay Bed turn-over interval
34	(Omrani et al., 2018)	288 hospitals of 31 province in Iran	Number of employees Number of surgeries equipment Number of active beds	Number of inpatients Number of outpatients Number of specific patients Bed occupancy per day
35	(Şahin & İlgün, 2018)	865 hospitals guided by Ministry of Health in 81 provinces in Turkey	Number of beds Number of physicians Number of nurses and midwives Number of other medical personnel	Number of policlinic admission Number of inpatients Number of surgeries Crude death rate
36	(Sultan & Crispim, 2018)	11 general hospital from West Bank in 2010 to 2015 with 66 examination targets in Palestine	Number of beds Number of doctors Number of administrations staff Number of medicine and technology	Days of inpatients Outpatients visit Emergency visit
37	(Zhang et al., 2018)	213 hospital in Japan with adjusted criteria	Number of doctors Number of nurses Number of other staff Number of beds Region areas	Number of outpatients per day Average of admission Discharges per year Number of emergency beds
38	(Zheng et al., 2018)	84 general hospital in Chongqing, China	Number of staff Government financial subsidiary Number of beds Fixed assets	Number of outpatients and emergency visits Number of discharged patients Health and medical services revenue Bed occupancy rate
39	(Ahmed et al., 2019)	62 district hospitals in Bangladesh	Number of beds Number of doctors Number of nurses	Number of mothers who received 4 ANC services Number of normal services Number of Caesar services Number of mothers who received PNC service Number of outpatient services Number of inpatients

No	Author(s)	DMU	Variable	
			Input	Output
40	(Cinaroglu, 2019)	688 general hospitals in Turkey	Number of staff beds Number of full-time doctors Number of full-time nurses and midwives	Number of admissions Number of inpatients Number of surgeries
41	(Ferreira & Nunes, 2019)	27 centred hospital in Portugal	Services cost Number of beds Number of full-time medical personnel	Number of inpatients Number of examination appointment Number of emergency visit Number of surgeries
42	(Fuentes et al., 2019)	9 general acute hospital from Health Services Murcia, Spain	Number of beds Number of surgery room Personnel cost Operational cost	Average length of stay Turn-over rate Case-mix considered discharged Number of emergency visits Number of surgeries
43	(Küçük et al., 2019)	669 of Health Ministry Hospital in Turki	Number of doctors Number of beds Number of CT Scanners and MRI units Total expenditures	Number of outpatients Total inpatients Number of emergency department visit Number of outpatients visit per physician Number of surgeries Total revenue
44	(Li et al., 2019)	Chinese township hospital of 29 provincial areas in China	Number of medical personnel Number of medical beds Number of township hospital	Number of outpatient visit Number of inpatients Medical bed utilization rate
45	(Lin et al., 2019)	15 veteran hospitals in Taiwan	Number of physicians Number of patient beds Number of other medical personnel Number of nurses Equipment Floor area	Number of patient days Number of patients receiving surgery Net inpatient survivors
46	(Liu et al., 2019)	72 hospitals in Chingqing, China	Physical area of hospital Actual number of open beds Total fixed assets Number of healthcare technicians	Total income Number of hospital bed rotations Number outpatient and emergency visits Number of discharged patients

No	Author(s)	DMU	Variable	
			Input	Output
47	(Park et al., 2019)	1185 hospitals in Korea Selatan	Number of doctors Number of nurses Number of beds	Number of hospitalized patients Number of operations Medical revenues
48	(Saquetto & Araujo, 2019)	98 hospitals of National Association of Private Hospitals (ANAHP) Brazil	Operational hospital beds Registered physician Number of active employees	Number of consultations in the emergency room Number of hospitalizations Number of surgeries
49	(Alatawi et al., 2020)	91 public hospitals in Arab Saudi	Number of beds Number of doctors Number of nurses Number of allied health personnel	Outpatients visit Discharged patients Number of surgical operations Number of radiological investigations Number of laboratory tests Hospital mortality rate
50	(Botega et al., 2020)	3504 general hospitals in Brazil	Human resources (doctors, nurses, nursing assistants, and technicians) Infrastructure (number of beds, number medical equipment)	Number of hospitalizations according to five groups of ICD-10 and two age groups.
51	(Jing et al., 2020)	154-232 hospitals from "Beijing's Health and Family Planning Statistical Yearbooks" in Beijing, China	Number of beds Number of health technicians	Outpatients and emergency visit Inpatient discharges Revenue

In Table 2, it shown that five most used input to assess hospital efficiency in DEA application are the number of beds, the number of medical personnel, the number of non-medical staff, operational cost, and the number of medical technicians.

