

A Systematic Review Of Health Efficiency Measurement In Indian Hospitals Using Data Envelopment Analysis In Comparison With Global Settings

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Abstract

Aim & Objectives: The determination of this project is to produce a comprehensive prose review of works in health care on data envelopment analysis (DEA). The aim of this revision was to look at many revisions on healthcare efficacy that were conducted in India and to compare it with global studies. The study also portray where India lies when compared with World health expenditure index. The input and output variables, as well as which decision-making unit (DMU) was employed most frequently in these studies, were also determined.

Method: One of the utmost and often utilized efficiency measuring procedures in health care is the data envelopment analysis (DEA). Selecting input and output variables is precarious for analyzing the efficacy of decision-making components in DEA. This assortment is subjective since it varies from investigator to investigator. From 1991 to 2021, researchers looked at papers on the usage of DEA in health care.

Results & Conclusions: It is obvious that India's governmental healthcare systems are inefficient, while private enterprises are enlightening the efficiency of the industry. In the entire research, hospitals were utilized as decision-making units. In the bulk of the research, a range of physicians, nurses, bed and paramedical staff were employed. A large amount of IPD, OPD, and surgeries were the most common output variables. Moreover India lies far behind the global marking in case of healthcare expenditure.

Keywords: Healthcare, Data Envelopment Analysis, efficiency, review

INTRODUCTION

Health services are vital for all countries since they are one of the measures of a society's development. Healthcare breadwinners should be more cautious in delivering healthcare facilities and examine their efficiency as a result of the acceleration of globalization, advancements in technology, increased

awareness among healthcare consumers, and growing health-care prices.

Today's needs are limitless, but the resources available to address them are scarce. As a result, one of the greatest crucial aspects of challenging in a changing and evolving ecosphere is to effectively and efficiently practice existing assets. It is vital to establish if

capitals are being used proficiently, at what level they are being used resourcefully, and to compare nations or firms that function in the similar industry or generate related products/facilities. Efficacy investigation is one of the most often utilized approaches by academics for this goal. It is thinkable to determine the existing condition, weaknesses and powers, relate with comparative activities of similar monetary units, determine differences and conduct further analyses on these differences, identify priorities for decision-making, set strategies, accurate goals, and new plans for refining efficiency using efficiency measurement. This provides information that may be used as a guide for enterprises, administrations, and policymakers. The valuation of the comparative efficiency of decision-making elements that yield parallel outputs with parallel inputs is one of the fundamental difficulties in enterprise management. This is a problem that health-care institutions face as well. According to Moreno et al (1999), hospital efficiency may be improved if resources are distributed effectively by hospital administrators. Despite the various ways for measuring efficiency, the DEA method is becoming increasingly popular. DEA is a nonparametric, linear programming-based method for calculating relative proficiency of numerous comparable decision-making elements and producing alike outputs from comparable inputs. The "best" decision-making unit is chosen using this procedure, which provides the greatest output composition with the minimum input configuration. The efficient border is dogged by this "finest" decision-making element. This is referred to as a "reference," and the inefficient decision-making unit's efficiency is assessed radially in relation to it. Other decision-making units' efficiency is established by proportionately calculating their distance from this frontier. As a result, the DEA only evaluates all decision-making element to the "best." Each decision-making unit is analyzed individually in the DEA, and their efficiency is judged by whether they are above or below the efficient frontier.

The most essential difficulty for researchers doing DEA applications is determining inputs

and outputs. In light of this, the purpose of this revision was to discover which of the decision-making element, as well as which among the input and output variables, are usually engaged in the evaluation of health efficiency. As a result, this research will assist scholars and teachers in evaluating the proficiency of health care utilizing DEA in rappers of input and output factors, which is the most critical stage of DEA solicitations.

