Evaluating the efficiency of public hospitals in the State of Hawaii

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Introduction

Hospital in the United States has two main categories. Acute Care Hospital (ACH) and Critical Access Hospital (CAH). The key differences between the two is that CAHs are smaller in size (can not have more than 25 inpatient beds), located in rural areas with more than 35 miles drive away from other hospitals (CAHs or Acute Care), provide 24/7 emergency care services and allows no more than 96 hours of length of stay (Rossi, Rossi, Rossi & Rossi, 2011). Depending on their ownership, CAH and ACH can be either a Public Hospital, Private Hospital, Nonprofit Hospital or a combination of the three ownerships. Public hospitals provide health care social "safety net" and they are owned by the government (Fraze et al., 2008). They are particularly established to provide care for those who may not be able to get care elsewhere. Other health care safety net providers include: nonprofit hospitals, private or for-profit hospitals and community hospitals. According to Fraze et al. (2008), in the United States public hospitals provide health services to the majority of low-income citizens who covered by Medicaid, a government-subsidized insurance program who do not have insurance. They are also the most targeted hospitals for trauma care, unreimbursed care and mostly serve as teaching institutions.

In Hawaii, 40% of active hospitals are public hospitals (KFF.org, 2016) and the other 60% are either nonprofit or private hospitals. According to the Kaiser Family Foundation, the national average State government's ownership of hospitals is 20 percent. Specifically, there are thirteen

hospitals or health care facilities administered by the State of Hawaii government through Hawaii Health Systems Corporation (HHSC). HHSC is a public independent agency created under a landmark Act 262 passed by the State legislature in July 1st, 1996. HHSC administer and operates 13 facilities throughout the state of Hawaii by region. The East Hawaii Region looks after Hilo Medical Center, Ka'u Hospital, Hale Ho'ola Hamakua and Yukio Okutsu State Veterans Home. West Hawaii Region has Kona Community Hospital and Kohala Hospital, the Maui Region has Maui Memorial Medical Center, Kula Hospital and Lanai Community Hospital. Maluhia and Leahi Hospital are under the Ohau Region and finally West Kauai Medical Center and Samuel Mehelona Memorial Hospital are under the Kauai Region.

According to HHSC 2015 Annual Report there are: 21,676 acute care admissions, 1187 long term admissions, 118,850 acute care patient days and 239,285 long term care patient days and 119,225 emergency room visits provided by HHSC in Fiscal Year 2015. There were a 1,253 licensed beds and employed a total of 4201 Full Time Equivalent (FTU) personnel. Statewide, HHSC provides 21% of all acute care discharges and 27% of all emergency room visits. However, in the neighboring islands of Hawaii, Kauai and Maiu, HHSC is responsible for providing 75% of emergency room care and 65% of acute care discharges.

HHSC is facing critical financial and structural challenges. In 2015, HHSC announced an expected $50 million downfall for its 2016 financial year (Powderly, 2016). Part of the reason is the increase in pension funding, State-negotiated pay raise for staffs and the declining reimbursement rates. The East Region will be affected the most with a $7million cut. Consequently, HHSC laid off more than hundred staffers particularly in the clinical level. Further, the State's subsidy to HHSC is shrinking. HealthCare Finance reported that HHSC was asking the State $156 million for the FY 2016 but they only provided with $106 million (Powderly, 2016).

For the 2017 FY, the State is considering granting HHSC $85 million with another $48 million appropriations bill (Powderly, 2016). Back in 2013, Banner Health, an Arizona-based nonprofit was in a series of negotiations with HHSC to take over the operations of HHSC's facilities in Maui, West Hawaii and East Hawaii regions (Steward, 2016). The reason for this take over move as HHSC Board Chairman, Avery Chumbley, reported is to reduce the State's subsidies for the HHSC in the long run. In 2013, Hawaii State government granted more than $82 million.

