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Redeployment and Replacement of Physicians and Nurses between Health Regions in Saudi Arabia Using Data Envelopment Analysis

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Abstract: ***The problem which Ministry of health in Saudi Arabia is facing now is that, if a given Region (R_i) is capable of producing outputs (Inpatients and outpatients) with inputs (Physicians, Nurses), then other Region should also be able to do the same, if they were to operate efficiently to meet the strategic plans that has been stated by Ministry of health's policy makers for each and every (20) health Regions located in Saudi Arabia. This creates the problem of how can we rank the efficient health Regions over their inefficient counterpart?. This question leads to the importance of redistribution of physicians and Nurses between Health Regions in Saudi Arabia with an objective to show variation in terms of efficiency of health sector services in Saudi Arabia, and in turn it encourages the two researchers to better understand competition between these (20) Health Regions in Saudi Arabia in terms of human resource allocation, and how to make improvement for inefficient Regions in terms of redistribution and replacement of Non-Saudi physicians and nurses by Saudi citizens? The results revealed that there is an excess of (4653) Physicians and (15408) nurses in the Kingdom of Saudi Arabia, and proved that decision making policies of increasing the Physicians (including dentists) by 28.3 % and Nurses by (57%) when comparing the year (2015) to the a year (2016) is not correct. Therefore, we recommended that all these excesses of physicians and nurses in the inefficient Health Regions must be redeployed to the efficient (6) Regions or to be replaced by Saudi (physicians and nurses) citizens.***

Keywords: Statistical Thinking, Global Technical Efficiency, Local Pure Technical Efficiency, Scale Efficiency, Constant Return to Scale, Variable Return to Scale

1.Introduction

ASQ (1999) mentioned some experts statements that support statistical thinking for management like Deming who once said "If I had to reduce my message for management to just a few words, I would say it all had to do with reducing variations."Another, expert E.S. Woolard said "To compete and win, we must redouble our efforts - not only in the quality of our goods and services, but in the quality of our thinking, in the quality of our response to customers, in the quality of our decision making, in the quality of everything we do."On the other hand, Lord Kelvin said "When you can measure what you are speaking about and express it in numbers, you know something about it. When you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."Moreover, Seetharaman and Parasad (2015) said that all of us are aware that "what gets measured gets managed – and what gets managed gets accomplished.

Targeting measurements and accomplishment of tasks with efficiency and effectiveness at Ministry of Health in the Kingdom of Saudi Arabia, the statistical yearly book (2016) stated that "the ministry is committed to provide the most recent health statistics and information for all partners in the health sector, including decision-makers and healthcare service providers. From that end, the Ministry issues its annual report, which includes all the figures and data pertaining to healthcare across different health sectors of the Kingdom. Among the most important data to be included in the yearly statistical books are the main indicators that reflect the growth of the health sector and the development of health services over years. Health Indicators do gain their importance for two chief reasons: Firstly: They provide a comprehensive review of the current situation in terms of health performance. Secondly: Indicators allow for a close assessment of health strategies and evaluation of progress towards achieving the stated goals, whether on short-or long-term (Health statistical Book, 2016). These indicators revealed in the annual statistical books issued by Ministry of Health is not sufficient, therefore deeper analysis is required. Therefore, this paper, tried to provide a new approach for discovering, redeploying and replacing excesses of physicians and nurses across Health regions, and to be used by Health human resource decision makers.

In terms of health human resources, there has been an increase in the rate of personnel per 10, 000 population in 2016: For an example in (2016) the Physicians (including dentists) increased by 28.3 % and Nurses increased by (57%) compared to the a year (2015). This yearly increment raise the question: **On what bases the Health human resource stakeholders increase this huge percentage of physician and nurses?.** The problem which Ministry of health in Saudi Arabia is facing now is that, if a given Region (R_i) is capable of producing outputs (Inpatients and outpatients) with inputs (Physicians, Nurses), then other Region (R_j) should also be able to do the same, if they were to operate efficiently to meet the strategic plans that has been stated by Ministry of health's policy makers for each and every (20) health Regions located in Saudi Arabia. Also this creates the question of how can we rank the efficient health Regions over their inefficient counterpart?. This problem leads to the importance of redistribution of physicians and Nurses between Health Regions in Saudi Arabia with an objective to show variation in terms of efficiency of health Regions services in Saudi Arabia, and in turn it encourages the two researchers to better understand the need of human resource in these (20) Regions working in Saudi Arabia and how to make improvement for inefficient Regions in terms of redistribution and replacement of non-Saudi physicians and nurses by Saudi citizens.

