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Review Article

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Does the Efficiency Frontier of Large US Hospitals provide a Strategy for Future Success?

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Abstract

This study evaluates the performance of large US hospitals related to efficiency analysis, an important characteristic with today's economic challenges. Within these large US hospitals, nurse staffing is a key resource and is vital to the success of the healthcare industry. The study uses Data Envelopment Analysis (DEA). For this study, large US hospitals are identified as those hospitals 400 beds and larger. The data show that in 2019 there were 448 US hospitals 400 beds and larger with an average of 646 beds. Results indicate overall efficiency for these hospitals was. 86 or 86% in 2019. As a model for future success, 42 or 9% of the hospitals were on the efficiency frontier. DEA efficiency results were also evaluated based on for-profit hospitals versus not-for-profit/non-federal government hospitals. The overall efficiency of for-profit hospitals was 87% versus 86% efficiency for not-for-profit/non-federal government hospitals. Additionally, 16% of for-profit hospitals were on the "efficiency frontier" versus only 9% of not-for-profit/non-federal government hospitals. Healthcare leaders, nursing administrators, and other stakeholders benefit from studies that improve hospital efficiency. From a policy perspective, this study shows that large US hospitals are highly efficient and serve as an important community resource.

Keywords: Hospital efficiency; Large US hospital efficiency; Data envelopment analysis (DEA).

Introduction

Health expenditures in the United States in 2018 reached $3.6 trillion representing 17.7% of Gross Domestic Product (CMS 2018) [1]. US hospitals provide a wide range of inpatient and outpatient services designed to improve the health status of their local community. Specifically, in 2019, hospital inpatient services were 19% of medical spending while outpatient facility expenditures accounted for 29% of total medical spending. These changing practice patterns demonstrate the need for better coordination of care across the continuum of healthcare services. It is also important to realize that nurse staffing is a key resource across the changing healthcare landscape. This article evaluates how large US hospitals are responding to changes in the healthcare industry by improving hospital efficiency [2].

As state and federal governments face growing budget constraints and an increased nursing shortage, hospitals can anticipate reduced reimbursement rates for Medicare and Medicaid Services. For example, federal value-based payment initiatives are designed to cut hospital payments to hospitals with lower quality and increase hospital payments for those with the best quality. Beginning in 2017, the CMS withhold rate for Value-Based Purchasing increased to a 2% reduction from the hospitals' base operating diagnosis-related group payment. The amount withheld in 2017 was $1.8 billion and this money was redistributed to hospitals that met the CMS TPS quality performance metrics. Those hospitals that perform well in pay-for-performance metrics received a bonus payment that was funded by the amount withheld

from hospitals that did not meet quality requirements [3]. History suggests CMS will continue to look for innovative approaches that will reduce cost while increasing healthcare quality and value. As a result, large US hospitals are being challenged to increase efficiency in order to gain greater access to capital and remain competitive in the changing healthcare market [3]. This has important implications for nursing leadership as well as nursing practice in the coming years.

As industry pressures mount many hospitals are being acquired, merging or closing. Those hospitals that approach the efficiency frontier have the best opportunity for profitability and long-term survival. As discussed by Cooper, Seiford & Tone (2003), the "efficiency frontier" is where inputs and outputs are maximized [4]. This efficiency frontier becomes the optimal solution as large US hospitals search for the best hospital operations model.

Many healthcare executives believe that efficiency is the key to the future success of the healthcare system. As discussed by Rosko and Mutter (2011), improvements in efficiency allow a reduction in costs without negatively affecting quality or the access to healthcare [5]. More recently found hospitals on the efficiency frontier were larger, had higher occupancy rates, were part of a health system, and were more profitable [6]. These findings show that large US hospitals should use the "efficiency frontier" as a model for future success.

Literature Review

The Institute of Medicine (IOM) was founded in 1970 as a nongovernmental not-for-profit organization with a mandate to provide impartial recommendations to improve US healthcare [7]. The IOM in its report titled "Crossing the Quality Chasm" identified efficiency as one of six aims for the US health system in the twenty-first century. The IOM defined efficiency as reducing waste as well managing inputs of resources with a goal to maximize output (IOM 2001) [7].