These stories of HHSC's financial and operational status drives the need of a closer look at the efficiency of its individual facilities. One of the very first aspects of public hospitals productivity management is their efficiency status. From funding allocation to quality ranking purposes, knowing a numerical efficiency score of each hospital can plays a critical role. The objective of this paper is to carefully study the resources, outputs and outcomes of each facility. By using Data Envelopment Analysis (DEA), a sophisticated analytical tool for relative efficiency, this paper will try to quantify the technical, scale and overall efficiency of each public hospital under the umbrella of HHSC. Literature review is used to identify and discuss the efficiency model and to draw some insights on how to best select the inputs and output variables for DEA in hospital settings.

Literature Review

Data Envelopment Analysis (DEA) does not need a *priori* to be effective and meaningful in policy analysis and management. It is an *ex post facto* way to evaluate relative efficiencies of management accomplishments or when everything has been done however they may have been planned and utilized (Banker et al., 1984). Together with its ability to handle more than one output and input variables, DEA can be the best tool for certain purposes and problems. The model is a

non-parametric technique developed by Charnes, Cooper and Rhodes (1978) which uses a linear programming method to calculate relative efficiencies of homogenous and comparable observations or Decision Making Units (DMUs) (Chiou et al., 2012). It is designed to determine a comparative efficiencies of different units of an organization. The main feature of the model that provides its strong comparative ability and advantage for performance benchmark is that it can simultaneously determine the efficiency of a group of DMUs using multiple inputs and outputs common to each DMU (Yen et al., 2014). The model does not provide an actual efficiency value but rather provides a comparison benchmark for a group of units or departments. In other words, one cannot assure the government that Hospital A is efficient but rather one, can guarantee that Hospital A is relatively more efficient than Hospital B and C. Without using inputs and outputs variables from Hospital B and C, we cannot run the model to begin with so we basically cannot make any conclusions. Often times, it is difficult to gather all possible inputs and outputs of a single firm to evaluate its operational efficiency by itself without comparing it to any other hospital. Often times, it needs a substantial amount of time to gather and list down hundreds of input and output variables that are relevant for the efficiency analysis. With DEA, you can use only a few input and output variables and comparing them with other hospitals. In that sense, DEA gives corporate management a general sense of efficiency of a particular hospital in a timelier manner and efficient approach. It also provides a direct way to compare different units at the same time.

The public sector can make the most of this technique to effectively analyse the relative efficiency of different units of an agency or public services (Jacob, 2000). Government departments that provide public goods and services can use this analytical tool to quantify the efficiency score of different departments implying the need to close down, reform or adjust funding

decisions toward the inefficient ones. (Kirigia et al., 2002). De Borger, et al. (2008) states that DEA is a method that analyses the "relative efficiency" of some "similar-type decision-making units with a multi-input and multi-output system". Graphically, it plots the inputs and outputs of all decision-making units (DMUs) in a standard 'x' and 'y' axis and finds its boundary points; those that fall on its boundary are considered to be the most efficient combination of input and output. These efficient combinations should have a score of '1' and '0' being the extreme case of inefficiency (Yanjun, 2008). Goudarzi et al. (2007); Torabipour et al. (2014); Sabermahani et al. (2009) used the number of nurses, number of occupied beds and number of physicians as input measures. The same scholars used the number of outpatients and inpatients, average of hospital stay, and number of major operations as output measures. However, there are some valid criticisms on how inputs and outputs of hospitals are selected to generate efficiency scores.

A systematic review conducted by Hussey, et al. (2009) found that most of the existing efficiency measurement of hospitals lack validity and reliability. Hussey and his colleagues studied 265 efficiency measures of peer-reviewed literature for hospitals and found that most of them focus on the cost of care and not the quality of care or efficiency. They found evidence of reliability and validity in only 2.3 percent of the measures. Hussey et al. (2009) stated that the "design perspective" of inputs and output measures matters because "different entities have different objectives for considering efficiency, have control over a particular set of resources or inputs, and may seek to deliver or purchase a different set of services." They pointed out that most measures of productivity are designed by "delivery systems and purchasers", and therefore they are often not aligned with needs of policymakers or patients. This same study found over 80 percent of the measurement metrics used for efficiency studies supply information to "hospitals or physicians".