This paper, tried to equip the health human resource managers with measurement skills and new methods to deploy physicians and nurses across the different health regions (20) as well as to be used by Health (H R) decision makers. To do this one of the statistical methods (Data Envelopment analysis) was used. It is a linear programming technique that identifies the apparent best providers of services by their ability to produce the highest levels of services with given set of inputs (physicians, nurses …etc), or to produce given services (inpatients, Outpatients) with the least amount of inputs. The technique can also determine whether the main source of inefficiency is scale of operations or the managerial capabilities. Focusing on Saudi Health sector effectiveness and efficiency, the Ministry of health has a good efforts towards improving labor force performance, promoting their skills, developing their productive abilities, and enabling them to deal effectively with technological developments, but health human resource policy makers, pay little attention to reconsider the balance between the labor force recruited in the ministry of Health and their redistribution in different Regions.

Efficiency measure, in the raw sense, measures the efficiency with which input resources like human resource (eg: physicians and nurses) are used to produce outputs (e.g.: Outpatients and Outpatients). In that context, the input-output methodology can be reasonable applied when outputs and input are easily identifiable and quantifiable. The data envelopment Analysis methodology meets these needs. This methodology is recommended for use by ministry of health human resource managers. It offers the flexibility and global view of the organization needed to assess technical efficiency and support management decisions about process reengineering and human resource redistribution and replacement.

2.Literature Review And Previous Studies

Al- Shakawy, A (2012) said that the availability of a system for public sector performance evaluation is an essential requirement, as it provides decision makers with the information they need to make suitable administrative recommendations and have fruitful feedback discussions with workers. Such a system also helps in spotting the Regions which require a modification or improvement of performance. A person who observes performance evaluation systems in the public sector, however would discover several problems and challenges that impede this requirement. Al- Shakawy (2012) also provide an argument that the focus on subsequent evaluation, which is done at the end of each year, in most cases, such evaluation is defensive, striving to explain the reasons of performance being as it is rather than arriving at a fair evaluation of actual performance, and misleading performance measurement most often, the public sector opts for a duality of measurements, there is internal measurements in which the department relies on facts, there is also external measurement with which the sector involved gives an unreal picture to mislead the outside observers represented by public opinion or service clients. These statements of Al- Shakawy (2012) raise a question of whether the ministry of health yearly statistical books are giving sufficient information to health stakeholders to take right decision and provide the two researchers to think statistically about some indicators provided in the yearly statistical books (2015) and (2016) in particular human resource (physicians and nurses) yearly increment indicators. Statistical thinking is a philosophy of learning and action as defined by (Hoerl & Snee, 2012, p 15) based on the following fundamental principle: All work occurs in a system of interconnected processes, variation exists in all processes, and understanding and reducing variation are keys to success, they said that the first principle provides the context for under-standing the organization, improvement potential, and sources of variation mentioned in the second and third principles defined a process as one or more connected activities in which inputs are transformed into outputs for a specific purpose. They continued and said that (in page 15) the second principle provides the focus for improvement work. Variation is the key. If there were no variation: Processes would run better, Products would have the desired quality, service would be more consistent, managers would manage better and conclude that focusing on variation is a key strategy to improve performance. Moreover, the third principle as they said focuses on unintended variation and how it is analyzed to improve performance. First we must identify, characterize, and quantify variation to understand both the variation and the process that produced it. With this knowledge we work to change the process (e.g., operate it more consistently) to reduce its variation. Hoerl and Snee (2012). Moreover, the discussions of (Hoerl & Snee) provide us to think about the variation of human resources in health regions (physicians and nurses) annual increment. To study variations in any governmental or private systems, a wide range of approaches have been proposed. Among these approaches are: Reengineering, Total quality management, Learning organizations, Self-managed work teams, Benchmarking, Six Sigma and Lean Manufacturing. In addition to this list are the philosophies proposed by Peter Drucker, Stephen Covey, W. Edwards Deming (1986), Joseph Juran (1989), Tom Peters (2010), Peter Senge, and many others. Benchmarking is the process of improvement that finds the best practices in other organizations and adapts those practices to make improvements. The best practices are often identified in outside industries. American Society For Quality (ASQ) explains how statistical thinking and statistical process monitoring, which have been practiced in manufacturing for the past thirty years, are proving valuable for process improvement in business environments that range from healthcare to financial services. Al-Shayea (2011) said that Data Envelopment Analysis (DEA) is a fractional linear programming based technique that has gained wide acceptance in recent years due to its effectiveness in comparing efficiencies of departments, sectors, organizations, etc. The effectiveness of such techniques in measuring and comparing efficiencies of microeconomic systems, such ashealth and medical care industry, is debatable. In addition, managers of all health centers and hospitals in the last few years were keen to satisfy the needs of the out-patients and therein- patients of all kinds, and to give them a top quality service. The way to achieve this aim requires testing the performance and efficiency of every department in the health center or hospital. One