Today, US hospitals are forced to operate in an extremely turbulent and competitive marketplace. This environment leads to increases in uncompensated care and declining operating margins. These financial difficulties can limit a hospitals ability to acquire new technology, meet nursing staffing requirements, and invest in new facilities [8]. As discussed by Giancotti et al. (2017), larger hospitals are able to leverage greater economies of scale resulting in lower average costs and improved clinical outcomes [9]. Therefore, large hospitals can use efficiency to identify the optimal production level given a fair allocation of resources. Faced with the threat of reduced reimbursement, greater efficiency is important to continued hospital operations.

By 2020, more than 559 Medicare Accountable Care Organizations (ACO's) have been established and serve more than 12.3 million Americans. It is estimated that ACOs have produced a net savings of almost $740 million (NAACOS, 2020) [10]. This increase in ACO's has been driving change in the healthcare system and is putting the greatest pressure on hospitals. Most ACOs pay hospitals on a capitated (per person per month basis) or pay the hospital based on a discounted price. As a result, hospitals face added financial risks that may be impossible to control. Increased administrative costs also add significantly to hospital expenses. These factors could reduce a hospital's ability to generate profit and jeopardize its long-term survival [2].

Research Questions

This study analyzed 2019 American Hospital Association (AHA) data on large nonfederal, acute care US hospitals of 400 beds and greater to evaluate hospital efficiency. The primary research question was: What are the characteristics of large hospitals that operate on the efficiency frontier? The following underlying research questions are provided:

- To identify those large US hospitals on the efficiency frontier and calculate the level of inefficiency in those organizations not on the efficiency frontier.
- Are large US hospitals efficiently managing their key input resources, including staffing, during the hospital production process?
- Is there a difference in the efficiency of large for-profit hospitals versus large NFP/nonfederal government hospitals?
- How can a large US hospital improve it overall efficiency?

Measuring Efficiency

As discussed by Cooper, Seiford & Tone (2003), technical efficiency refers to the sources of waste that can be eliminated without worsening any other input or output [4]. This study utilizes technical efficiency analysis by measuring the inputs used to create outputs. Optimization is achieved when no other use of resources can improve efficiency and becomes the "efficiency frontier".

Technical efficiency studies treat staffing (FTEs), operating expenses, and hospital beds as inputs used to create outputs of healthcare services. Measuring the level of efficiency involves comparing large hospitals to identify the most efficient organizations. This efficiency frontier, reflected by a score of 1.0, represents production at the highest levels.

Data Envelopment Analysis

According to Giancotti et al. (2017), DEA is the most frequently employed quantitative method used to measure hospital efficiency [9]. DEA is a non-parametric approach that estimates efficiency scores from hospital data by using linear programming techniques. DEA remains the preferred method of efficiency analysis in hospitals because it evaluates multiple outputs of

production in an environment where it is difficult to obtain input and output cost/price data. Data Envelopment Analysis (DEA) is an analytic tool that redirects emphasis from financial assessment toward optimizing performance and decision-making. As a result, DEA is a good decision-making tool for measuring the efficiency of an organization relative to its peers.

Efficiency can be used to evaluate whether larger hospitals are more or less efficient than smaller ones. Their meta-analysis indicates that in US hospitals diseconomies of scale can be expected to occur below 200 beds and above 600 beds (Giancotti et al. 2017) [9]. This supports the premise that large hospitals take full advantage of economies of scale by producing maximum output per unit of input and thereby reducing the average unit cost of production.

From an efficiency perspective, DEA evaluates inputs (beds, FTE staffing, and operating expenses) in relation to outputs (inpatient days, outpatient visits, and surgical procedures). Performance is indicated by a DEA Theta (θ) score between zero (lowest possible score) and one (highest possible score). A theta value less than one ($\theta < 1$) indicates inefficiency while a $\theta = 0.5$ indicates that the organizations should be able to reduce resource input by 50 percent to be efficient.

