# Efficiency Analysis of Health Care Facilities in Ibadan, Nigeria: A Data Envelopment Analysis Approach.

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**Abstract**

With paucity of resources and competitive challenges, the need for efficient utilization of available quantum of resources by the sectors of the economy including health is being emphasized. Efficiency of resource utilization tends to focus more on hospital operations, since they account for the bulk resources in the health sector. The objective of this study were (a) to estimate the relative technical and scale efficiency of hospitals in Ibadan in Oyo State, based on data for 2010-2012, and (b) to estimate the magnitudes of input reductions and/or output increases that would have been required to make relatively inefficient hospitals more efficient.

A Data Envelopment Analysis (DEA) method is used to estimate efficiency of the hospitals and to explain the inefficiencies. The efficient frontier and the hospital-level efficiency scores are estimated using DEA. The methodology tries to evolve the criterion from within the decision-making units rather than imposition from outside. The input (number of physicians, nurses, and beds) and output (maternal and child care, inpatients and outpatients) data were used in the estimating the efficiency scores to illustrate the potential value of such efficiency analyses.

The key findings are as follows: (i) the average pure technical efficiency of the hospitals consistently declined over the years, as the efficiency scores were 72.8%, 68.2% and 65.1% for years 2010, 2011, and 2012 respectively; (ii) between 31% and 33% of the hospitals operated within technical efficiency range of 0.50 and less than 0.90, while between 33% and 46% of the hospitals operated within the technical efficiency score of greater than 0.90; and (iii) on the average between 2010 and 2012, the inefficient hospitals could have become more efficient by either increasing their outputs by 1524 (2.7%) inpatients admissions, 65,333 (12.3%) outpatient visits, and 8621 (10.3%) maternal and child care, or by transferring the excess 11 (1%) physicians, 23 (1%) nurses, 47 (3%) to other types of health facilities.

The existence of inefficiency resource slack among some of the HCFs is a pointer to the fact the available resources can be better utilized to positively impact the health of the population than applied in those years. Policy actions are required to explore the full potential of the services the available resources can provide. The hardship of dwindling resources can be minimized by improving the efficient use of allocated resources by hospitals.

Keywords: Technical efficiency, Scale efficiency, Health care facilities, DEA, Health inputs, Health outputs

## Introduction

Globally, there has been an increasing pressure on healthcare system to improve performance by controlling healthcare costs without compromising the quality of the provided services. While this has become particularly so, following the outbreak of the recent global economic crisis, in the case of Nigeria, the recent free fall of global oil prices, has specifically led to tightening of public budgets that have also affected healthcare. For a country that depends on oil proceeds as main revenue source, the drastic fall in oil prices in the last three to four years has put the Nigerian government, and most especially her component states under pressure. Nigeria as a federation, in addition to federal government, is composed of 36 states and 774 local government areas sub-units that shares revenue from oil-revenue-dependent joint federation account. Prior to the current oil glut experience, the relative adequacy of resources available to governments and the strong purchasing power of consumers appears to have beclouded the need for efficient use of resources by public agencies, and the push for value for money by consumers from private establishments. Consequent on the dwindling federal allocations, in the last one year, many of the states in the country, including Oyo State have been defaulting in payment of workers' salaries, and slowed down the social and infrastructural facilities development, which has negatively affected the purchasing power of households. Thus the major current challenges of state governments in the country are tightening budget and increasing pressures on the efficiency of public spending. One of the major concerns of mainstream economic theory is the efficient use of scarce resources, and efficiency measurement is a useful tool for making choices between alternatives. With the little available resources, demand for efficient use of resources has become more apt than ever before in all sectors and health is no exception. Healthcare industry is no exception to the many industries facing new challenges created by global competition. The challenge of reconciling growing demand for healthcare services with available funds is increasingly faced by decision makers. In setting priority, economists are of the opinion that the achievement of (greater) efficiency from scarce resources should be a key condition. Health outcomes gained from the resources allocated to healthcare are maximized when the criterion of economic efficiency is adopted by the society. To enhance efficient use of scarce resources, cost-containment measures are increasingly being adopted. With the importance of healthcare costs issue, healthcare research has commonly applied cost improvement or cost containment as a performance measure.

As an important component of health sector and accounting for the bulk of the sector's resources, hospitals are under increasing pressure to improve their performance and a variety of approaches have been used to assess performance in the healthcare management literature. The indicators of relative efficiency are necessary to gauge the possible success of cost-containment efforts in hospitals. Likewise, the private health sector is increasingly being confronted with the urge to get value for money by consumers. Thus the need to design methods to evaluate hospital performance is increasingly being given prominence in the face of resource constraints. Ranking efficient hospitals against their inefficient counterparts constitutes a benchmark for policy makers to discover and reduce potential inefficiencies, as well as identify measures to be adopted to compensate efficient hospital managers.

The healthcare system in Nigeria is operated by both public and private facilities, and composed of three tiers of care at primary, secondary, and tertiary levels. Though the country's healthcare system is dominated by primary facilities in terms of number, the bulk of resource usage and patients' attendant in the sector is accounted for by hospitals. While there are more private hospitals than public hospitals, the latter is on the average larger in capacity, being several folds the size of average private hospital. Nigerian hospitals (the dominant part of curative care) absorb the greatest proportion of the total health expenditure (THE), which is estimated at 75 –81% of THE [1]. The situation is not different in Oyo State and the state capital (Ibadan[1]), where around 75% of health sector resources are devoted to hospitals. While the government of Oyo State continues to provide massive support to existing as well as new projects in order to see that health services are accessible to all people at all levels of care, more than 52% of the state healthcare industry operates in Ibadan. The Oyo State yearly THE increased by an average of about 15% from N17.7 million in 2003 to N23.2million in 2005, with the household accounting for more than 60% [1]. Given the paucity and opportunity cost of resources, it is imperative for health facilities in Ibadan and Oyo State to ensure optimal utilization of resources in providing health care services. Given hospital dominance, the impact of the current resource constraints on the population health is bound to work more through operation of hospitals. Apparently the gap in the literature here lies in the absence of studies

[1] Ibadan is the third largest city in Africa, and shares one -third of the local government areas in the Oyo state.

focusing on efficiency of health facilities at any level in Ibadan. This paper therefore estimates the relative technical and scale efficiency of 52 (public and private) secondary hospitals[2] in Ibadan, the Oyo State capital, based on data for 2010-2012, as well as the magnitudes of input reductions and/or output increases that would have been required to make relatively inefficient hospitals more efficient, using Data Envelopment Analysis (DEA).

**Literature Review**

Concept of Efficiency

Efficiency has been generally defined as the allocation of scarce resources that maximizes the achievement of aims [2]. Efficiency analysis of a production or service unit refers to the comparison between the outputs and inputs used in the process of producing a product or services. According to [3], efficiency relates to how best a firm utilizes the resources (inputs) to produce the desired products or services (outputs), which is indicative of the success of the firm. Efficiency is defined as success in producing as large as possible an output from a given set of inputs [4]. Generally, efficiency measures whether resources are being used to get the best value for money.