technique which could be used to measure the efficiency of units such as general practices is Data Envelopment Analysis (DEA). It is a well established technique for measuring the relative efficiencies of units delivering similar services. It has advantage of being able to deal with multidimensional nature of input/output variables. This technique is applied in his paper to study the performance and efficiency of King Khalid University Hospital departments. The results showed that only two departments out of nine have 100% efficiencies throughout the 12 months period. This paper is providing new and different ideas from Al-Shayea (2011) paper in the sense that it is handling redeployment of health human resources (physician & nurses) across (20) health regions in the Kingdom of Saudi Arabia. Mudyarabikwa and Mbengwa (2006) said that The World Health Report 2000 (WHO 2000) argued that health human resources are key determinants of the success or failure of health systems, and continued to say that the performance of health care systems is a function of the availability, know-how, skills mix and motivation of personnel delivering services. Zimbabwe, like many other countries in the region, is badly affected by a shortage of health workers. Many of the health indicator improvements achieved during the first ten years of independence are on the decline and the main reason for this is shortage of skilled and experienced health workers at a time when demand for services is increasing due to a growing population and the challenges posed by HIV/AIDS. The public sector provides as much as 65% of health care services in the country (MoHCW 2004), and so a shortage of public sector health workers affects a great majority of the population.

Kiambat, Kiio and Toweett (2013) said “Universal health coverage depends on having the necessary human resources to deliver health care services. Kenya is among the African countries currently experiencing a crisis in the area of human resources for health (HRH). The major causes of the crisis include inadequate and inequitable distribution of health workers; high staff turnover; weak development, planning and management of the health workforce; deficient information systems; high migration and high vacancy rates; insufficient education capacity to supply the desired levels of health workers needed by the market; inadequate wages and working conditions to attract and retain people into health work, particularly in rural underserved areas. This shortage affects most of the available health worker categories. This document provides an overview of the HRH labour market in Kenya, highlighting the importance of a comprehensive approach to understanding the driving forces that affect the supply and demand for health workers, in order to provide a basis for developing effective HRH polices that can contribute to progress towards universal health coverage”. Making comment on the above two mentioned papers, Saudi Arabia is not like them, these two countries are suffering from shortages in physicians and nurses and Saudi Arabia is suffering from excesses in physicians, nurses and inadequate Saudi citizens to replace the non- Saudi physicians and nurses.