As discussed by Harrison & Kirkpatrick (2011), an important feature of DEA is the ability to identify slack within hospitals [11]. This allows us to determine which inputs and/or outputs appear to be inefficiently used or produced by hospitals. This, in turn, offers practical applications for healthcare leaders, nursing administrators, and other key stakeholders. Inefficiently used inputs or inefficiently produced outputs generate slack. This slack reflects either surpluses (inputs) or shortages (outputs) in production. Slack can be analyzed to determine which inputs or outputs contribute most to an inefficient hospital's efficiency scores.

Theoretical Foundation

Resource dependence theory (RDT) believes each organization is an open system and individual organizations do not control all the resources needed for their development and long-term survival. Therefore, every organization depends on the external environment to satisfy their resource needs. The foundation of RDT is the idea that all organizations are critically dependent on other organizations to provide them with vital resources they need for survival and future success. For example, large hospitals may need to access bond financing for facility expansion and their large size provides greater leverage. For this study, RDT was employed to examine the relationship between the external environment and efficiency in large hospitals.

From a RDT perspective, leadership's primary purpose is to enhance a healthcare organization's ability to deal with environmental constraints through its strategic plan, organizational structure, and operating model which maximizes performance through improved efficiency. Healthcare organizations attempt to improve efficiency by grouping together in health systems.

Methodology

This study evaluates the efficiency of 448 large hospitals using a DEA model. Data for this research was obtained from the American Hospital Association's (AHA) 2019 annual survey. The variables selected for this study are commonly used input and output variables affecting hospital efficiency [11]. AHA data for 2020 and 2021 was not used due to the sentinel event of the pandemic which impacted routine hospital operations such as the canceling of elective procedures.

Inputs:

Operating Expenses - Payroll expenses are not included because the number of full-time employees (FTEs) is used as a separate measure of labor input.

Hospital Beds - The number of hospital beds is an accepted indicator of capital investment [12].

Full Time Employees (FTEs) - Labor is an important facet of an organization's resource consumption.

Outputs:

Inpatient Days- Inpatient Days is a common measure of hospital productivity and is a widely accepted measure of inpatient workload [11].

Outpatient Visits- Outpatient workload is a widely accepted measure of hospital output [11].

Surgical Procedures- Surgical procedures is a widely accepted measure of hospital output [12].

Results

Variable N = 448	Mean	Standard Deviation	Maximum	Minimum
Operating Expenses	$987,104,473	$817,994,172	$6,554,748,000	$88,882,186
FTE's	4,849	3,733	32,397	606
Beds	646	306	3,890	400
Inpatient Days	171,683	86,224	775,202	61,089
Surgical Procedures	23,462	17,885	171,020	1,721
Outpatient Visits	633,306	641,160	8,091,607	35,543

Table 1: Descriptive Statistics for Large U.S. Hospitals; Data Source: 2019 American Hospital Association Survey.

Descriptive statistics for large hospitals in 2019 are shown in (Table 1). From an input perspective, the data show that the average operating expense of large hospitals was $987,104,473. The average number of hospital beds in large hospitals was 646. The average number of FTEs in large hospitals was 4,849.

From an output perspective, the average inpatient days in large hospitals was 171,683 and the average number of outpatient visits was 633,306. The average number of surgical procedures for large hospitals was 23,462. A review of the descriptive statistics clearly documents that productivity in large hospitals is high. However, using descriptive statistics to analyze overall efficiency is cumbersome and lacks precision.

N = 448	
Average Efficiency Score	0.86 or 86%
Minimum Score	0.58 or 58%
Maximum Score	1.00 or 100%
Standard Deviation	0.09
Number of Efficient Hospitals	42 or 9%
Number of Inefficient Hospitals	406

Table 2: Summary of DEA Measures for large U.S. hospitals; Data Source: 2019 American Hospital Association Survey.