Data Envelopment Analysis in Health Care Sector

In the health industry, data envelopment investigation is an approach that is commonly selected and broadly employed. While some studies involving DEA in the health care sector have been circulated as research papers, others have been developed as systematic review papers. "Researcher's looked at seventy-nine research from 1984 to 2004 that looked at the efficiency of hospitals using DEA in twelve different countries. The input and outcome variables are categorized in the research, and extensive information about them is provided" (O'Neill et al. 2008). "Researcher's gathered research that used DEA to measure the efficiency of primary health care organizations. A total of 39 studies were examined as a consequence of specified criteria. Some characteristics are given in their study, such as the nations where the studies are done, the types and quantities of decision-making units, and the models. When looking at the graph showing changes in study numbers over time, it appears that the most research utilizing data envelopment analysis in primary health care services were completed between 2011 and 2014 (Pelone et al. 2015). "Investigators used data envelopment analysis to investigate over a hundred papers published in Turkey between 1997 and 2012. They discovered that DEA was mostly utilized to assess the efficiency of health and financial organizations. Because there is no specific rule for selecting inputs and outputs, it is a subjective problem. The resources must be included in selected inputs, and the activities of decision-making units must be reflected in selected outputs. The efficiency metrics will be

unhealthy if the inputs and outputs of the analysis do not accurately represent the process. On the other hand, disregarding a critical variable might affect the efficiency outcome and lead to a reduction in the efficiency scores of the decision-making unit that employs the variable efficiently. As a result, a list of all variables considered necessary and impacted by the input and output selection procedure should be retrieved. The amount of inputs and outputs, on the other hand, should be maintained to a minimum. Because of this problem, the amount of decision-making units grows as the sum of variables grows. But this situation disrupts a homogeneity problem” (Ayrçay and Zçal 2014)

When talking about the review studies conducted in India, the data tends to fall to zero. Even though the data envelopment analysis is done in India, it's not on a wider scale. All the studies are restricted to a limited frame. Thus this review help to portrait the entire studies conducted in India and will help future researchers to identify the dark areas of the data envelopment analysis studies.

Studies on health efficiency in India are undertaken on a lower scale than in other countries throughout the world. “Researchers performed a research in 30 European nations in 2014 and found that countries that altered their healthcare systems were more likely to attain better efficiency” (Kujawska, 2018). “In 2010, the researchers used data envelopment analysis to examine the healthcare efficacy of 30 European countries. The findings show that a few of industrialized and emerging nations are on the verge of becoming more efficient, whereas the vast bulk of nations in the tester are inefficient” (Asandului et al., 2014). “The goal of the study was to find the most effective

healthcare systems in a section of 17 EU countries. The most efficient healthcare systems, according to the findings, are found in Sweden, the United Kingdom, and Romania, utilizing the Data Envelopment Analysis (DEA) approach” (Dincă et al., 2020). “The objective of the revision is to determine the technological efficacy of Asian health systems. The paper's major results indicate. Around 91.3 percent (42 of 46 nations) of the Asian countries surveyed were inefficient in their use of healthcare resources. The majority of the efficient countries were high-income countries” (Ahmed et al., 2019). “The researchers looked at the usefulness of healthcare and prosperity policies in 34 Asian emerging nations. According to the findings, creating an investment environment with a unified strategy and management is a critical component in increasing the efficiency of investments in the healthcare and welfare sectors. The consistency with which the national policy approach is implemented is also critical for each country's medium- to long-term goals to be met. The study also state that the health indexed in India are lower than the average of 34 Asian Countries” (Kim et al., 2020). “The researchers used a DEA programme to compare the performance of nations in the Middle East and North Africa. The effectiveness scores have a strong association with the wealth of the nations (in terms of GNP per capita) but not with the size of the countries, according to regression analysis” (Ramanathan, 2006). “The investigators evaluated the healthcare efficiency of the United States through data envelopment analysis from the data collected from 2005 to 2012. The results revealed that the state hospitals were only 15.4% efficient” (Chen et al., 2017). The input and output used in these studies are listed below

Sl no	Inputs	Outputs
1	Health expenditure per capita	Life expectancy
2	Financial and resources	Infant mortality rate/survival rate
3	Level of infrastructure	Incidence of T.B
4	Health utilization	GIM, GOM index