To provide a complete picture of studying variation of Health Human Resource, the following discuss the different approaches of scientists (**Shewhart and Deming)** who study variation to improve commodities or services:

Walter Andrew Shewhart (March 18, 1891 – March 11, 1967) was an American physicist, engineer and statistician, sometimes known as the father of statistical quality control and also related to the Shewhart cycle. He is the originator of the Statistical Process Control. Statistical process control (SPC) is a method of quality control which uses Statistical methods. SPC is applied in order to monitor and control a process. Shewhart's work pointed out the importance of reducing variation in a manufacturing process and the understanding that continual process-adjustment in reaction to non-conformance actually increased variation and degraded quality. Shewhart framed the problem in terms of assignable-cause and chance-cause variation and introduced the control chart as a tool for distinguishing between the two.

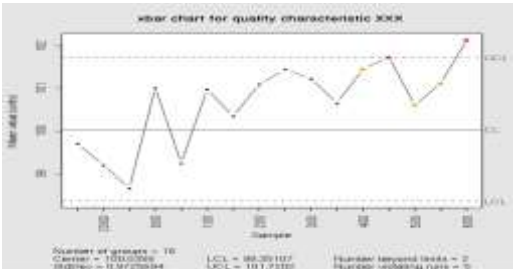

Chart No. 1: X bar for quality characteristic

Shewhart worked to advance the thinking at Bell Telephone Laboratories from their foundation in 1925 until his retirement in 1956, publishing a series of papers in the Bell System Technical Journal. His work was summarized in his book Economic Control of Quality of Manufactured Product (1931).

William Edwards Deming was an American statistician, professor, author, lecturer and consultant. The Knowledge of variation involves understanding that everything measured consists of both "normal”variation due to the flexibility of the system and of "special causes” that create defects. Quality involves recogni Ring the difference to eliminate "special causes” while controlling normal variation. Deming taught that making changes in response to "normal” variation would only make the system perform worse. Understanding variation includes the mathematical certainty that variation will normally occur within six standard deviations of the mean. The System of Profound Knowledge is the basis for application of Deming's famous 14 Points for Management.

Deming offered fourteen key principles to managers for transforming business effectiveness. The points were first presented in his book Out of the Crisis. (p. 23-24) Although Deming does not use the term in his book, it is

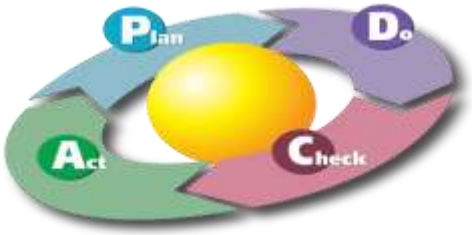

Chart No. 2 : Deming's Chart

By considering all above-mentioned approaches, The three main forms of benchmarking to study variations between Heath main Regions are:

1. Results benchmarking (comparing efficiency within and between Health Regions using indicators of efficiency),
2. Process benchmarking (analyzing systems, activities and tasks that turn resource inputs (physicians & nurses) and outputs (inpatients and outpatients) into outcomes (balanced distribution of human resource) and
3. Setting best practice standards peers (establishing goals and standards to which health regions can aspire).

Referring to the story of Data envelopment analysis (DEA) that begins with Edwardo Rhodes's Ph.D dissertation research under the supervision of W.W. Cooper, Edwardo Rhodes faced the challenge of estimating relative "technical efficiency" of the schools involving multiple outputs and inputs, without the usual information on prices, that resulted in formation of the CCR (Charnes, Cooper, and Rhodes) ratio form of DEA and the publication of the first paper introducing DEA in the European Journal of Operation Research in 1978. Building on the ideas of Farrell (1957), the seminal work "Measuring the efficiency of decision making units" by Charnes, Cooper & Rhodes (1978) applies linear programming to estimate an empirical production technology frontier for the first time. Since then, there have been a large number of books and journal articles written on DEA or applying DEA on various sets of problems. Other than comparing efficiency across DMUs within an organization, DEA has also been used to compare efficiency across firms. There are several types of DEA with the most basic being CCR based on Charnes, Cooper & Rhodes, however there are also DEA which address varying returns to scale, either CRS (constant returns to scale) or VRS (variable). Seaford & Thrall (1990) document the main developments of DEA in the 1970s and 1980s.