The conceptual discussion of measuring efficiency is attributed to [5, 6], while empirical measure of efficiency was pioneered by [4], who according to [7] classified efficiency into the two components of technical efficiency (TE) and allocative efficiencies (AE), both of which constitute the components of economic efficiency. A firm is technically efficient if it is impossible to produce more of an output without producing less of some other outputs or using more of some inputs [6]. The ability to avoid waste, either by producing as much output as technology and input usage allow or by using as little input as required by technology and output production is the focus of technical efficiency. By implication, there can be an output augmenting orientation or an input conserving orientation dimension to the analysis of technical efficiency. Technically inefficient producer could use the same inputs to produce more of at least one output, or could produce the same outputs with less of at least one input. TE reveals the ability of firms to employ the 'best practice' in an industry, such that no more than a given level of output can be produced using the minimum level of input.

[2] The hospitals are of secondary level because they all offer inpatient services (patients on admission) but not engaged in medical training or research programmes, which is an attribute of tertiary hospitals.

On the other hand, AE refers to the optimal combination of inputs and outputs at a given price. The ability to combine inputs and/or outputs in optimal proportions in light of prevailing prices is the focus of allocative efficiency. Optimal proportions satisfy the first-order conditions for the optimization problem assigned to the production unit. Allocation of resources is considered efficient when the output from the last unit of resources is the same for different Decision Making Units (DMUs).

In the health context, efficiency is concerned with the relation between resource inputs (labour, capital, material, or equipment) and health outcomes (e.g. numbers of patients treated, lives saved). Existence of inefficiency is indicated by possible reallocation of resources in a manner that results in increase in health outcomes produced. Technical efficiency of hospital or health facility refers to the physical relation between health resources (capital, labour, and materials) and health outcome.

Measurement of Efficiency[3]

While various approaches to measuring efficiency is prescribed in the literature, the difference between them lies in the assumptions made on the frontier functional form, extent to which random error is accounted for, and the probability distribution assumed for the inefficiencies in the presence of random error [8]. Zainal and Ismail [3] identified two approaches to measuring efficiency as parametric or non-parametric approaches.

*Parametric approach*

Parametric approach presumes an explicit functional form to estimate the frontier of either cost or profit functions. When estimating the efficient frontier, the approach accounts for random disturbance along with inefficiency residuals [9]. Parametric approach comes in three major frontier techniques, which are stochastic frontier approach (SFA), distribution-free approach (DFA) and thick frontier approach (TFA). SFA, which was developed by [10] and also known as econometric frontier approach. It specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and allows for random error [8]. It incorporates both the stochastic and inefficient terms, with the formal having a distributional assumption depicted by two-sided normal distribution, while the distribution of the latter is one-sided.

[3] For a comprehensive review of efficiency measures see Zainal and Ismail (2010).

Berger [11], in response to the criticisms of SFA developed the DFA, which also specifies a functional form for the frontier, but separates the inefficiencies in a different way, with the assumption that the efficiency of each firm is stable and does not change over time. With studies like [12, 13, 14] applying the technique, no specific type of distribution of the inefficiency term is set. Proposed by [8], TFA involves the estimation of the cost function of firms in the lowest average cost quartile of the industry (thick-frontier), and compares it with the highest average cost quartile of the industry [9]. It then decomposes the deviations into random noise and inefficiency residual. The random error is assumed to be represented by the deviation from the predicted costs of each quartile, while inefficiencies are denoted by the differences between the lowest and the highest average cost quartiles. TFA does not enforce any distributional assumptions on inefficiency as well as random error, and does not provide exact estimates of efficiency for individual firms [8]. However, TFA constitutes the least popular of the parameter techniques, with limited application by studies such as [15, 16]. Generally, the imposition of a specific functional frontier form, which could be subject to mis-specification constitute the main drawback of parameter approach.

*Non-parametric approach*

Devoid of specific functional form and random disturbance/error, the non-parametric, also referred to as linear programming approach, estimates the best practice frontier/firms, against which relative efficiency of other firms is used to identify the less efficient firms. Since each firm's data cannot lie above the estimated maximum production or fall below the minimum cost function, the inefficiency residuals are obtained as strictly one-sided deviation from the frontier data, being negative for output-oriented model, and positive for input-oriented model [8]. The two techniques under non-parametric approach are data envelopment analysis (DEA) and free disposal hull (FDH) approaches.

Developed by [17], DEA constitute a reformulation of Farrell's idea into mathematical problem. It is defined as "a linear programming technique where the set of best-practice or frontier observations are those which no other decision making unit or linear combination of units has as much or more of every output (given inputs) or as little or less of every input (given outputs)" [8]. The DEA basic concept is that the efficiency of each member of a set of DMU, in a field, is evaluated against its own performance and that of each of the other members of the field. An efficiency frontier is formed by the efficient DMUs in the combination of all dimensions, while the less efficient DMUs are described by a number indicative of their distance from the frontier.

Given the nature of the DEA technique, assumptions about the functional form of the production function are not necessary, while only information about quantities is required. Because of the homogeneity requirements it is often acknowledged that the most difficult thing is to compare efficiency level among and across the hospitals.

DEA frontier is shaped as the piecewise linear combinations that join the set of these best practice observations, ceding a convex production possibilities set [3]. According to [8], DEA computes a ratio of outputs to inputs for each decision making unit (DMU) and the result is reported as the relative efficiency score which ranges between zero and one or 0 and 100 percent. Major positive attribute of DEA includes non- requirement of explicit specification of the form of the underlying production relationship [8]; non-requirement of information about the process or relationship between the inputs and output [18], and ability to create prospective improvements for inefficient units and identify the units for benchmarking [10]. Examples of new studies using DEA approach can be found in [19, 20, 21, 22].

According to [9], FDH, which does not take into account the convexity assumption, was introduced by [23]. FDH production possibilities set is composed of only the DEA vertices and the free disposal hull points interior to these vertices [3]. FDH considers the variation of efficiency over time and makes no assumption as to the type of the distribution of the inefficiency component, and thus the measured distance between the estimated observation and the frontier is wholly considered as inefficiency [9]. Among the few application of the technique include [24] and [25]. DEA and SFA are the most prominent techniques in the literature, with the former being more prominent.

## Methods

Theoretical Underpinning and Assumptions of DEA

To avoid hospital production function misspecification problem, this paper applies the DEA technique. The underlining concept of DEA is based on Pareto Optimality [26]. Decision making units (DMUs) which can produce at least the same amount of all outputs with less of one input and not more of any other input are taken to be inefficient [27]. Each health care facility is considered as a

DMU. DEA employs linear programming techniques to measure efficiency as the distance of each firm from a nonparametric production frontier constructed from convex combinations of observed input-output combinations. It involves construction of a piece wise linear-segmented efficiency frontier based on best practice. The underlining assumptions of DEA include: All actual observed inputs and outputs of any health care facility are feasible for all HCFs. All linear combinations of observed inputs and outputs are feasible. Free disposal of inputs and outputs is assumed.

The DEA measure of efficiency can be presented either as an Input-Oriented Model or Output-Oriented Model. While the former centres on how much input(s) could be proportionally reduced to reach the frontier, keeping output constant, the latter focus on how much output could proportionally be expanded to reach the frontier, keeping input constant. The mathematical modelling of DEA can either be Charnes, Cooper and Rhodes (CCR), or Banker, Charnes and Cooper (BCC). CCR assumes constant return to scale (CRS), with restrictive assumption on technology, while BCC assumes a variable return to Scale (VRS), with less restrictive assumption on technology.