The results of the DEA for large hospitals in 2019 are presented in (Table 2) and shows the average efficiency score of large hospitals was .86 or 86 percent. The number of large hospitals on the efficiency frontier with a Theta score of 1.0 was 42 for 9 percent of large hospitals.

Those large hospitals located on the efficiency frontier represent the optimal application of inputs to create outputs. As a result, the large hospitals on the efficiency frontier serve as benchmarks for less efficient peer organizations and provide a strategy for future organizational success. This DEA analysis provides clear evidence of high efficiency among large US hospitals.

N = 448	
Input Inefficiency per Hospital	
Excess Beds	0
Excess Operating Expenses ($)	$ 67,797,153
Excess FTEs	344
Output Inefficiency	
Shortage – Inpatient Days	1,668
Shortage – Outpatient Visits	35,231
Shortage – Surgical Procedures	706

Table 3: Analysis of inefficiency or slack for large U.S. hospitals; Data Source: 2019 American Hospital Association Survey.

Data for (Table 3) was calculated using DEA solver software and shows the average amount of slack among large hospitals, compared to those on the efficiency frontier (DEA score of 1). These results represent the combined scores of slack for the respective group of inefficient large hospitals. The combined scores were then divided by the number of inefficient hospitals to calculate the average level of slack for an inefficient large hospital. This average level of slack provides a measure of overall inefficiency.

From an input perspective, the results show that based upon the level of output, there was no slack in beds for large hospitals and that these hospitals are optimally sized for their outputs of production. The average slack in operating expenses for large hospitals was $ 67,797,153. The average slack in FTEs for large hospitals was 344.

DEA also measures the level of inefficiency in output. From an output perspective, DEA showed the level of output in inpatient days for large hospitals was underutilized by 1,668. Similarly, outpatient visits in large hospitals were underutilized by 35,231. The slack in surgical procedures in large hospitals was 706. DEA shows that based on the efficiency frontier, the level of performance among the outputs could be improved.

As discussed in (Table 4), the overall efficiency of for-profit hospitals was 87% versus 86% efficiency for not-for- profit/non-federal government hospitals. Additionally, 16% of for-profit hospitals were on the efficiency frontier versus only 9% of not-for-profit/non-federal government hospitals. The data show a higher percent of the for-profit large US hospitals are on the efficiency frontier which indicate they better manage the use of resources to enhance outputs through the reduction of slack.

	For-Profit N = 43	**NFP/Non-Fed = 405**
Average Efficiency Score	0.87 or 87%	0.86 or 86%
Number of Efficient Hospitals	7 or 16%	35 or 9%
Number of Inefficient Hospitals	36	370

Table 4: DEA Measures of For-Profit and NFP/Non-Federal Govt. large U.S. hospitals; Data Source: 2019 American Hospital Association Survey.

Level of Efficiency	**.69 or 69%**
Input Inefficiency of large U.S. hospital	
Excess Beds	0
Excess Operating Expenses	$448,592,433
Excess FTEs	1048
Output Inefficiency of NFP	
Shortage – Inpatient Days	0
Shortage – Outpatient Visits	284,477
Shortage – Surgical Procedures	0

Table 5: Case Study of an inefficient large U.S. hospital; Data Source: 2019 American Hospital Association Survey.

(Table 5) is a case study for a large hospital operating below the average efficiency of similar hospitals in 2019. As stated previously, healthcare leaders, nursing administrators, and other stakeholders of inefficient hospitals can improve efficiency by analyzing DEA

results. For example, the DEA score of 0.69 or 69 percent is not on the efficiency frontier and is well below the average efficiency score of 0.86 or 86 percent for other large hospitals in 2019. According to the DEA analysis, in order to become efficient, the case study large hospital should reduce operating expenses by $448,592,433 and reduce FTEs by 1,048.

As addressed previously, the case study hospital has no excess beds. From an output perspective, the case study hospital does not need to improve its output in inpatient days or surgical procedures. However, it should increase outpatient visits by 284,477. If all the adjustments discussed previously are implemented, DEA suggests that this case study large hospital could approach the efficiency frontier.