Data envelopment analysis (DEA) is a nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (or DMUs). Although DEA has a strong link to production theory in economics, the tool is also used for benchmarking in operations management, where a set of measures is selected to benchmark the performance of manufacturing and service operations. In the circumstance of benchmarking, the efficient DMUs, as defined by DEA, may not necessarily form a "production frontier", but rather lead to a "best-practice frontier" (Cook, Tone & Zhu, 2014). DEA is referred to as "balanced benchmarking" by Sherman and Zhu (2013).Non-parametric approaches have the benefit of not assuming a particular functional form/shape for the frontier, however they do not provide a general relationship (equation) relating output and input. There are also parametric approaches which are used for the estimation of production frontiers (see Lovell & Schmidt 1988 for an early survey). These require that the shape of the frontier be guessed beforehand by specifying a particular function relating output to input. One can also combine the relative strengths from each of these approaches in a hybrid method (Tsolas, 2011) where the frontier units are first identified by DEA and then a smooth surface is fitted to these. This allows a best-practice relationship between multiple outputs and multiple inputs to be estimated. The framework has been adapted from multi-input, multi-output production functions and applied in many industries. DEA develops a function whose form is determined by the most efficient producers. This method differs from the Ordinary Least Squares (OLS) statistical technique that bases comparisons relative to an average producer. Like Stochastic Frontier Analysis (SFA), DEA identifies a "frontier" on which the relative performance of all utilities in the sample can be compared: DEA benchmarks firms only against the best producers. It can be characterized as an extreme point method that assumes that if a firm can produce a certain level of output utilizing specific input levels, another firm of equal scale should be capable of doing the same. The most efficient producers can form a 'composite producer', allowing the computation of an efficient solution for every level of input or output. Where there is no actual corresponding firm, 'virtual producers' are identified to make comparisons" (Berg 2010). In microeconomic production theory a firm's input and output combinations are depicted using a production function. Using such a function one can show the maximum output which can be achieved with any possible combination of inputs, that is, one can construct a production technology frontier. (Seiford & Thrall 1990). Some 30 years ago DEA (frontier techniques in general) set out to answer the question of how to use this principle in empirical applications while overcoming the problem that for actual firms (or other DMUs) one can never observe all the possible input-output combinations.

To measure the Technical efficiency of Saudi Arabia (20) Health Regions, we adopt the statistical thinking philosophy explained in the introduction of this paper by using Data Envelopment Analysis (DEA) approach. DEA is a linear programming technique that identifies the apparent best providers of services by their ability to produce the highest levels of services with given set of inputs, or to produce given services with the least amount of inputs. Other service providers receive an efficiency score that is determined by their performance relative to that of the best performers. The technique can also determine whether the main source of inefficiency is scale of operations or the managerial capabilities and effort of service provider. One of the main advantages of data envelopment analysis is that it can readily incorporate

multiple inputs and outputs, and to calculate technical efficiency, only requires information on output and input quantities (not prices). This make it particularly suitable for analyzing the efficiency of government service providers and reveals the performance variations of the organization's processes, especially those providing human services where it is difficult or impossible to assign prices to many of the outputs. Moreover possible sources of inefficiency can be determined as well as efficiency level. SCRGSP (1997) mentioned that "one of the drawbacks of (DEA) is that it produces results that are particularly sensitive to measurement error. If one organization (Health Region) can become an outlier that significantly distorts the shape of the frontier and reduces the efficiency scores nearby organizations (other Health Regions). Another drawback of (DEA) is that it only measure efficiency relative to best practice within the particular sample". Beside what mentioned above (DEA) scores are sensitive to input and output specification and the size of the sample (increasing the sample size will tend to reduce the average efficiency score, because including more organizations (Health Regions) provides greater scope for (DEA) to find similar comparisons partners and conversely, including too few organizations (Health Regions) relative to the number of outputs and inputs can artificially inflate the efficiency scores (Cooper, 2006).