5	Number of doctors, nurses, beds, special equipment's	Number of IPD, OPD, Surgeries, Emergency visits
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Table 1: Variables of DEA

Current health expenditure (% of GDP)

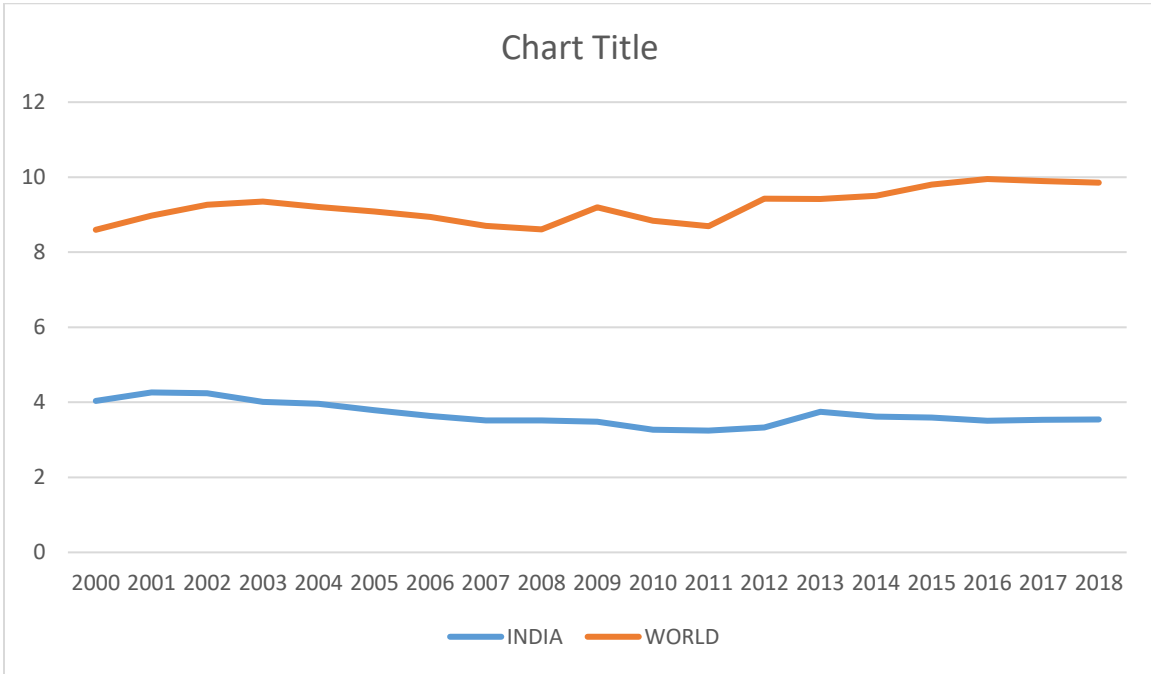


Fig1: Health Expenditure (source: World Bank)

METHODOLOGY

The output and input variables of choice is grave, particularly in the health industry. In general, finding acceptable variables, obtaining precise input and output statistics, and accessing dependable records with standard descriptions of input and output is extremely challenging for health services. As a result, the goal of this research is to find out what input, output, and decision-making elements are used in revisions, how DEA evaluates healthcare sector efficiency, and what input and output elements have been employed in recent ages. To begin, researchers looked at the health-care literature to see how DEA judged efficiency. Data envelopment investigation has been employed in extensive assortment of research in healthcare delivery system, according to a thorough evaluation of the literature. To reduce the number of research and gather the most up-to-date information, it was chosen to focus on those that spanned a thirty-year period. As a result, research involving the use of DEA in

health care were investigated between 1991 and October 2021. India followed the LPG model and liberalized its economy in 1991. That's why this 30 years have been considered for the search.

Screening process

All papers that use data envelopment analysis to estimate health care efficiency were examined in databases such as Google Scholar, Pub Med and Web of Science. Following that, certain eliminations were carried out based on the author's criteria.