This supports the argument that the appropriate variables for inputs and outputs depends on the context of the study and the researcher's judgement as other DEA scholars also stated.

Data

According to Callen (1991); Cholos (1997); Charnes, Cooper & Rhodes (1981); Watson, Wickramanayke & Premachandra (2011), there is no fixed process to choose which aspects of the project are inputs and outputs. It all depends on the context and nature of the research objective. Callen (1991); Adler & Golany (2001) and Norman & Stoker (1991) pointed out that the methods used by early DEA scholars to select inputs and outputs based on "expert judgement, principal components analysis, a step-wise approach to input-output variable selection or a combination of all the above". This paper will use the same inputs and outputs variables as previous scholars used. Though the DEA model is designed to measure or analyze multiple inputs and outputs, it can still lose its clarity and reliability when the large number of DMUs are used (Adler & Golany, 2001; Gregoriou, Sedzro & Zhu, 2005). Five inputs and three outputs is a reasonable and most common number of inputs and outputs to use for any project.

Nevertheless, all hospitals have relatively similar operating expenses incurred to deliver health care services. The aim of efficiency valuation is to identify which hospital provides health care services at a least cost. If one hospital pays its staffs directly or through outsourcing arrangements, the operating expense will be differ from those that pay salary in-house. In the case of public hospital, no matter how each hospital uses up the federal funds each one will ultimately provide output using such financial inputs. In general, the output of a hospital in a perfect world is the total count of inpatient and outpatient that are successfully discharged with optimal satisfaction and expediency. McKellar et al. (2013) aptly explains this:

> "The annual output of the hospital industry is based on the total number of inpatient hospital discharges and outpatient hospital visits in a given year. Positive outcomes of hospital treatment are the most direct indicator of the quality of service, followed by expediency and comfort."

These positive hospital outcomes are difficult to keep track of as it would require the quantity of treatments being adjusted to the end result of that treatment - the quality of the services provided (McKellar et al., 2013). This measurement is infeasible simply because of data unavailability.

Valdmanis et al. (2008) uses bassinets, acute beds (i.e., the number of licensed and staffed beds minus the number of beds in nonacute units, such as long-term care), licensed and staffed ''other'' beds, FTE (full-time equivalent) RNs, licensed practical nurses (LPNs), medical residents, and other personnel as Inputs and used Medicare Case Mix Index (MCMI) adjusted admissions (MCMI admissions), total surgeries (inpatient 1 outpatient surgeries), total outpatient visits (ER visits 1 outpatient visits), total births, and total other patient days (i.e., patient days in nonacute care units) to measure Output. On the other hand, Caballer-Tarazona et al. (2010) used weighted admissions (Income*case-mix), First Consultations, Successive consultations, Number of surgical interventions as Outputs and the Number of Doctors and Beds as Inputs.

Furthermore, the argument in the literature about choosing the most representative variable (inputs and outputs) boils down to a choice between cost measures or physical measures. Depending on the context and judgement of the researcher, Banker, Das and Datar (1989) chose to use cost information (broken down by labour type and non-labour resources) to measure inputs. In contrast, Valdmanis (1992) and Burgess and Wilson (1993) chose to use physical inputs, such as the number of full–time equivalent staff by skill category; the number of beds as a proxy for

capital; the number of admissions; and the number of visits by physicians. This paper will use both cost and physical assets information to measure the efficiency of Hawaii Health System Corporation facilities. Provided that these hospitals are under the umbrella of one management (HHSC), all non-labor and labor costs are homogeneous which a typical requirement of DEA model. The study is from the perspective of HHSC corporate management therefore the focus of this analysis is the outcome of spending a certain amount of money to provide a given level of: patients' satisfaction, total revenue,

Given the above concerns about the selection design of the variables, this paper is being mindful in determining the inputs and outputs. Following the literature of hospitals efficiency studies in the U.S and other countries, this paper chose to use inputs and output variables outlined in the Table 1 below:

Table 1: Input and Output variables

Inputs	**Outputs**
Labor Cost	Patient Experience rating
Non-Labor Cost	Total Patient Days
Staffed Beds	Operating Revenue
FTE Employees	Total outpatient visits (ER visits + outpatient visits)
	Case Mix Index

In the case of Hawaii State public hospitals, Inputs and Outputs data were obtained from a variety of online health care databases. American Hospital Association (AHA) Annual Survey, Hawaii State Center for Nursing, State Inpatient Databases (SID) provided by the Healthcare Cost

and Utilization Project (HCUP), Medicare database, American Hospital Directory, Hawaii Health Information Corporation (HHIC), and the Bureau of Labor Statistics database are some of these direct sources of secondary data to use. Out of 13 public hospitals, 9 have complete datasets required to perform the analysis and therefore 4 are not included in the study.

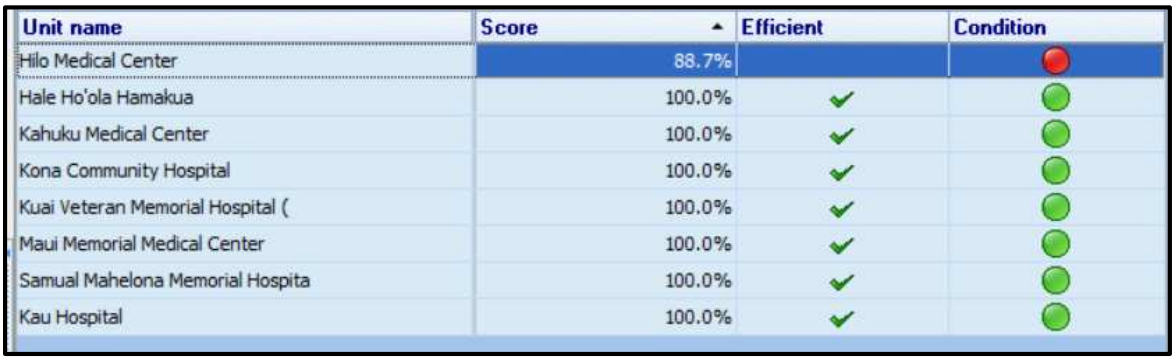
Methods

Data Envelopment Analysis is the analysis technique used to compute relative efficiency scores of each selected hospitals. Frontier Analyst software is used to generate all the required analysis outputs. The actual analysis is first carried out manually using Excel and then Frontier Analyst application was utilized to confirm the solution and to generate graphs and necessary tables more easily. Efficiency scores are generated which basically present the benchmark at which those within or below it have rooms to improve by adjusting either their inputs or outputs accordingly. The following Result and Discussion section explains more about that.

Result and Discussions

Table 1 below displays the efficiency of the Hawaii public hospitals in ascending order of efficiency. The red button bullet point in the ‘Condition’ column represents the inefficient hospitals. Clearly, it is found that only Hilo Medical Center is the only facility to be the least efficient hospital among the nine public hospitals studied.

Table 2: Efficiency Scores of selected Hawaii Public Hospitals (2015)



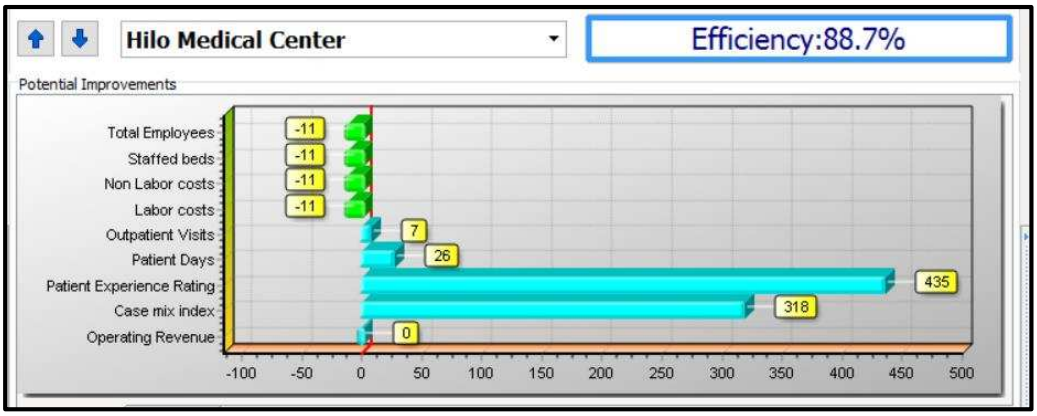
Unit name	Score	Efficient	Condition
Hilo Medical Center	88.7%		
Hale Ho'ola Hamakua	100.0%	✓	
Kahuku Medical Center	100.0%	✓	
Kona Community Hospital	100.0%	✓	
Kuai Veteran Memorial Hospital (	100.0%	✓	
Maui Memorial Medical Center	100.0%	✓	
Samual Mahelona Memorial Hospita	100.0%	✓	
Kau Hospital	100.0%	✓	