(1). The Number of Beds

The number of beds which can be included for hospital efficiency assessment were suitable and available to use. The number of beds often considered as the capital of the hospital (Omrani et al., 2018). The number of beds in this case are chronic care beds and special care beds (Soares et al., 2017). An effective bed allocation planning, such as considering the number of beds by the size of the hospital could have an impact on calculating efficiency and have a role for hospital management (Kakeman et al., 2016) restriction on access and optimum use of resources is the main challenge of development in all organizations. Therefore, the aim of this study was to determine the technical efficiency and its factors, influencing hospitals of Tehran. Methods: This research was a descriptive-analytical and retrospective study conducted in 2014-2015. Fifty two hospitals with public, private, and social security ownership type were selected for this study. The required data was collected by a researcher-made check list in 3 sections of background data, inputs and outputs. The data was analyzed by DEAP 1.0.2, and STATA-13 technique. Results: Seventeen (31/48.

(2). The Number of Medical Personnel

Human resources have the most important role in the health service system. The number of doc-

Table 2. Details of The Amount of Use of Input and Output Variables to Calculate Hospital Efficiency in Data Envelopment Analysis (DEA) Application

No.	Input	Amount of used	Output	Amount of used
1	Number of beds	41	Number of inpatients	31
2	Number of medical personnel (doctor, nurse, dentist, midwife)	39	Number of outpatient services	23
3	Number of non-medical staff	15	Number of surgeries	17
4	Operational cost	16	Days of inpatient	12
5	Number of medical technician personnel	9	Number of emergency visit	10
6	Area of hospital	4	Number of outpatient and emergency services	8
7	Number of fixed assets	4	Hospital revenue	7
8	Number of medical equipment	4	Utilization of beds	4
9	Number of equipment / technologies	4	Number of patients with specific treatment	3
10	Finance	2	Services	3
11	Number of staff beds	2	Number of beds	2
12	Average Length of Stay	2	Income of inpatient	2
13	Staff working time	1	Crude Death Rate (CDR)	2
14	Construction	1	Net income of patient	1
15	Income per year	1	Case mix	1

tors who are counted are doctors who work full time including dentists and Chinese medicine doctors. The other medical personnel who are counted are nurses who work in hospital and nurses who work in patient home (Soares et al., 2017) also midwives (Şahin & İlgün, 2018)for the pre-PHAs period, 24 provinces in 2010, 27 provinces from 2010 to 2011, and 32 provinces from 2011 to 2012 were assessed as efficient. From 2012, the year of implementation, to 2013, the number of efficient provinces dropped to 16. However, 20 provinces were subsequently found to be efficient from 2013 to 2014, and 26 from 2014 to 2015. The efficiency scores average of all provinces were found to be 0.89, 0.92, 0.92, 0.82, 0.88, and 0.90, respectively. Further, the efficiency score average of the 3 years before PHAs (0.91 ± 0.09.

(3). The Number of Non-medical Staff

Non-medical personnel in this case were a staff who did not perform medical treatment on patients in their work. The number of non-medical personnel included in the calculation are the number of full-time staff or equivalent, social workers, researchers, non-professional workers (Soares et al., 2017), full-time management staff (Hsiao et al, 2018), and logistics staff (Xu et al., 2015).

(4). Operational Cost

Total hospital expenditure counted as a part of the hospital's economic investment (Li et al., 2017). The expenses referred to the total of costs spent on purchasing goods and services to support hospital services (Miguel et al., 2019)as compared with traditional management. Specifically, we compare traditionally managed public hospitals, public hospitals managed by a private finance initiative (PFI. The expenditure of goods and services commonly referred as hospital operational costs (Fuentes et al., 2019). Operational costs often included in the productivity analysis which can show good comparisons in terms of units and time (Anthun et al., 2017)1999–2014. This period was characterized by a large ownership reform with subsequent hospital reorganizations and mergers. We describe how technological change,

technical productivity, scale efficiency and the estimated optimal size of hospitals have evolved during this period. Material and methods Hospital admissions were grouped into diagnosis-related groups using a fixed-grouper logic. Four composite outputs were defined and inputs were measured as operating costs. Productivity and efficiency were estimated with bootstrapped data envelopment analyses. Results Mean productivity increased by 24.6% points from 1999 to 2014, an average annual change of 1.5%. There was a substantial growth in productivity and hospital size following the ownership reform. After the reform (2003–2014. Expenses incurred by hospitals are usually in the term of cost allocations for medical services (such as payroll, capital, and equipment depreciation costs) as well as non-medical supplies (Büchner et al., 2014). In a study in China, large hospital expenditures affected by policy reforms did not lead to raised hospital operational efficiency (Jiang et al., 2016). Hospital operational costs used in calculating efficiency can be in several units of currency per year.