DEA Model Specification

This study employs both the CCR and BCC input-oriented models on 52 secondary hospital DMUs with each DMU having s outputs and m inputs (where s = 3 and m = 3). Fundamentally the extent of the homogeneity of the hospitals included in the study has implication on the results. In the absence of information about case-mix, case severity, and quality of health care, there is no means a complete representation of hospital operation can be made, bearing in mind that dissimilar cases have dissimilar resource implications. The consequence of this step is that while measuring efficiency and productivity, hospitals are not penalised for using more resources due to treatment of more severe or complicated cases. However, this requires high levels of statistical information, which were not available and hence, we selected this model specification which is consistent with the literature in terms of the selection of inputs and proxy outputs [28]. Generally, output of hospitals is difficult to capture in discrete countable units, because it is multiple and heterogeneous. DEA analysis requires the homogeneity of inputs and outputs across DMUs; however, the mix of skilled and unskilled workers do often vary significantly across hospitals, and similarly the characteristics of physical capital. This is often addressed in the literature by concentrating on the set of inputs and outputs that are common to the decision making units, to promote some degree of homogeneity among the hospital.

The operations of hospitals can be represented by means of input-output models in which quantities of inputs are used to generate outputs in the form of healthcare services. This study imposes the strong as homogeneous. The production process utilises medical sumption that capital and labour are material, labour resources, such as doctors and nurses, and capital resources, such as buildings and technologies, approximated in the number of beds.

Analogous to the variables used in similar studies we specified as labour inputs the number of physicians and the number of nurses, and the number of beds, which is assumed to be a proxy measure of capital content. In order to increase the homogeneity of outputs, the number of inpatient discharges, the number of outpatient visits, and the number of maternal and child care services, which common to all hospitals are included. This study is therefore limited to analysis of the efficiency of the secondary hospitals. These sets of inputs and output serve as homogeneity platform for the study. For the DMU0, the model is specified as:

$$Max\ E_0 = \sum_{j=1}^{3} u_j\, y_{j0} + u_0;\ \ \text{s.t} \sum_{i=1}^{3} v_i\, x_{i0} = 1$$
$$\sum_{j=1}^{3} u_j\, y_{jk} - \sum_{i=1}^{3} v_i\, x_{ik} + u_0 \ \le 0;\ v_i \ \ge\ 0,$$
$$u_j \ \ge\ 0, u_0 \text{ is free in sign} \qquad (1)$$

where $E_0$ is the efficiency score for $DMU_0$, $x_{i0}$ is the quantity of input i used by $DMU_0$, $y_{j0}$ is the quantity of output $x_{i0}$ produced by $DMU_0$, $x_{ik}$ is the actual amount of input $i$ used by efficient $DMU_k$, $y_{jk}$ is the actual amount of output $j$ produced by efficient $DMU_k$, and $u_i$ and $v_i$ are the weights attached to output $j$ and input $i$. $E_0$ equals 1 if $DMU_0$ is efficient and $E_0$ is less than 1 if otherwise. The inputs are number of physicians, number of nurses and number of beds while the outputs are number of inpatients, number of outpatients and number of maternal and child care.

The overall technical efficiency of a health DMU can be broken down into pure technical efficiency and scale efficiency. Pure technical efficiency denotes health decision making unit technical efficiency that cannot be attributed to deviations from optimal scale, while scale efficiency is a measure of the extent to which a health decision making unit deviates from optimal scale. The technical efficiency scores obtained from the CRS DEA was decomposed into two components, one due to scale inefficiency and the other due to pure technical inefficiency. If there is a difference in the technical efficiency scores obtain from both a CRS and a VRS DEA for a particular DMU, this gives an indication that the DMU has scale inefficiency. The scale efficiency is equal to the ratio of the CRS technical efficiency score to the pure technical efficiency score. Moreover, scale efficiency value does not give indication to whether the DMU is operating in an area of increasing or decreasing returns to scale. To determine this, an additional DEA problem is run with non-increasing returns to scale (NIRS) condition imposed. This is done by altering the DEA model in equation (1) to provide:

$$Max\ E_0 = \sum_{j=1}^{3} u_j\, y_{j0} + u_0; \qquad \text{s.t} \sum_{i=1}^{3} v_i\, x_{i0} \leq 1$$

$$\sum_{j=1}^{3} u_j\, y_{jk} - \sum_{i=1}^{3} v_i\, x_{ik} + u_0 \leq 0;\ v_i \geq 0,$$

$$u_j \geq 0, u_0 \text{ is free in sign} \qquad (2)$$

Comparison is made between NIRS TE score and the VRS TE score to determine the nature of the scale inefficiencies (i.e. due to increasing or decreasing returns to scale) for a particular DMU. If the scores are equal, then decreasing returns to scale apply and if the scores are unequal, then increasing returns to scale exist for that DMU.

Data and Analytical Technique

Data for this study is based on information from 52 health facilities in Ibadan, Oyo State, which is one of the six states that make up the South West Geo-political zone of Nigeria. Covering an area of 3,080 square kilometers, with a population of more than 3.8million people (2006 census figures), Ibadan accounts for 11 LGAs of the 33 LGAs in Oyo State, and has more than half of the state population, and 37% (123 public and private HCFs) of the HCFs in the state. The data collection process follows a systematic random sampling technique covering a representative sample of 49 private and the 3 public[4] HCFs in Ibadan. The data collection instrument used is based on a structured questionnaire to collect information on inputs and outputs of the HCFs. Three outputs were identified for the DEA model: maternal and child care (including antenatal care, postnatal care and child immunization), inpatients and outpatients, while inputs are measured by number of physicians, nurses, and beds (Table 1).

[4] The three public hospitals are owned by state government in the city of Ibadan. The only public hospital owned by the federal government, excluded from this study is of tertiary level status.

**Table 1: Input and Output Variables and Operating Definitions**

| **Input Variables** | **Operating Definitions** |
|---|---|
| Number of Physicians | The yearly total number of physicians who are full-time employees (FTEs) during January 2010 to December 2012 |
| Number of Nurses | The total number of nurses (including midwives) who are full-time employees (FTEs) during January 2010 to December 2012 |
| Number of Beds | The yearly total number of staffed beds (beds that are licensed and physically available for which staff is on hand to attend to patients who occupies the beds) during January 2010 to December 2012 |
| **Output Variables** | **Operating Definitions** |
| Number of Inpatients | The yearly total number of patients receiving inpatient treatment services during January 2010 and December 2012, excluding patients' antenatal related services. |
| Number of Outpatients | The yearly total number of outpatient visit to HCF during January 2010 to December 2011, excluding patients' antenatal related services. |
| Number of Maternal and Child care | The yearly total number of patients receiving antenatal, postnatal and child immunization treatment services during January 2010 and December 2012 |

The technical efficiency score was computed using the DEA programme, version 2.1 (DEAP 2.1) designed by [29]. The variable returns to scale (VRS) input-oriented model was used in this study since the decision to or not to use HCF services is at the discretion of the patient (consumer). The decision, therefore, is an exogenous factor that may not be controllable by HCF managers. Moreover, it is thought that since most HCFs aim is to achieve a higher level of services for the patients through the use of fewer scarce resources, the BCC input-oriented model is most appropriate for this study.