DEA does not just show an efficiency score for each hospital, it also allows us specify by how much and in what areas Hilo Medical Center(HMC) can improve on in order to be efficient (Cooper et al. 2011). This set of information should give HHSC the ability to set targets which as a solid guide to improve the concerning hospitals' performance. Since Hilo Medical Center is inefficient, it simply means that it can either produce its current level of outputs with fewer inputs (cost or input minimization) or produce/provide higher level of outputs using the same level of inputs (maximizing outputs). This potential improvement analysis is now provided for the inefficient hospital, Hilo Medical Center (HSM).

Hilo Medical Center

The Potential Improvement graph below shows the percentage that Hilo Medical Center needs to adjusts its inputs and outputs in order to become 100% efficient. For Hilo Medical Center, Graph 1 above shows that it need to reduce its: number of employees by 11%, staffed beds by 11%, non-labor costs by 11% and labor costs by 11% as well. While reducing such inputs by that amount, Hilo Medical Center also need to increase: outpatient visits by 7%, patient days by 26%, Patient experience ratings by 435%, case mix index by 318% and maintaining all its current level of operating revenue.

Graph 1: Hilo Medical Center's Potential Improvement Graph



To be more specific, table 3 below shows the targets for Hilo Medical Center to achieve full efficiency as its fellow facilities. The 'value' column shows the actual values of inputs used and values of output actually produced/provided by HMC. The 'Target' column shows the absolute values of inputs and outputs that HMC should use or produce in order to be on the efficiency frontier along with the rest of the hospitals (100% efficient). For example, Hilo has to reduce its total employees from 1150 to 1020 (a 11% cut), reduce its staffed beds from 276 to 245 and so forth in order to be as efficient as the other 8 hospitals.

Though these are very direct and specific guides for HHMS, it is important to note that some changes are simply impractical or that HMC will find it impossible to change for the sake of matching the higher performers Cooper et al. (2011). Also the changes suggested are not applicable for certain variables that DEA did not recognized. For example, a recommended change of 'patient experience rating' from 3 to 16 is not valid since the highest rating is 5. However, this result should give a clear way forward to adjust resources in a way that optimize outputs or minimize the costs.

Table 3: Target data for Hilo Medical Center

Input / output name	Value	Target	Potential impro
Total Employees	1150	1,020.28	-11.28%
Staffed beds	276	244.87	-11.28%
Non Labor costs	1189.17242	1,055.04	-11.28%
Labor costs	742.0151	658.32	-11.28%
Outpatient Visits	30243	32,475.07	7.38%
Patient Days	37542	47,670.23	26.98%
Patient Experience Rating	3	16.08	435.87%
Case mix index	1.32	5.53	318.68%
Operating Revenue	152.040122	152.04	0.00%