The inclusion and exclusion criteria

- Using data enveloping investigation in presentations for health care sector
- Only to embrace research article, not review article
- Expending India, the attendance of health establishments functioning in India as decision-making elements

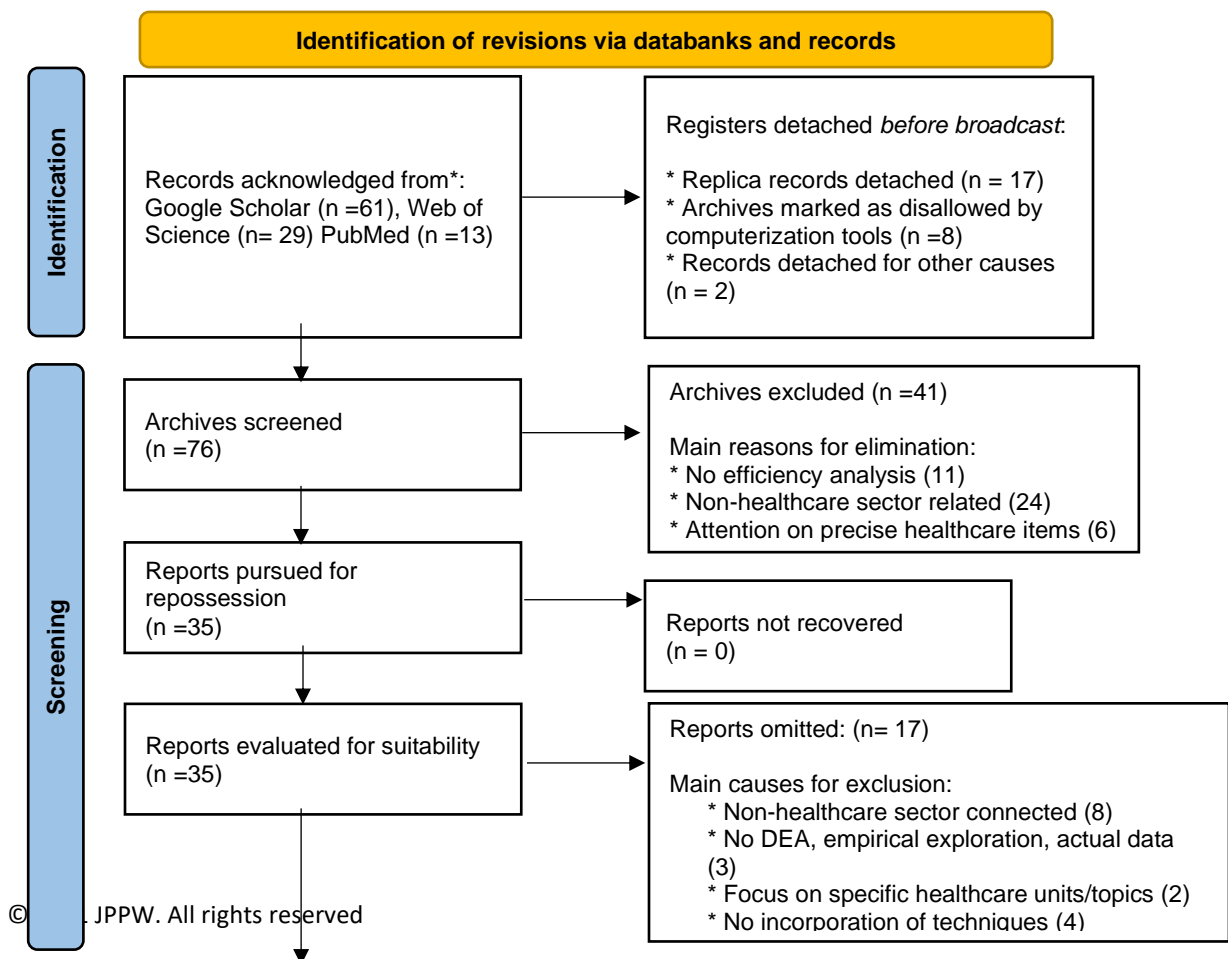
- To admittance the complete manuscript of research
- Use only the studies published between 1991 and Oct 2021
- English is the only language considered
- "data envelopment analysis", "efficiency "or "efficiency analysis" announcements in the title of the study are taken into accord
- Due to the scarcity of articles both Scopus and non-Scopus indexed articles were considered.