**Results**

This study utilizes three measures for each of the input and output variables. Though DEA allows for engagement of zero quantity of an input or output by any of the DMUs, the health facilities included in the study are characterized by positive quantities of the three inputs and output variables. As shown in table 2, it was observed that an average of 5 physicians are employed by the health facilities included in this study. The least number of physicians employed by any of the health facilities is 2, while a maximum is 19 physicians. An average of 13 nurses are employed in the health facilities, while the least is 5 HCFs and the highest number of nurses employed is 46. Average bed size of the health facilities covered is 14, while the least and maximum being 4 and 31 beds, respectively. The average. The descriptive statistics of the output variables in the health facilities reveals that an annual average of 3,312 inpatient clients were attended to, while the facility with the minimum inpatients output is 1,032 and as high as 11,879 as maximum. For the outpatient visits to the health facilities, an annual average of 21,783 patient visits were attended, while the facility with the least inpatient output handled 5,839, and maximum outpatient visit recorded is 45,811 per annum. The maternal and child care output of the facilities averaged 1,318 per annum, with minimum and maximum of 472 and 4,609 per annum, respectively (see Table 2). It should be noted that inpatient services provided to mother and child within the natal period, are excluded from the inpatient output counts for the facilities.

**Table 2: Descriptive Statistics of Input and Output Variables (2000 – 2001)**

| | **Mean** | **Minimum** | **Maximum** | **Standard Deviation** |
|---|---|---|---|---|
| **Input Variables** | | | | |
| Number of Physicians | 5 | 2 | 19 | 7.34 |
| Number of Nurses | 13 | 5 | 46 | 10.55 |
| Number of Beds | 14 | 4 | 31 | 8.45 |
| **Output Variables** | | | | |
| Number of Inpatients | 3,312 | 1,032 | 11,879 | 2,678 |
| Number of Outpatients | 21,783 | 5,839 | 45,811 | 8,901 |
| Number of Maternal and Child care | 1,318 | 472 | 4,609 | 2,654 |

Individual HCFs' pure technical and scale efficiency scores during the three years are presented in Appendix A. Twenty-three (44%), nineteen (37%), and seventeen (33%) hospitals exhibited pure technical efficient, scoring 100% in 2010, 2011, and 2012, respectively. The remaining twenty-nine (56%), thirty-three (63%) and thirty-five (67%) of the hospitals are inefficiently ran over the same period, with varying degree of inefficiency. Average pure technical efficiency scores of hospitals covered were obtained as 72.8%, 68.2% and 65.1% for years 2010, 2011, and 2012 respectively. However, majority of the HCFs does not exhibit consistency over the period. For instance, only 4 HCFs exhibited overall technical efficiency and scale efficiency of 100% consistently for the years 2010, 2011, and 2012 (Appendix A).

The grouped percentage distribution of the HCFs by technical efficiency estimates are further presented in table 3. The result shows that over the period, substantial number of the HCFs (between 30.8 and 32.7 percent) operated within overall technical efficiency range of 0.50 and less than 0.90, while between 32.7 and 46.2 percent of the HCFs operated within the overall technical efficiency score of greater than 0.90.

**Table 3: Percentage Distribution of HCFs by Technical Efficiency Estimates**

| | **2010** | | **2011** | | **2012** | |
|---|---|---|---|---|---|---|
| **Efficiency Estimates** | **Frequency** | **Percentage** | **Frequency** | **Percentage** | **Frequency** | **Percentage** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.01<0.10** | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| **0.10<0.50** | 12 | 23.08 | 15 | 28.85 | 18 | 34.62 |
| **0.50<0.90** | 16 | 30.77 | 17 | 32.69 | 17 | 32.69 |
| **≥0.90** | 24 | 46.15 | 8 | 34.50 | 17 | 32.69 |
| **Minimum efficiency** | 0.25 | | 0.26 | | 0.19 | |
| **Maximum efficiency** | 1.00 | | 1.00 | | 1.00 | |
| **Mean efficiency** | 0.73 | | 0.68 | | 0.65 | |

Demonstrating the nature of scale exhibited by the operating HCFs covered, the number of HCFs operating under constant, increasing, and decreasing returns to scale technical efficiency is reported in Table 4. Out of the 52 HCFs, four HCFs, which represent 7.7%, in each of the years 2010 to 2012 demonstrated constant returns to scale (CRS). Within the scope of increasing returning to scale, majority of the HCFs: forty-six (88.5%), and forty-one (78.8%) were found to exhibit increasing returns to scale (IRS) or sub-optimal scale, in the first two years (2010 and 2011), and 2012, respectively.

**Table 4: Distribution of Health Facilities by Return to Scale**

| **Year** | **Types of Return** | | | |
|---|---|---|---|---|
| | IRS | CRS | DRS | TOTAL |
| **2010** | 46 | 4 | 2 | 52 |
| **2011** | 46 | 4 | 2 | 52 |
| **2012** | 41 | 4 | 7 | 52 |

The grouped percentage distribution of the HCFs by scale efficiency estimates is presented in table 5. While the distribution of the scale scores slightly differs across the years, majority of the HCFs (57.69%, 53.85%, and 55.7% in 2010, 2011, and 2012, respectively) operated within a scale efficiency range of 0.10 and less than 0.50. Relatively lower proportion of the HCFs (between 26.92% in 2012 and 32.69% in 2010) operated at score of 0.50 and above.

Though in the short run, HCFs may operate with increasing returns to scale (IRS) or decreasing returns to scale (DRS), HCFs must shift towards constant returns to scale (CRS) to be efficient in order to achieve the desired increase in efficiency of health service delivery in Ibadan in the long run. The required output increase and input reduction for each inefficient HCFs to be efficient during the period of study is reported in Appendix B. These figures are estimations from the input slacks and output target under the VRS specification. The inputs slack is the amount of excess number of inputs used in the outputs production. In other words, the output levels realized could still have been realized if the number of inputs in the production had been reduced by input slacks.

**Table 5: Percentage Distribution of HCFs by Scale Efficiency Estimates**

| | **2010** | | **2011** | | **2012** | |
|---|---|---|---|---|---|---|
| Efficiency Estimates | Frequency | Percentage | Frequency | Percentage | Frequency | Percentage |
| 0.01<0.10 | 5 | 9.62 | 10 | 19.23 | 8 | 15.38 |
| 0.10<0.50 | 30 | 57.69 | 28 | 53.85 | 29 | 55.77 |
| 0.50<0.90 | 9 | 17.31 | 6 | 11.54 | 4 | 7.70 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ≥0.90 | 8 | 15.38 | 8 | 15.38 | 11 | 21.15 |
| Minimum efficiency | 0.03 | | 0.05 | | 0.05 | |
| Maximum efficiency | 1.00 | | 1.00 | | 1.00 | |
| Mean efficiency | 0.41 | | 0.73 | | 0.40 | |

The total input reductions and/or output increases needed to make inefficient HCFs efficient are reported in Table 6. In 2010, the inefficient HCFs combined could become efficient by reducing the number of physicians by 7 (1 percent), number of nurses by 23 (1 percent) and number of beds by 63 (4 percent). Otherwise, the inefficient HCFs would need to increase number of inpatients by 1,382 (2 percent), number of outpatients by 40,515 (9 percent), and number of maternal and child care by 6,833 (11 percent) so as to become efficient. In 2011, the inefficient HCFs combined would need to reduce the number physicians by 10 (1 percent), number of nurses by 24 (1 percent) and number of beds by 31 (4 percent) in order to become efficient. Instead, the inefficient HCFs could become efficient by increasing the number of inpatients by 1,527 (3 percent), number of outpatients by 32,871 (6 percent), and number of maternal and child care by 6,623(9 percent). The results for 2012 shows that the inefficient HCFs combined could become efficient by reducing the number of physicians by 16 (1 percent), number of nurses by 22 (1 percent) and number of beds by 48 (3 percent). Alternatively, the inefficient HCFs would need to increase number of inpatients by 1,664 (3 percent), number of outpatients by 122,613 (22%), and number of maternal and child care by 18,408 (21%) so as to become efficient.