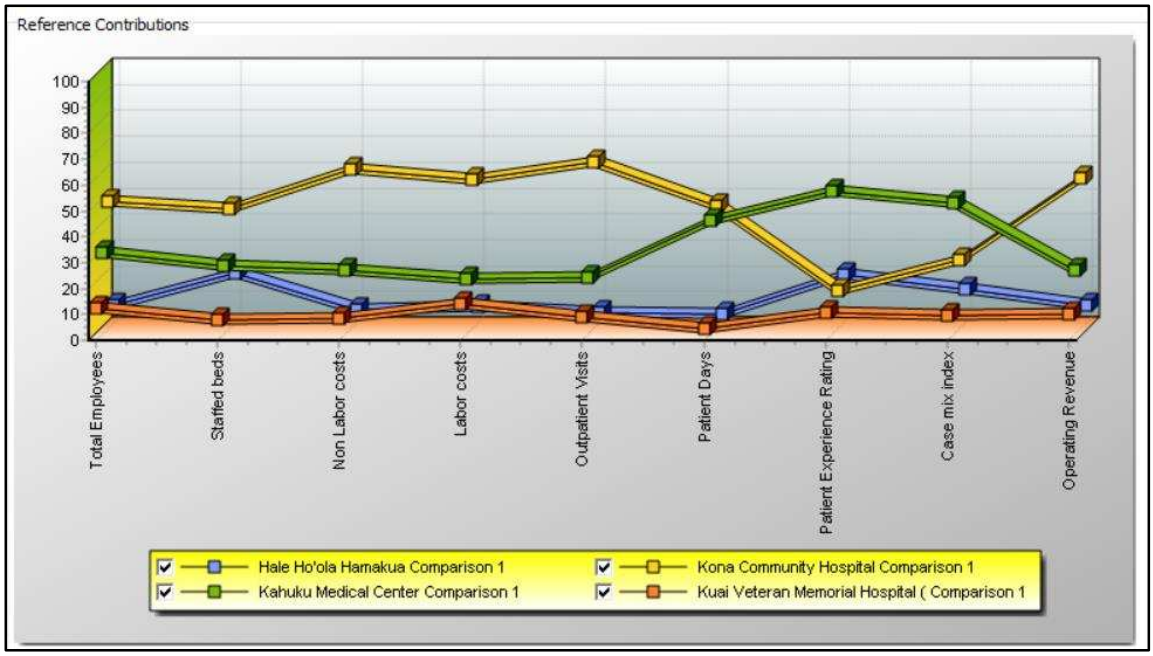
Furthermore, to set up a target values for HMC, it is important to examine the 8 efficient hospitals to find which one or more of them can provide an example of a "good operating practice" for HMC to "emulate". The fist first step to do that is to create a "reference set". A reference set is a list of efficient hospitals that have the "most similar input/output orientation to" to HMS input/out values. It is a set of efficient hospitals that HMC has been "mostly compared with when calculating its efficient rating.

Frontier Analyst generate a reference set for HMC as Hale Ho'ala Hamakua, Kahuku Medical Center, Kona Community Hospital and Kuai Veteran Memorial Hospital. Studying these four particular hospitals allows HHSC to better understand the nature of HMC's inefficiency. HMC's efficient score of 88.7% displayed in Table 2 is actually mean that it is operating 89% as efficiently as these four hospitals. HMC need to identify which one of the four hospitals is more important to look at for comparisons. However, according to Cooper et al. (2011), the efficient units (hospitals in this case) in the reference set of an inefficient unit do not contribute equally to the "target values" for that inefficient unit (or HMC). In other words, the target values provided in Table 3 are derived from hospitals listed in HMC's efficient reference set at different proportions.

Therefore, it is necessary to rank first those four hospitals in HMC's reference set to identify which one has the highest percentage contribution to HMS's target values.