Discussion

Our study shows large hospitals are highly efficient but there is opportunity for improvement. This study clearly documents that the number of excess hospital beds is not a cause of large hospital inefficiency. The data show that the average large hospital could reduce staffing by an average of 344 FTEs. The AHA data for hospital FTE's includes administrative support staff as well as direct care FTE's. Healthcare leaders need to carefully examine which FTE's might contribute to the inefficiency. At $64,647 per FTE this represents a potential average savings in staff at large hospitals of $22,238,568 per hospital. Also, the average large hospital could reduce operating expenses by $67,797,153.

The volume of outpatient visits in large hospitals is significant and will continue to increase over time. This is consistent with changes in the healthcare industry resulting in shorter hospital lengths of stays and increased outpatient services. Large hospitals also have significant workload with an average of 171,682 inpatient days per hospital, 23,462 surgical procedures and with an average of 633,306 outpatient visits per hospital. Based on a low rate of slack among these variables, this clearly documents high productivity and efficiency.

Managerial Implications

From a management perspective, the results of this study show that with an average efficiency of 86%, large US hospitals are among the most efficient in the hospital industry. From a resource allocation perspective, this study found the continuing opportunity for reducing the level of operating expenses. When reviewing the allocation of manpower, the DEA data showed an excess of FTEs among large US hospitals.

Reducing operating expenses and labor may improve efficiency and enhance the hospital's bottom line. Efficiency gains as represented by higher productivity must be realized on a sustainable basis. Hospitals have been successful in increasing occupancy rates by expanding market presence through increased inpatient volume. Such increases in productivity allow for greater economies of scale. Benchmarking against the efficiency frontier will help the organization to further ascertain its competitive position in the market.

Our research is supported by Rosko et al. (2020) who also believe hospital leaders may respond to reductions in federal hospital payment policy by cutting expenses [6]. However, it is important to reduce expenses in a manner consistent with the organizations strategic plan with a focus on improved quality to increase value based payments. We believe that hospitals which can increase efficiency while maximizing quality will be rewarded with increased profits. These profits could then be used to fund critical staffing shortages, future capital projects, or expand services to the community.

In contrast, inefficient hospitals which face financial losses will be forced to reduce the volume or quality of their services. As a result, hospitals must implement a strategy to move towards the "efficiency frontier" because it is the only way to increase services without increasing costs or compromising quality.

Policy Implications

It is clear that healthcare policymakers are seeking increased efficiency in the care delivery system. For example, Medicare and Medicaid currently account for over 40% of payments to hospitals. The payment in the early years of fee for service has been reduced for many hospitals under the Value Based Purchase (VBP) program. As a result, in recent years many hospitals tended to lose money when serving Medicare and Medicaid patients (MedPac, 2018) [13].

Inefficient large hospitals must develop a strategy to improve their efficiency in order to increase profitability. Clearly, large hospitals must continue their focus on efficiency, quality and profitability to ensure their long-term survival. This is supported by Giancotti et al. (2017) whose meta-analysis supports a government policy of expanding larger hospitals and restructuring or closing smaller hospitals [9]. Their research found the optimal bed size for hospital economies of scale start at 200-300 beds and diseconomies of scale can begin to occur above 600 beds.

In summary, many countries have been reorganizing their hospital industries to reduce excess capacity. These actions have reduced the numbers of hospital beds operated in many countries. Fortunately, the results of our study show success in this planning because there is no hospital bed inefficiencies among large U.S. hospitals.

However, the number of hospital mergers continues to grow as other hospitals try to leverage economies of scale and improve the quality of care. The research shows a policy of expanding larger hospitals and restructuring or closing smaller hospitals is

appropriate for allocating scarce resources (Giancotti et al, 2017). This was supported by our research which found large hospitals at 86% efficiency are among the most efficient in the US [9]. Most importantly, the" efficiency frontier" of large US hospitals provides a benchmark for other hospitals to use as they strive for future success.

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