**Table 6: Total Output(input) Increases(Reductions) Needed to make Inefficient HCFs Efficient**

| | **2010** | | **2011** | | **2012** | |
|---|---|---|---|---|---|---|
| | Actual Values | Shortfall/Excess | Actual Values | Shortfall/Excess | Actual Values | Shortfall/Excess |
| Number of Inpatients | 42,727 | 1,382 (2%) | 47,689 | 1,527 (3%) | 56,000 | 1,664 (3%) |
| Number of Outpatients | 465,039 | 40,515 (9%) | 514,879 | 32,871 (6%) | 550,848 | 122,613 (22%) |
| Number of Maternal & Child care | 59,807 | 6,833 (11%) | 71,561 | 6,623 (9%) | 86,137 | 18,408 (11%) |
| Number of Physicians | 1,136 | 7 (1%) | 1,170 | 10 (1%) | 1,215 | 16 (1%) |
| Number of Nurses | 1,772 | 23 (1%) | 2,274 | 24 (1%) | 2,533 | 22 (1%) |
| Number of Beds | 1,730 | 63 (4%) | 1,749 | 31 (2%) | 1,941 | 48 (3%) |

**Discussions**

As expected, the labour mix reflect the standard relative composition by the physician and nursing staff. Across the health facilities, more number of nurses are combined with fewer number of physicians. Since it takes relatively longer time to attend to inpatients, compared to outpatients, the number of outpatients treated is generally greater among the health facilities covered in the study. For the maternal and child health, it should be noted that the healthcare services rendered may or may not require admission of patients overnight in the hospital, thus the number of this category of patients is relatively higher than inpatients, and lower than outpatients visit.

The reported technical efficiency scores for HCFs covered in this study generally indicate that the hospitals are not utilizing their production resources efficiently, meaning they are not annexing maximal output from their given quantum of inputs. In other words, technical efficiency of the hospitals can be increased by 27.2%, 31.8% and 34.9% in 2010, 2011 and 2012, respectively through better use of available production resources (inputs), given the current state of technology. The pure technical efficiency findings imply that if run efficiently, the inefficient hospitals could, on average, have produced their current levels of output with 27.2%, 31.8% and 34.9% less inputs (number of physicians, number of nurses and number of beds, respectively) than they were currently using. However, it would have been more ideal to further investigate the relative quality of services provided by these hospitals. The average pure technical efficiency scores are comparable to those estimated in other health facilities efficiency studies in Africa. These scores were higher than those obtained by [30] and [31] for hospitals in Angola (65.8%) and Ghana (67%), respectively. However, the scores were fairly similar to those obtained in Zambia (67%) by [32], Benin (63.3 – 85.8%) by [27], Kenya (84%) by [33], Namibia (74.3%) by [34], and three Cape Provinces of South Africa (82 – 82.8%) by [35]. Technical efficiency scores obtained for Kwazulu-Natal Province of South Africa (90.6%) and Uganda (90.2 – 97.3%) Uganda by [36], and [37], respectively is significantly higher than those obtained for HCFs in this study.

The obtained result of only 4 HCFs exhibiting overall technical and scale efficiency can be adduced to the fact that HCFs have little or no influence on the demand for their outputs. Thus the reflected inefficiency for many HCFs in some year(s) may not be born out lack of preparedness to service patients but as a result of underutilization due to drop in demand for one or the other healthcare service outputs. The existence of large scale inefficiencies among the HFCs is indicative of the fact that many of the facilities are not operating optimally. With majority of the HCFs having scale efficiency between 0.1 and 0.90, there are indications that majority of the facilities are not scale efficient. With average scale efficiency between 40% and 73%, it means that on the average, the size of the scale inefficient hospitals could be reduced by between 60% and 23%, while their current output level remains unaffected. Based on the reported scale efficiency score, we can infer that increasing the quantity of all HCFs inputs by a certain proportion is expected to result in the following outcomes:

- Constant returns to scale in 4 (7.69%) HCFs meaning increasing their input by certain proportion, their health service outputs would increase by the same proportion. These are HCFs that were operating at their most productive scale sizes.
- Increasing returns to scale in 44 (84.62%) HCFs mean that their health service outputs would increase by a greater proportion relative to proportional increase in inputs. Required of these HCFs is the need to increase their size to achieve optimal scale, i.e. the scale at which there is constant returns to scale in the relationship between inputs and outputs.
- Decreasing returns to scale in average of 4(7.29%) HCFs imply that their health service outputs would increase by a smaller proportion relative to proportional increase in inputs. These HCFs would need to reduce their size to achieve optimal scale.

On the whole majority of HCFs are within the increasing returns to scale region which implies existence of inherent capacity for expansion of operation by the HCFs. One health policy decision tool to address inefficient resource use by majority of the HCFs is by increasing coverage of health services. Though, cutting back on the available inputs is another way out, it may not be optimal choice in an environment where health care demand of the population is currently being inadequately met. Also crucial is the reported nature of scale with which the sampled HCFs operated, because in addition to obtaining the number of efficient HCFs, degree of inefficiency and optimal scale of operation, it is vital to determine how many HCFs are operating under increasing returns to scale (IRS), decreasing returns to scale (DRS) or constant returns to scale (CRS). Using DEA, every HCF was evaluated, given its size level to determine its scale measures. This type of analysis is, according to [38], relevant for each firm in determining the implications for expansion.

Among the HCFs that demonstrated constant returns to scale (CRS), the doubling of health system inputs potentially leads to a doubling of health service outputs. In other words, the size of these HCFs did not affect productivity. The average and marginal productivity of these HCFs remained constant whether the HCF is small or large. They were operating at their most productive scale. Given that majority of the HFCs operate within the scope of increasing returning to scale, health care services production scale of these HCFs could increase by more than double should there be a doubling of their health inputs, as they operate at the region below optimum. This may have arisen because the larger scale of a particular operation allowed health managers and workers to specialize in their tasks and make use of more sophisticated health technologies. Thus HCFs manifesting IRS ought to expand their scale of operation in order to become scale efficient. With respect to HCFs that experienced decreasing returns to scale (DRS) or supra-optimal scale it can be inferred that HCFs will experience less than double in their health output, should the health inputs be doubled, which may be associated with the problems of coordinating tasks and maintaining lines of communication between management and workers. However, resources can be saved by cutting back on health service delivery. Thus HCFs experiencing DRS need to reduce their scale of operation in order to operate at the most productive scale size.