There are only limited studies conducted in India on the basis of data envelopment investigation in healthcare sector. From the keywords search, a total of 103 studies were found. Only peer-reviewed publications were included in the search, therefore technical papers, conference paper's, editorial documents, and book subdivisions were not included in the findings. 27 studies were deemed to be repetitive, leaving 76 unique research for the screening procedure.

Within the scope of the investigation, publications that met these criteria were assessed. An over-all of 18 published manuscripts met the requirements for enclosure. These studies were analyzed based on the publication year, study kind, input variables, output variables, and decision-making elements employed in the revisions. As a consequence of the findings, graphs and tables are used to display arithmetical and ratio data regarding input, output variables, and decision-making elements of periodicals that meet the requirements.

Search strategy: The search was conceded out in acquiescence with the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses criteria" (PRISMA).

Keywords for searching: Data envelopment analysis, Hospitals, Healthcare, India



Included	Studies involved in evaluation (n =18) Reports of encompassed studies (n = 18)
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As a consequence of the discoveries, graphs and tables are used to display arithmetical and ratio data regarding input, output variables, and decision-making elements of publications that meet the requirements.

RESULTS

The competence of various decision-making components is assessed using a variety of input and output factors. It was established in this investigation which output and input variables were often utilised in the papers. However,

because Data envelopment analysis is a data-driven approach, the findings are highly dependent on the factors used. As a result, information regarding the most regularly used output a input nvariables to measure hospital competence was included in this work to offer uniformity.

After 2010, DEA was widely employed in India to assess the effectiveness of healthcare services. The list of publications per year in efficiency in healthcare sector by using data envelopment analysis in India is shown in figure 1