(5). The Number of Medical Technicians

Medical technician personnel referred to medical personnel other than doctors, nurses, and not including hospital administrative staff (Lin et al., 2019). Medical technician including clinical social workers, psychologists, hearing and speech therapists, and respiratory therapists (Hsiao et al., 2018); pharmacists, pharmacist assistants, dietitians, physiotherapists, occupational therapists, and radiology technicians (Kalhor et al., 2016; Soares et al., 2017); clinical laboratory technicians and medical imaging technicians (Cheng et al., 2016).

Beside of inputs, there were five most used outputs to assess hospital efficiency in DEA application are the number of inpatients, the number of outpatient services, the number of surgeries, days of inpatient, and the number of emergency visit.

(1). The Number of Inpatients

Inpatient is a patient who are treated and need more treatment which requires a day or night of stay or more in the hospital (Bateman et al., 2007). Inpatient could come from referrals from other health facilities and or referrals from other unit within a hospital. In terms of efficiency, the number of inpatients is usually expressed by the number of patients per year.

Many articles use the term "discharged patient" to represent the number of inpatients (Li & Dong, 2015; Narcı et al., 2015; Jiang et al., 2016; Jia & Yuan, 2017; Li et al., 2017; Giancotti et al., 2018; Kiani et al., 2018; Zhang et al., 2018; Zheng et al., 2018; Fuentes et al., 2019; Miguel et al., 2019; Liu et al., 2019; Jing et al., 2020). From patients who have been discharged, it can shows how was the capacity of services that have been used (Li et al., 2017). Patients who are discharged consist of various results of treatment, such as recovered (Lin et al., 2019) or have died (Narcı et al., 2015).

(2). The Number of Outpatient Services

Outpatients are patient who are hospitalized but do not require treatment that requires the patient to stay overnight (Bateman et al., 2007). Outpatients usually only receive pre-admission assessment or diagnostic procedures until consultation and can leave afterwards. In calculating efficiency, outpatients were expressed by the number of patients per poly in one year (Soares et al., 2017). As an output variable for calculating hospital efficiency, the number of outpatients often combined with the number of emergency patients (Li & Dong, 2015; Cheng et al., 2015; Narcı et al., 2015; Cheng et al., 2016; Wang et al., 2017; Zheng et al., 2018; Liu et al., 2019; Jing et al., 2020).

(2). The Number of Surgeries

The number of operations are the number of treatments for a disease of disorder by means of procedures that require some actions such as cutting, removing, or manipulating tissues, organs or parts (Bateman et al., 2007). In efficiency calculations, the number of surgeries usually expressed per year.

(3). Days of Inpatient

Days of inpatient is the cumulative length of stay of hospitalized patient or in emergency department (Lin et al., 2019); including length of stay in general care, acute care, intensive care, dan chronic care (Kalhor et al., 2016). Days of inpatient also referred as the specific duration of patient admission and utilization of clinical and non-clinical inputs such as treatment, pharmacy, paramedical support services, and administrative services (Sultan & Crispim, 2018). Realized that inpatient services have different features and consume more resources that outpatients, the use of term "days of inpatient" is considered more medically homogenous than the term "number of patients hospitalized" and can provide a more significant output (Wang et al., 2017). The use of days of inpatient widely used in the form of the Average Lentgh of Stay (ALoS) (Fuentes et al., 2019; Pirani et al., 2018; Giancotti et al., 2018; Jia & Yuan, 2017; Kalhor et al., 2016). But in other hand, the varying length of days the hospitalized can be considered a distortion of ALoS calculation because the level of use can be higher or lower within patient (Flokou et al., 2017). In the calculation of efficiency, days of inpatient can be expressed by the number of days the patient was treated per year.

(4). The Number of Emergency Visit

The number of emergency visit is the number of the arrival of patients in a condition that urgently requires prompt treatment and care (Bateman et al.,

2007). In calculating efficiency, the number of visits by emergency patients is counted in one year (Soares et al., 2017)

CONCLUSION

Each of the five most used input and output variables for the calculation of hospital efficiency can be applied in the Data Envelopment Analysis (DEA). The hospital input variables that are often used in the DEA application include the number of beds, the number of medical personnel, the number of non-medical personnel staff, hospital expenses, and the number of medical technician personnel. While the hospital output variables that are often used include the number of inpatients, the number of outpatient services, the number of operations, days of inpatient and the number of emergency department visits.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15