The findings on the average scale efficiency score suggest that the HCFs are operating in less than optimal scale size. That majority of the HCFs were operating under IRS in the years under study suggests that HCFs in general were scale inefficient, since scale inefficiency is usually due to the presence of either IRS or DRS. The differences in size or scale of operation of hospitals often account or explain the efficiency variation in hospital activities. The size of a hospital affects its efficiency, since large hospitals are often more efficient than small ones because they can gain from economies of scale. Such size or scale of operation advantage often allow hospitals to spread administrative and management cost, as well as enjoy bulk purchasing discount. As observed in this study's descriptive statistics, the collection of hospitals covered in the study exhibit varying scale of operation, depending on their size. However, there exist an optimal large size of a hospital, beyond which it suffers diseconomies of scale. The size support for efficiency of operation is limited to a certain level prior to the setting in of diseconomies of scale.
Thus scale efficiency among the HCFs can be increased by operating in optimal scale size, given the current state of technology. Given the technical and political feasibility, this can be achieved through the expansion of the size of the HCFs, since majority operates at IRS level. This would enable the HCFs operate in optimal scale size, and hence increase their hospital productivity and profitability. This result is also in consonance with that of [39] who found that nearly half of the DMUs studied were operating at less than optimal scale size. These average scale efficiency scores were within the range of that obtained for Benin (41.9%). However, the average scale efficiency scores for Ibadan, were lower than those obtained for Angola (81–89%), Ghana (81%), Namibia (73.2–83.7%), Eastern, Northern and Western Cape Provinces of South Africa (82.5–90%), Zambia (80%), and Uganda (97.5%) by [31], [32], [36], [35], [33], and [38], respectively.

**Conclusion**

For both health policy makers and health managers, the estimation of hospital efficiency has become a major concern. To assess hospital performance at the aggregate level and to inform policy decisions, there has been an increasing use of DEA method in the computation of efficiency scores. In this study DEA was applied to a mixed size 52 secondary hospitals in Ibadan, operating within the framework of both the public and private system. The scope of the analysis was to assess the technical efficiency and scale efficiency. The hospital operations were represented by means of an input-output model whereby each hospital uses quantities of inputs to generate outputs in the form of services. Specifically, hospitals were considered to transform labour (physicians and nurses) and capital (approximated by the number of beds) into services, which were assumed to be approximated by the number of inpatient discharges, outpatient visits, and maternal and child care. Unlike in health care system where products are multiple and heterogeneous, DEA works better when the product is homogeneous and uni-dimensional. Despite the difficulties in conceptualising hospitals in terms of an input-output model, the DEA methodology is useful in benchmarking intra-hospital best practices and correction of inefficiencies. The obtained result can be used to improve the performance of inefficient hospitals and thus increase overall hospital efficiency.

The existence of inefficiency resource slack among some of the HCFs is a pointer to the fact the available resources can be better utilized to positively impact the health of the population than applied in those years. Actions towards improving access and utilization of under-utilized inpatient, outpatient, and maternal and child care services by relevant health care sector policy-makers can be directed at HCFs with the same level of inputs. Within the public HCFs setting, attempt could be made to transfer excess facility inputs to areas with apparent shortage to boost health care service provision and access, such as the primary health centers. Also policy measures geared towards removing access constraints can go a long way in increasing utilization of health facilities, thus increasing facilities' outputs with existing inputs. By making the inefficient HCFs to be efficient, resources wastage can be reversed.

**Competing Interest**

The author declares that there is no competing interest

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**Appendix A: Hospital's Technical and Scale Efficiency During 2010 – 2012**