3.Methodology

We adopt the methodology of Data Envelopment Analysis (DEA) as explained in the above sections and we add that (DEA) scores are sensitive to input and output specification and the size of the sample. Increasing the sample size will tend to reduce the average efficiency score, because including more organizations provides greater scope for DEA to find similar comparison partners. Conversely, including too few organizations relative to the number of outputs and inputs can artificially inflate the efficiency scores. Increasing the number of outputs and inputs included without increasing the number of organizations will tend to increase efficiency scores on average. This is because the number of dimensions in which a particular organization can be relatively unique (and, thus, in which it will not have similar comparison partners) is increased. DEA gives the benefit of the doubt to organizations that do not have similar comparison organizations, so they are considered efficient by default. There are different rules as to what the minimum number of organizations in the sample should be; one rule is that the number of organizations in the sample should be at least three times greater than the sum of the number of outputs and inputs included in the specification (Nunamaker 1985).

3.1 population and sample:

Every and each Region of the (20) Heath Regions in Saudi Arabia is considered to be an element of the population under study. To measure efficiency, the minimum sample size needed to achieve the objectives is depending on the selection criteria of summing the numbers of inputs and the outputs multiplied by (3). In this paper, Regions inputs and outputs {(2 inputs +2 outputs) X 3= 12}. Inputs are Physicians, Nurses, and outputs are Inpatients, Outpatients.

3.2 Data collections

To measure the efficiency of Governmental Heath sectors the secondary data about The (20) Region's inputs: ($Input_1$:Physicians), ($Input_2$:Nurses), and outputs: ($Output_1$:Inpatients), ($Output_2$:Outpatients) and a controlling variable (Population) to adopt the relation between inputs and outputs were collected for each and every element of the sample (20) health Regions under study. Therefore, the total number of (Health Regions) and scientifically we call it the Decision making unit (DMU) under study is revealed in the following table (1).

Table 1: Inputs and Outputs of Governmental Health Regions (2016)

No.	DMU	(I) physicians	(I) Nursing	(O) Inpatients	(O) outpatients	(C) Population
1.	Riyadh	6346	16742	180376	3118390	8002100
2.	Makkah	2559	5504	92833	1058538	2232923
3.	Jeddah	2575	5926	70612	984022	4514968
4.	Taif	1401	4105	50906	566718	1273236
5.	Medinah	2403	5566	85016	873621	2080436
6.	Qaseem	1724	4645	101205	1115765	1387996
7.	Eastern	3051	6839	63771	1600850	3144578
8.	Al-Ahsa	1248	3430	55828	451828	1198113
9.	Hafr Al-Baten	583	2034	19761	253935	437928
10.	Aseer	1522	3798	87241	973472	1782711
11.	Bishah	412	985	27062	272051	381461
12.	Tabouk	1165	3124	47810	504402	890922
13.	Hail	725	2225	35487	295368	684619
14.	Northern	764	2218	27900	262792	359235
15.	Jazan	1591	3724	59140	739865	1533680
16.	Najran	886	2507	46125	292824	569332
17.	Al-Bahah	784	1737	33241	616210	466384
18.	Al-Jouf	686	2545	51888	271202	331773
19.	Qurayyat	272	947	20416	178640	165736
20.	Qunfudah	415	760	13354	98606	304177

Source: Ministry of Health Statistical Year Book (2016)

3.3 The Model Used

In this paper, the model is run with the assumption that the objective is to minimize inputs (Physicians & Nurses) for a given level of output (Inpatients and outpatients) using Global Technical Efficiency (Charnes-Cooper – Rodes CCR model, 1978) in two folds, the first without including the Health Regions population and the second is to include Health Regions population. Given the above data (table 1), we measure the efficiency of each Decision Making Unit (DMU: Health Region) once and hence need (20) optimizations (twenty Health sectors), one for each DMUj (Health Region) to be evaluated.