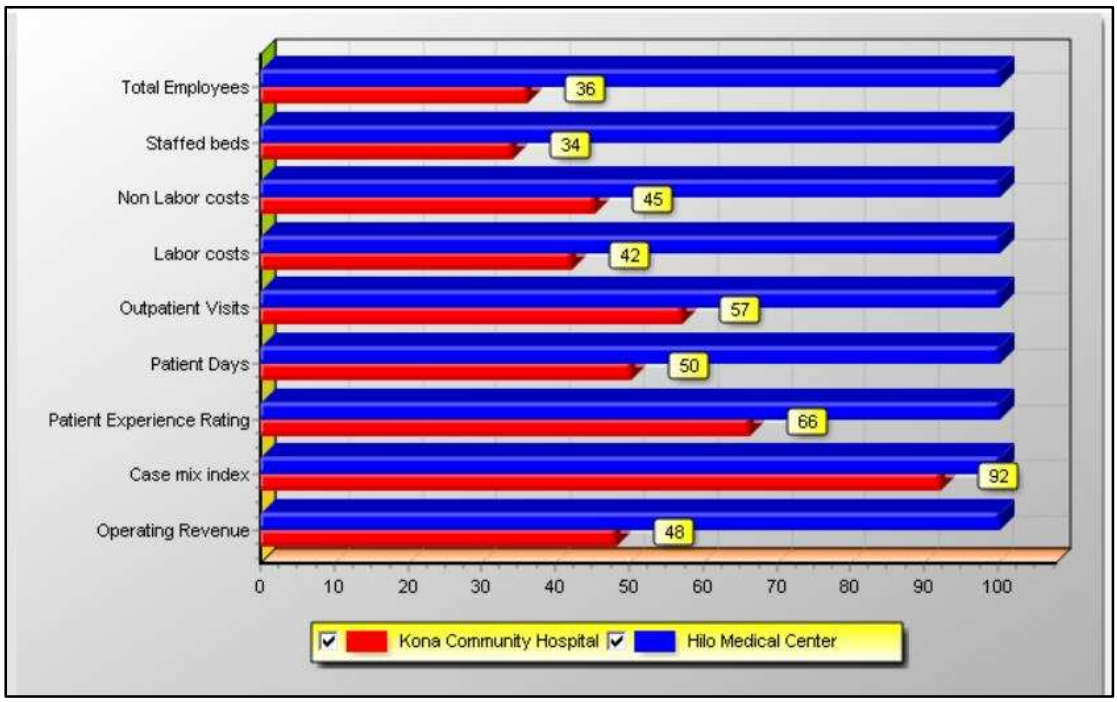
The hospital that predominates is the one that HMC should pay attention to. Clearly this process allows HHSC management to compare the inefficient facility with the one that is most similar to and thus save time from having to study all the 8 efficient hospitals or the other 3 hospitals in HSC's reference set. The Reference Contribution graph below (Graph 2) presents HSC's reference set and also shows that Kona Community Hospital is the biggest contributor to HMS's target values provided in Table 2. Based on these reasons, HHSC management doesn't need to spend time looking at any other hospitals to understand the nature of HSC's inefficiency record. Management can now compare HMC with Kona Community Hospital using the Reference Comparison graph below (Graph 3).

Graph 2: Reference Contribution graph for Hilo Medical Center



To allow a comparison, the input and output values for HMC are being scaled to 100% while corresponding input and output values for Kona Community Hospital are expressed as percentages of HMC's values and plotted as in Graph 3 below.

Graph 3: Reference Comparison graph for HMC (against Kona Community Hospital)