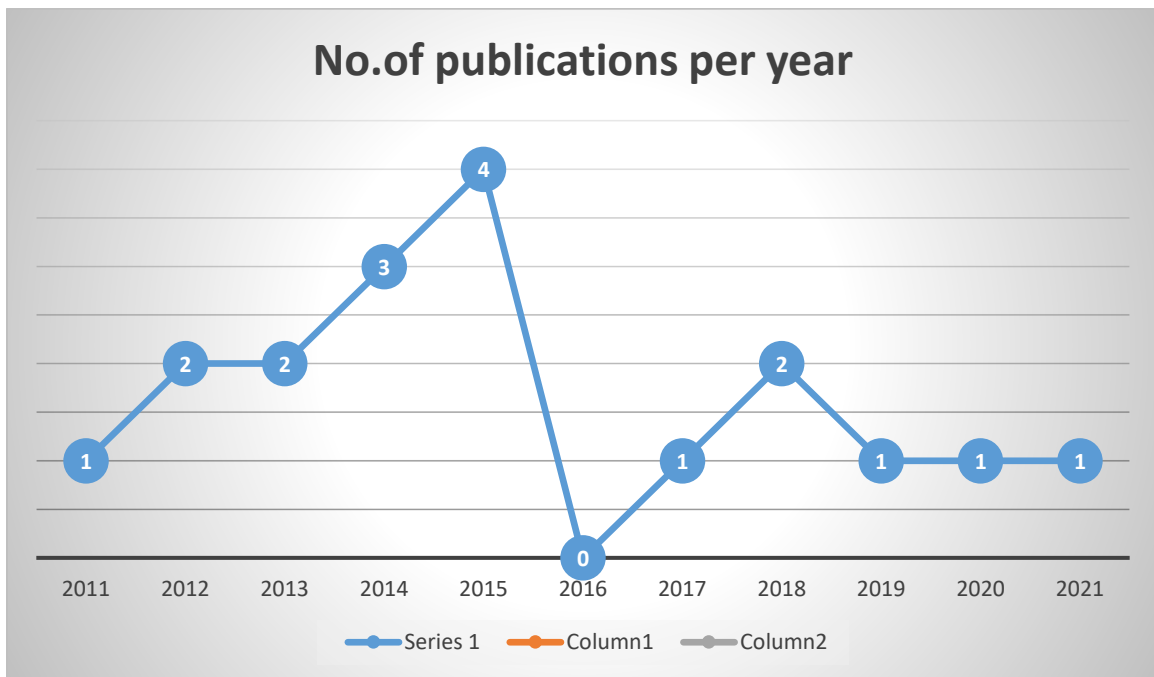


Fig 2: No. of publications per year

Evidence about input variables used in the 18 publications that nominated the hospital as a decision-making element is given in Figure 2.

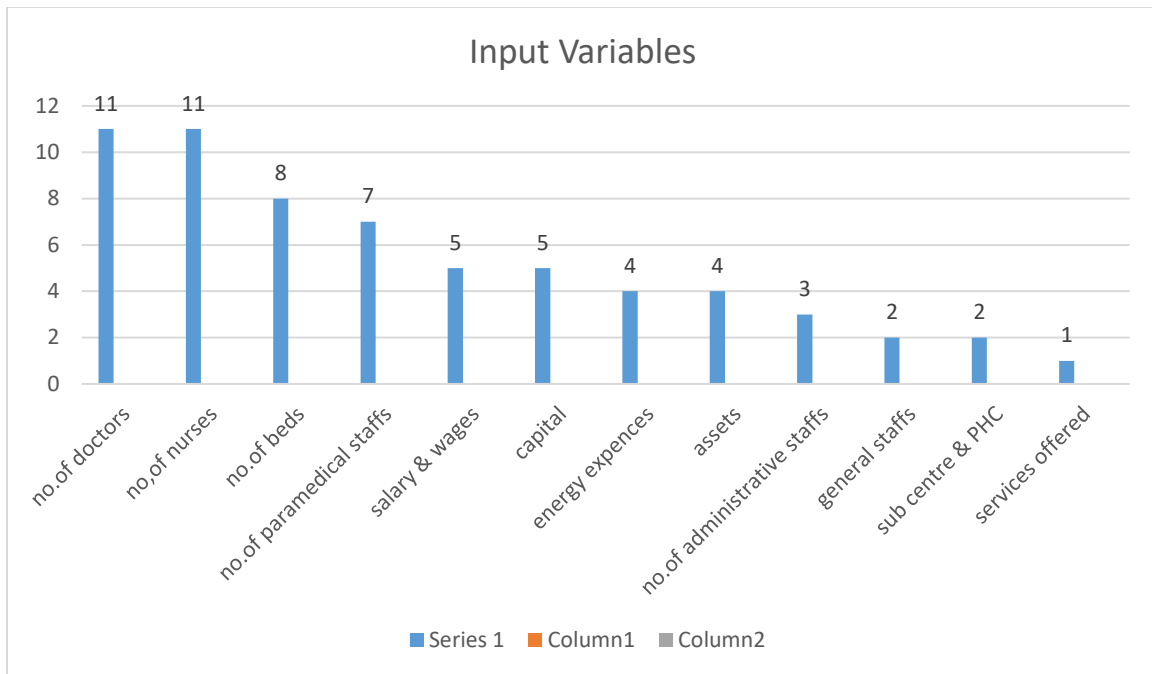


Fig 3: input variables used in the articles

Evidence about output variables used in the 18 publications that designated hospital as a decision-making element is given in Figure 3.