| HCFs | Efficiency 2010 | | | | Efficiency 2010 | | | | Efficiency 2010 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CRSTE | VRSTE | SCALE | Returns to Scale | CRSTE | VRSTE | SCALE | Returns to Scale | CRSTE | VRSTE | SCALE | Returns to Scale |
| **H01** | 0.12 | 0.424 | 0.282 | IRS | 0.084 | 0.38 | 0.22 | IRS | 0.071 | 0.35 | 0.203 | IRS |
| **H02** | 0.108 | 1 | 0.108 | IRS | 0.09 | 0.831 | 0.109 | IRS | 0.059 | 0.75 | 0.079 | IRS |
| **H03** | 0.304 | 1 | 0.304 | IRS | 0.184 | 1 | 0.184 | IRS | 0.114 | 1 | 0.114 | IRS |
| **H04** | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| **H05** | 0.109 | 0.353 | 0.307 | IRS | 0.036 | 0.333 | 0.109 | IRS | 0.038 | 0.34 | 0.111 | IRS |
| **H06** | 0.315 | 0.365 | 0.864 | IRS | 0.24 | 0.328 | 0.733 | IRS | 0.279 | 0.283 | 0.986 | DRS |
| **H07** | 0.072 | 0.264 | 0.273 | IRS | 0.074 | 0.283 | 0.262 | IRS | 0.089 | 0.331 | 0.268 | IRS |
| **H08** | 0.032 | 1 | 0.032 | IRS | 0.029 | 0.5 | 0.058 | IRS | 0.022 | 0.429 | 0.052 | IRS |
| **H09** | 0.244 | 1 | 0.244 | IRS | 0.157 | 1 | 0.157 | IRS | 0.155 | 0.75 | 0.207 | IRS |
| **H10** | 0.042 | 0.528 | 0.08 | IRS | 0.039 | 0.619 | 0.064 | IRS | 0.032 | 0.75 | 0.207 | IRS |
| **H11** | 0.277 | 1 | 0.277 | IRS | 0.213 | 0.954 | 0.223 | IRS | 0.208 | 1 | 0.208 | IRS |
| **H12** | 0.385 | 1 | 0.385 | IRS | 0.351 | 0.829 | 0.424 | IRS | 0.268 | 0.639 | 0.419 | IRS |
| **H13** | 0.27 | 0.351 | 0.771 | IRS | 0.226 | 0.295 | 0.766 | IRS | 0.193 | 0.194 | 0.993 | IRS |
| **H14** | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| **H15** | 0.254 | 0.5 | 0.507 | IRS | 0.243 | 0.568 | 0.428 | IRS | 0.218 | 0.5 | 0.437 | IRS |
| **H16** | 0.112 | 0.8 | 0.14 | IRS | 0.165 | 0.737 | 0.224 | IRS | 0.253 | 0.678 | 0.373 | IRS |
| **H17** | 0.176 | 1 | 0.176 | IRS | 0.094 | 1 | 0.094 | IRS | 0.088 | 1 | 0.088 | IRS |
| **H18** | 0.325 | 0.494 | 0.657 | IRS | 0.211 | 0.464 | 0.454 | IRS | 0.328 | 0.455 | 0.722 | IRS |
| **H19** | 0.41 | 0.426 | 0.963 | IRS | 0.472 | 0.477 | 0.99 | IRS | 0.468 | 0.477 | 0.98 | DRS |
| **H20** | 0.128 | 1 | 0.128 | IRS | 0.075 | 1 | 0.075 | IRS | 0.065 | 1 | 0.065 | IRS |
| **H21** | 0.061 | 0.538 | 0.113 | IRS | 0.027 | 0.5 | 0.054 | IRS | 0.041 | 0.5 | 0.083 | IRS |
| **H22** | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| **H23** | 0.145 | 0.5 | 0.29 | IRS | 0.111 | 0.539 | 0.207 | IRS | 0.073 | 0.5 | 0.147 | IRS |
| **H24** | 0.064 | 1 | 0.064 | IRS | 0.064 | 1 | 0.064 | IRS | 0.061 | 1 | 0.061 | IRS |
| **H25** | 0.489 | 0.521 | 0.938 | IRS | 0.519 | 0.539 | 0.964 | IRS | 0.41 | 0.438 | 0.935 | IRS |
| **H26** | 0.791 | 0.868 | 0.912 | IRS | 0.468 | 0.502 | 0.931 | IRS | 0.598 | 0.645 | 0.927 | DRS |
| **H27** | 0.34 | 0.583 | 0.583 | IRS | 0.425 | 0.619 | 0.686 | IRS | 0.486 | 0.639 | 0.76 | IRS |
| **H28** | 0.091 | 0.333 | 0.273 | IRS | 0.086 | 0.352 | 0.245 | IRS | 0.108 | 0.388 | 0.278 | IRS |
| **H29** | 0.186 | 0.528 | 0.352 | IRS | 0.09 | 0.448 | 0.202 | IRS | 0.085 | 0.334 | 0.256 | IRS |
| **H30** | 0.679 | 0.883 | 0.769 | IRS | 0.346 | 0.381 | 0.908 | IRS | 0.405 | 0.411 | 0.987 | DRS |
| **H31** | 0.109 | 1 | 0.109 | IRS | 0.075 | 1 | 0.075 | IRS | 0.103 | 1 | 0.103 | IRS |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **H32** | 0.1 | 0.512 | 0.196 | IRS | 0.066 | 0.36 | 0.184 | IRS | 0.063 | 0.379 | 0.167 | IRS |
| **H33** | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS | 1 | 1 | 1 | CRS |
| **H34** | 0.137 | 0.359 | 0.381 | IRS | 0.092 | 0.505 | 0.183 | IRS | 0.098 | 0.337 | 0.293 | IRS |
| **H35** | 0.955 | 1 | 0.955 | IRS | 0.708 | 1 | 0.708 | IRS | 0.528 | 0.802 | 0.657 | IRS |
| **H36** | 0.061 | 0.575 | 0.106 | IRS | 0.066 | 0.598 | 0.11 | IRS | 0.079 | 1 | 0.079 | IRS |
| **H37** | 0.073 | 1 | 0.073 | IRS | 0.059 | 1 | 0.059 | IRS | 0.057 | 1 | 0.057 | IRS |
| **H38** | 0.08 | 0.5 | 0.161 | IRS | 0.077 | 1 | 0.077 | IRS | 0.117 | 1 | 0.117 | IRS |
| **H39** | 0.077 | 1 | 0.077 | IRS | 0.059 | 1 | 0.059 | IRS | 0.06 | 0.6 | 0.101 | IRS |
| **H40** | 0.154 | 0.301 | 0.512 | IRS | 0.122 | 0.292 | 0.419 | IRS | 0.135 | 0.275 | 0.491 | IRS |
| **H41** | 0.182 | 0.694 | 0.262 | IRS | 0.081 | 0.564 | 0.143 | IRS | 0.076 | 0.519 | 0.145 | IRS |
| **H42** | 0.13 | 1 | 0.13 | IRS | 0.13 | 1 | 0.13 | IRS | 0.152 | 1 | 0.152 | IRS |
| **H43** | 0.373 | 1 | 0.373 | IRS | 0.275 | 1 | 0.275 | IRS | 0.254 | 1 | 0.245 | IRS |
| **H44** | 0.128 | 1 | 0.128 | IRS | 0.13 | 1 | 0.13 | IRS | 0.137 | 0.544 | 0.253 | IRS |
| **H45** | 0.38 | 1 | 0.38 | IRS | 0.251 | 0.594 | 0.422 | IRS | 0.176 | 0.557 | 0.316 | IRS |
| **H46** | 0.071 | 0.252 | 0.282 | IRS | 0.069 | 0.258 | 0.206 | IRS | 0.07 | 0.208 | 0.338 | IRS |
| **H47** | 0.121 | 0.516 | 0.235 | IRS | 0.107 | 0.518 | 0.206 | IRS | 0.108 | 0.521 | 0.207 | IRS |
| **H48** | 0.174 | 1 | 0.174 | DRS | 0.11 | 1 | 0.11 | DRS | 0.108 | 1 | 0.108 | DRS |
| **H49** | 0.76 | 1 | 0.76 | DRS | 0.76 | 1 | 0.76 | DRS | 0.537 | 1 | 0.537 | DRS |
| **H50** | 0.124 | 0.463 | 0.268 | IRS | 0.068 | 0.256 | 0.256 | IRS | 0.065 | 0.206 | 0.316 | IRS |
| **H51** | 0.153 | 0.508 | 0.302 | IRS | 0.118 | 0.498 | 0.237 | IRS | 0.093 | 0.412 | 0.225 | IRS |
| **H52** | 0.716 | 0.915 | 0.783 | IRS | 0.437 | 0.559 | 0.781 | IRS | 0.685 | 0.694 | 0.987 | DRS |
| **MEDIAN** | 0.164 | 0.834 | 0.286 | | 0.12 | 0.596 | 0.2215 | | 0.1155 | 0.6195 | 0.2545 | |
| **MEAN** | 0.3 | 0.728 | 0.412 | | 0.25 | 0.682 | 0.374 | | 0.248 | 0.651 | 0.398 | |
| **STDEV** | 0.292 | 0.277 | 0.3160 | | 0.2749 | 0.2781 | 0.3288 | | 0.2720 | 0.2815 | 0.3436 | |

**Appendix B: Output (Input) increases (reductions) needed to make individual inefficient health care facilities efficient during 2010 - 2012**