3.4 Without including the Health Regions population:

Let the DMU_j (Health Region) to be evaluated on any trial be designated as DMU_o where $_o$ ranges over 1, 2,..., 20. We solve the following fractional programming problem to obtain values for the input "weights"$\{V_i\}$ {i = l,..., m) and the output "weights"{Ur) (r = 1,..., 5) as variables. The DEA formula for the first Health Region (Riyadh) in the two output (Inpatients & Outpatients), two input (Physicians & Nurses), twenty Health Sector (data listed in in table one above) would be:

Minimize E_1 (Riyadh) with respect to w_1, w_2, …, w_{20} and E_1 subject to:

$$180376w_1 + 92833w_2 + 70612w_3 + \ldots + 51888w_{18} + 20416w_{19} + 13354w_{20} - 180376 \geq 0 \quad (1)$$

$$3118390w_1 + 1058538w_2 + 984022w_3 + \ldots + 271202w_{18} + 178640w_{19} + 98606w_{20} - 3118390 \geq 0 \quad (2)$$

$$6346w_1 + 2559w_2 + 2575w_3 + \ldots + 686w_{18} + 272w_{19} + 415w_{20} - 6346E_1 \leq 0 \quad (3)$$

$$16742w_1 + 5504w_2 + 5926w_3 + \ldots + 2545w_{18} + 947w_{19} + 760w_{20} - 16742E_1 \leq 0 \quad (4)$$

$$w_1 \geq 0, w_2 \geq 0, w_3 \geq 0, \ldots, w_{18} \geq 0, w_{19} \geq 0, w_{20} \geq 0 \quad (5)$$

The first constraint requires that the weighted average of the output of Inpatients, less Region 1's (Riyadh) output of (18037) Inpatients, be greater than or equal to zero. This means that the hypothetical frontier Region for (Riyadh Region) has to produce at least (18037) Inpatients. Similarly, the second constraint requires that the frontier Region for (Riyadh Region) produce at least (3118390) Outpatients. The third and fourth constraints require the hypothetical Region to not use any more than Riyadh Region (6346) physicians and (16742) nurses, respectively. Solving this system of equations is not trivial and requires a computer program. We used specialize (DEA) learning version soft attached with the (Charnes - Cooper – Rodes CCR model, 1978) Reference book to run and find the results.

5. Results: without including Health Region Population

The results obtained from solving this DEA problem are presented in Table (2) below. The efficiency scores estimate the extent to which both inputs (Physicians & Nurses) would need to be reduced in equal proportions to reach the production frontier. In addition, for some (Health Regions), after both inputs have been reduced in equal proportions, one input could be reduced still further without reducing output (these are referred to as 'slacks' in the DEA literature. The table also contains the peer group for each (health Region), the peer weights and the peer count — the number of times this Heath Region appears in the peer group of other Heath Regions (excluding itself).

Riyadh Health Region obtains an efficiency score of (0.63) or (63) per cent (see Table 2).That means it appears that it could be able to reduce its number of nurses and Physicians by (37%) per cent and still produce its (180376) inpatients and (3118390) outpatients to operate at observed best practice. In practical terms, this means that Riyadh Health Region would have to reduce its number of nurses by (6194) to a new total of (10547) and its number of Physicians by (2346) to a new total of (4000). The peer group and peer weights columns indicate that the best practice for Riyadh Health Region is given by a weighted average of (81) per cent of Al-Bahah Health Region and (19) per cent of Qurayy at Heath Region. However, as evident from the input slack columns, as well as reducing both nurses and Physicians by 37 per cent, Riyadh Health Region has an additional (1310) Nurses. That means that to remove all the apparent waste and inefficiency relative to Health Regions Al-Bahah and Qurayyat, Riyadh Health Region would appear to have to reduce its number of Nurses to a new total of (9237). Overall, four Health Regions achieve efficiency scores of 100 per cent (Bishah, Al-Bahah, Al-Jouf, and Qurayyat). It is evident from the peer count column that all of the apparently efficient Heath Regions appear in peer groups for other Heath Regions (and thus, none are efficient by default). However, it is far more likely that Heath Regions Bishah, Al-Bahah, and Qurayyat are truly efficient because they are peers for (13) or (12) other Heath Regions in the sample.