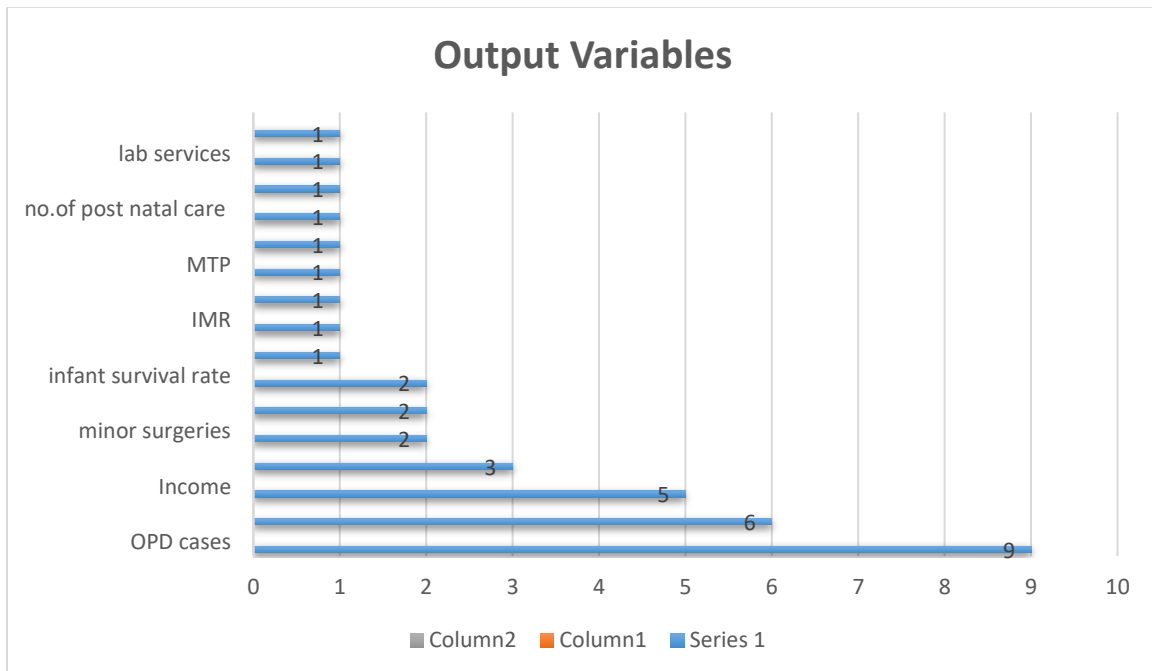


Fig 4: output variables used in the articles

The total of the integers is higher than 18 since more than one input and out variable is utilized in the same research.

The data shows that the efficiency of hospitals in India was taken for study and assessment only after 2010 and the studies that have been conducted state-wise is alarming. A study conducted in 2013 among public hospitals in Madhya Pradesh reveals that out of 40 hospitals selected only 20 of them are efficiently working (50%). A study in the state of Bihar conducted in the same year shows out of 37 selected public hospitals only one is efficient (2.7%). In 2014 a study among 78 public hospitals in West Bengal was conducted out of 26 that were technically competent (33%). In the same time, a comparative study among public and private hospitals was done in Bihar which sketched multiple input-output methods that can be used. In 2015 Uttarakhand and Tamilnadu conducted a study among their public hospitals and found out the efficiency of 27.73% and 29% respectively. In the same year, a study assessed the health efficiency in India and revealed the healthcare sector is only 22% efficient. The only better result came from the state of Kerala which portrayed the NRHM as functioning effectively with a score of 78.5% in 2017. In 2018 a study claimed that only 16.6% of the Kerala govt hospitals are effective. In 2020 a study among private hospitals in a district of Kerala revealed that out of 20 selected hospitals 12 are efficient (60%).

Though the public healthcare sectors are not running up to the mark, the private healthcare sectors in India is improving day by day. A study conducted in 2011 among private sanatoria in India showed out of 15 selected sanatoriums only 2 were efficient (13.13%) whereas it increased to 18 % in 2012. By the end of 2018 the private hospital's efficiency in India raised up to 54% and a study conducted in 2019 showed that from selected 25 hospitals 7 were efficient (28%). A study in 2015 among the public hospitals in India revealed out of 21, 5 were technically efficient (23.8%)

Even though there are very limited studies conducted in India regarding efficacy of healthcare sectors through data envelopment analysis the review of health efficiency measurement in Indian hospitals clearly states that there is an upward trend in improving the

efficiency among private hospitals in India whereas the public health care sectors are lacking the efficiency behind.