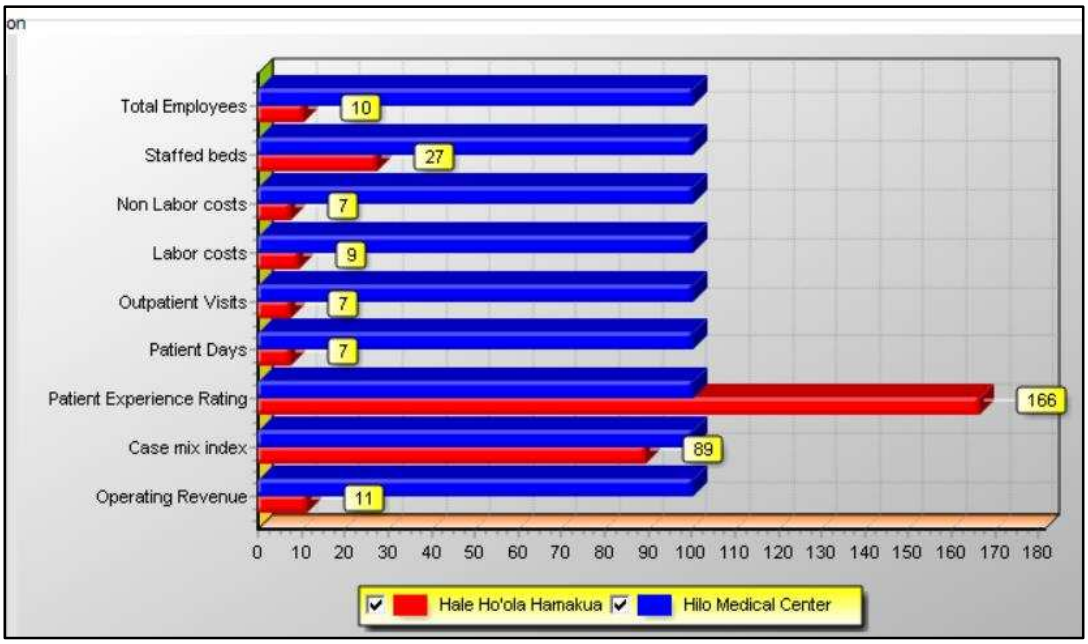


Graph 3 above shows that, virtually, KCH (Red bar) utilized only: 36%, 34%, 45% and 42% of HMC's employees, staffed beds, non-labor costs and labor costs respectively to produce or provide 57%, 50%, 66%, 92% and 48% of HMC's outpatient visits, patient days, patient experience rating, case mix index and operating revenue outputs respectively. These relative percentages between such inputs used and output generated between these two hospitals gives a clear sign of where HMC is inefficient and to what extent. For example, how and why KCM used a small portion of HMC's inputs (labor, beds etc.) to produce about the same level of 'case mix index'? These are the questions that HHSC can investigate to see why or how KCM produce almost

the same level of certain outputs (such as Case mix index) using a much lower level of inputs that KCM used. Depending on the context of the units of interest (DMUs), the quality of the data and relevance of the variables employed will produce a meaningful and important guide for specific actions to be made when it comes to these comparison and target values part of the analysis.

Finally, apart from KCM, Hale Ho'ola Hamakua can also be used to learn more about the inefficient score of HMC. Referring to Graph 4 you can quickly see that Hale Ho'oala Hamakua used less employees (only 10% of HMC's employees), less staffed beds, less labor and non-labor costs compared to HMC while Hale Ho'oala Hamakua provided a substantial level of patient experience rating (output).

Graph 4: Reference Comparison for HMC



This finding should hint HHSC management to look specifically at the quality and satisfaction of patients admitted to HMC. It reasonable to investigate why or how Hale Ho'oala Hamakua was able to obtain 166% of HMC's patient rating score (i.e. 66% higher).

Conclusion

Finally, this study looked very closely at nine of the 13 public hospitals active in the State of Hawaii, operated by Hawaiian Health Systems Corporation. The idea was to put these 9 hospitals in a one basket, look at their respective outputs and inputs and identify the ones that provided a higher output at a given level of inputs using Data Envelopment Analysis. The result identified Hilo Medical Center to be the one that falls below the benchmark and therefore labeled inefficient relative to the rest of the facilities in the study. The paper went forth on exploring more about the options that HHSC may consider as first moves to investigate their Hilo Medical Center performance. The paper also found Kona Community Hospital to be the closest facility to HMC that it can learn from. The paper also provided specific target values for each variable that HMC should aim for in order to reach the benchmark set by the other eight hospitals. Like most statistical tools, DEA also provides a guide for better decision making rather than final decisions to follow. The paper acknowledges that some specific recommendations may not be applicable in the real context of the problem. Further, this paper contributes some solid suggestions that wouldn't be acquired otherwise, without combining the actual data from the 9 hospitals using Data Envelopment Analysis. Overall, in light of HHSC's ongoing financial difficulties, the explicit results that this study put forward can be useful for HHSC's broader management to better understand the ambiguous problem within the system or among its regional facilities concerning relative efficiency.

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