| HCFs | Outputs 2010 | | | Inputs 2010 | | | Outputs 2011 | | | Inputs 2011 | | | Outputs 2012 | | | Inputs 2012 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of | | | | | | Number of | | | | | | Number of | | | | | |
| | Inpatients | Outpatients | Maternal & Child care | Physicians | Nurses | Beds | Inpatients | Outpatients | Maternal & Child care | Physicians | Nurses | Beds | Inpatients | Outpatients | Maternal & Child care | Physicians | Nurses | Beds |
| **H01** | 129 | 1285 | 0 | 0 | 0 | 0 | 58 | 204 | 0 | 0 | 0 | 0 | 0 | 4112 | 0 | 1 | 0 | 1 |
| **H02** | 131 | 1218 | 0 | 0 | 0 | 1 | 96 | 50 | 0 | 1 | 0 | 0 | 0 | 4357 | 67 | 1 | 0 | 3 |
| **H03** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H04** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H05** | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | 198 | 158 | 0 | 2 | 7 |
| **H06** | 0 | 0 | 630 | 1 | 0 | 0 | 241 | 0 | 845 | 0 | 0 | 0 | 552 | 0 | 714 | 0 | 0 | 0 |
| **H07** | 19 | 566 | 0 | 0 | 0 | 0 | 0 | 0 | 54 | 0 | 0 | 0 | 0 | 2009 | 224 | 0 | 0 | 0 |
| **H08** | 38 | 2108 | 97 | 0 | 3 | 4 | 19 | 346 | 0 | 0 | 1 | 1 | 0 | 4362 | 210 | 0 | 0 | 1 |
| **H09** | 103 | 0 | 0 | 0 | 0 | 2 | 86 | 16 | 0 | 0 | 0 | 1 | 0 | 2067 | 83 | 0 | 0 | 2 |
| **H10** | 70 | 2005 | 63 | 0 | 0 | 0 | 90 | 30 | 24 | 0 | 0 | 0 | 0 | 5371 | 167 | 1 | 0 | 8 |
| **H11** | 0 | 365 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H12** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 420 | 1037 | 0 | 0 | 0 | 0 | 6058 | 1109 | 0 | 0 | 0 |
| **H13** | 0 | 0 | 423 | 0 | 0 | 4 | 119 | 0 | 315 | 0 | 0 | 0 | 11 | 0 | 453 | 0 | 0 | 0 |
| **H14** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H15** | 8 | 585 | 4 | 0 | 0 | 0 | 15 | 0 | 25 | 0 | 0 | 0 | 0 | 1933 | 110 | 0 | 2 | 0 |
| **H16** | 12 | 1092 | 86 | 1 | 0 | 0 | 0 | 0 | 340 | 0 | 0 | 0 | 0 | 6533 | 537 | 1 | 0 | 0 |
| **H17** | 0 | 1392 | 82 | 0 | 3 | 2 | 0 | 205 | 0 | 0 | 3 | 3 | 0 | 1539 | 150 | 0 | 4 | 3 |
| **H18** | 26 | 2380 | 0 | 0 | 0 | 0 | 138 | 1842 | 0 | 1 | 0 | 0 | 48 | 5568 | 0 | 1 | 0 | 0 |
| **H19** | 0 | 0 | 951 | 2 | 0 | 0 | 0 | 5952 | 0 | 4 | 2 | 0 | 0 | 0 | 1681 | 4 | 0 | 0 |
| **H20** | 120 | 688 | 24 | 0 | 1 | 2 | 101 | 0 | 77 | 0 | 1 | 1 | 0 | 4500 | 172 | 0 | 0 | 6 |
| **H21** | 52 | 1636 | 142 | 0 | 0 | 0 | 32 | 0 | 50 | 0 | 0 | 0 | 0 | 4472 | 254 | 0 | 1 | 1 |
| **H22** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| **H23** | 0 | 2220 | 0 | 0 | 0 | 0 | 65 | 166 | 0 | 1 | 0 | 0 | 0 | 4328 | 140 | 0 | 1 | 0 |
| **H24** | 0 | 231 | 19 | 0 | 2 | 2 | 0 | 387 | 11 | 0 | 2 | 2 | 0 | 3308 | 208 | 0 | 0 | 2 |
| **H25** | 0 | 1536 | 1638 | 2 | 0 | 0 | 0 | 8985 | 1091 | 1 | 0 | 0 | 0 | 3582 | 3324 | 2 | 0 | 0 |
| **H26** | 230 | 0 | 0 | 0 | 0 | 13 | 185 | 0 | 96 | 1 | 0 | 0 | 880 | 0 | 177 | 1 | 0 | 0 |
| **H27** | 0 | 3062 | 193 | 0 | 0 | 0 | 0 | 2928 | 647 | 0 | 0 | 0 | 0 | 5593 | 1374 | 0 | 0 | 0 |
| **H28** | 0 | 545 | 0 | 0 | 0 | 0 | 0 | 619 | 419 | 0 | 0 | 1 | 0 | 1484 | 599 | 0 | 2 | 1 |
| **H29** | 81 | 308 | 0 | 0 | 0 | 0 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 1623 | 90 | 0 | 0 | 0 |
| **H30** | 0 | 0 | 476 | 0 | 6 | 7 | 0 | 3596 | 99 | 0 | 0 | 0 | 0 | 0 | 1615 | 1 | 0 | 0 |
| **H31** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3798 | 188 | 0 | 0 | 0 |
| **H32** | 161 | 757 | 0 | 0 | 0 | 0 | 91 | 0 | 0 | 0 | 0 | 0 | 0 | 2213 | 9 | 0 | 0 | 0 |
| **H33** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H34** | 19 | 2257 | 0 | 0 | 0 | 0 | 60 | 2453 | 0 | 0 | 0 | 0 | 0 | 4974 | 43 | 0 | 0 | 2 |
| **H35** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 173 | 5939 | 0 | 0 | 0 | 1 |
| **H36** | 0 | 2601 | 171 | 0 | 0 | 0 | 0 | 49 | 28 | 0 | 0 | 0 | 0 | 2974 | 126 | 0 | 1 | 1 |
| **H37** | 13 | 2168 | 125 | 0 | 0 | 0 | 18 | 2 | 39 | 0 | 0 | 0 | 0 | 4147 | 273 | 0 | 0 | 9 |
| **H38** | 61 | 960 | 119 | 0 | 1 | 2 | 46 | 0 | 91 | 0 | 6 | 8 | 0 | 3716 | 258 | 0 | 6 | 0 |
| **H39** | 14 | 1893 | 81 | 0 | 2 | 3 | 1 | 0 | 8 | 0 | 3 | 3 | 0 | 3689 | 193 | 0 | 0 | 0 |
| **H40** | 0 | 1163 | 812 | 0 | 0 | 0 | 0 | 13 | 551 | 0 | 0 | 0 | 0 | 6289 | 862 | 1 | 0 | 0 |
| **H41** | 0 | 1163 | 283 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2991 | 154 | 0 | 0 | 0 |
| **H42** | 0 | 14 | 46 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H43** | 0 | 1295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix B (Cont'd)**

| HCFs | Outputs 2010 | | | Inputs 2010 | | | Outputs 2011 | | | Inputs 2011 | | | Outputs 2012 | | | Inputs 2012 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of | | | | | | Number of | | | | | | Number of | | | |
| | Inpatients | Outpatients | Maternal & Child care | Physicians | Nurses | Beds | Inpatients | Outpatients | Maternal & Child care | Physicians | Nurses | Beds | Inpatients | Outpatients | Maternal & Child care | Physicians | Nurses | Beds |
| **H44** | 0 | 1295 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 388 | 0 | 0 | 0 |
| **H45** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1240 | 18 | 0 | 5 | 0 | 0 | 1926 | 0 | 0 | 0 | 0 |
| **H46** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 147 | 0 | 0 | 1 | 0 | 0 | 130 | 0 | 0 | 0 |
| **H47** | 0 | 0 | 144 | 0 | 0 | 0 | 0 | 211 | 210 | 0 | 0 | 0 | 0 | 1227 | 438 | 0 | 0 | 0 |
| **H48** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H49** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **H50** | 85 | 613 | 0 | 1 | 0 | 0 | 0 | 2836 | 0 | 0 | 0 | 0 | 0 | 4175 | 0 | 0 | 0 | 0 |
| **H51** | 10 | 1114 | 0 | 0 | 0 | 0 | 0 | 321 | 36 | 0 | 0 | 0 | 0 | 1558 | 0 | 1 | 0 | 0 |
| **H52** | 0 | 0 | 224 | 0 | 4 | 10 | 0 | 0 | 335 | 0 | 0 | 3 | 0 | 0 | 1730 | 1 | 1 | 0 |
| **TOTAL** | 1382 | 40515 | 6833 | 7 | 23 | 63 | 1527 | 32871 | 6623 | 10 | 24 | 31 | 1664 | 122613 | 18408 | 16 | 22 | 48 |
| **MEDIAN** | 0 | 556 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1971 | 152 | 0 | 0 | 0 |
| **MEAN** | 27 | 773 | 131 | 0 | 1 | 1 | 29 | 632 | 128 | 0 | 0 | 1 | 32 | 2358 | 354 | 0 | 0 | 1 |
| **STDEV** | 50 | 877 | 296 | 0 | 1 | 3 | 53 | 1639 | 261 | 1 | 1 | 2 | 144 | 2191 | 613 | 1 | 1 | 2 |