Studies conducted in other parts of the world are also considered, and for the ease of classifying the data, the studies have been grouped into Asian countries, European countries, the US, Arab and African countries. The results show that European hospitals are efficient when compared to hospitals in other countries in the world.

CONCLUSION

The constant growth in health expenses, fluctuates the disease structure, advancements in medical research and expertise, and rivalry among facility suppliers have all necessitated health care amenities to be supplied successfully and economically in recent years. As a result, firms monitor their efficiency on a regular basis. In the literature, data envelopment analysis (DEA) is one of the greatest extensively used efficiency measurement methods. However, there is no universal DEA model that can fulfil the demands of all enterprises. According to its structure, each company selects the suitable input and output variables. The choice of input or output variables is a critical consideration that changes based on what you want to perceive as an outcome and which inputs or environmental factors are more likely to influence it. As a result, the input and output variables that are used to evaluate the relative efficacy of decision-making elements are carefully chosen. Furthermore, in order to quantify health outcomes, the proper analytical approach should be devised, which incorporates the maximum number of inputs and outputs.

In health care, data envelopment investigation is frequently used to assess efficiency. In the health industry, the assortment of input and output factors is so perilous. In general, finding relevant variables based on the nature of health services, obtaining correct input and output data, and accessing dependable databanks with standard descriptions for input and output variables connected to healthcare sector is

extremely challenging. There are many inputs and outputs in the texts due to the lack of a customary input–output set in health care service sector. For researchers who wish to use data envelopment analysis to gauge efficiency, this is a painful and confusing scenario. This research will aid researchers, academics, and health economists by resolving the complexity, providing information on the utmost often used input and output variables, and assisting researchers, academics, and health economists.

There is 18 research in this study that fulfill the author's criteria, and the entire readings utilized the hospitals as decision-making elements. Because the hospital was the sole decision-making unit employed in this study, information regarding the supreme, extensively used input and output variables of publications that assessed hospital efficacy was supplied. The review states that the main stream studies have taken the sum of hospitals, nurses, doctors and paramedical workforce as their inputs and inpatient status, outpatient status, revenue, and a number of major and minor surgeries as their output variables. The majority of the studies have focused on the CCR model and adopted the input-output VRS model. Seldom studies are primarily focusing on Slack based DEA model which is a new and revised one, that deals with slacks directly. The review is very shocking that the healthcare sector in India is not efficient up to the mark. All the studies conducted to evaluate the efficacy of public healthcare sectors in India are floating around 20 to 30 percent efficiency. But the private players are working hard in this matter and their efficiency scores are increasing year by year.

As a result, the goal of this work is to conduct a systematic review to discover widely utilized decision making elements, input and output variables in Indian health care. This research will aid hospital administrators, policymakers, researchers, academics, and health economists in better accepting the strengths, slits, and limits of appraising health efficiency. This research will also be added to the literature and future studies on healthcare efficiency. In forthcoming studies, it is suggested that holes in the choice of input and output variables be

filled, as well as the incorporation of additional significant input and output components such as socio-economic and lifestyle characteristics. Education, income, unemployment, income disparity, and age structure were considered socio-economic variables, whereas cigarettes, alcohol, food choice, and pollution were considered lifestyle factors (Varabyova and Müller 2016). All of these elements, whether directly or indirectly, have an impact on one's health. Because health is a multifaceted idea, not a single concept.

The researchers also found out that European countries are much higher in healthcare efficiency when compared with other countries in the world. In comparison, the Republic of India is far behind the rest of the world in terms of healthcare expenditure in terms of percentage of GDP.

Compliance with Ethical Standards

Conflict of interests Authors affirms that there is no conflict of interest.

Funding: No funding received to conduct this study

Ethical approval: No human participants or animals were involved in this study.

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