Table 2: Constant return to scale DEA Results for the (20) Health Sectors

No.	DMU	Efficiency Score	Rank	Physician slacks	Nurses Slacks	Peer Group	Peer weight	Peer count
1	Riyadh	0.633145	15	0	1310	17, 19	4.7, 1.1	0
2	Makkah	0.656449	10	143	0	11, 17	2.9, 0.4	0
3	Jeddah	0.522174	19	0	0	11, 17, 19	1.4, 1.0, 0.05	0
4	Taif	0.577165	17	0	0	11, 17, 19	0.2, 0.3, 1.6	0
5	Medinah	0.562315	18	38	0	11, 17	3.0, 0.1	0
6	Qaseem	0.936085	5	0	0	11, 17, 19	1.7, 0.5, 1.9	0
7	Eastern	0.667568	9	0	53	17	2.6	0
8	Al-Ahsa	0.650603	12	0	0	11, 19	1.3, 1.0	0
9	Hafr Al-Baten	0.597308	16	0	250	17, 19	0.25, 0.56	0
10	Aseer	0.92941	6	0	0	11, 17, 19	2.2, 0.4, 0.69	0
11	Bishah	1	1	0	0	11	1	13
12	Tabouk	0.636232	14	0	0	11, 17, 19	0.97, 0.16, 0.8	0
13	Hail	0.684461	8	0	0	11, 19	0.46, 0.1.13	0
14	Northern	0.52178	20	0	0	11, 17, 19	0.5, 0.002, 0.67	0
15	Jazan	0.655412	11	0	0	11, 17, 19	1.5, 0.52, 0.06	0
16	Najran	0.749544	7	0	0	11, 19	0.96, 0.98	0
17	Al-Bahah	1	1	0	0	17	1	12
18	Al-Jouf	1	1	0	0	18	1	0
19	Qurayyat	1	1	0	0	19	1	12
20	Qunfudah	0.639549	13	62	0	11	0.5	0

6. Model With including the Health Regions population

Let the DMU_j (Health Region) to be evaluated on any trial be designated as DMU_o where $_o$ ranges over 1, 2,..., 20. We solve the following fractional programming problem to obtain values for the input "weights" $\{V_i\}$ $\{i = l,..., m)$ and the output "weights"$\{Ur)$ $(r = 1,..., 5)$ as variables. The DEA formula for the first Health Region (Riyadh) in the three output (Inpatients & Outpatients, Population), two input (Physicians & Nurses), twenty Health Sector (data listed in table1) would be: Minimize E_1 (Riyadh) with respect to $w_1, w_2, \ldots, w_{20}$ and E_1 subject to:

$$180376w_1 + 92833w_2 + 70612w_3 + \ldots + 51888w_{18} + 20416w_{19} + 13354w_{20} - 180376 \geq 0 \quad (1)$$

$$3118390w_1 + 1058538w_2 + 984022w_3 + \ldots + 271202w_{18} + 178640w_{19} + 98606w_{20} - 3118390 \geq 0 \quad (2)$$

$$8002100w_1 + 2232923w_2 + 4514968w_3 + \ldots + 331773w_{18} + 165736w_{19} + 304177w_{20} - 8002100 \geq 0 \quad (3)$$

$$6346w_1 + 2559w_2 + 2575w_3 + \ldots + 686w_{18} + 272w_{19} + 415w_{20} - 6346E_1 \leq 0 \quad (4)$$

$$16742w_1 + 5504w_2 + 5926w_3 + \ldots + 2545w_{18} + 947w_{19} + 760w_{20} - 16742E_1 \leq 0 \quad (5)$$

$$w_1 \geq 0, w_2 \geq 0, w_3 \geq 0, \ldots, w_{18} \geq 0, w_{19} \geq 0, w_{20} \geq 0 \quad (5)$$

7. Results: with including Health Region Population

The results obtained from solving this DEA problem with respect to Health Region with including their population are presented in Table (3) below. The efficiency scores estimate the extent to which both inputs (Physicians & Nurses) would need to be reduced in equal proportions to reach the production frontier. In addition, for some (Health Regions), after both inputs have been reduced in equal proportions, one input could be reduced still further without reducing output (these are referred to as 'slacks' in the DEA literature). The table also contains the peer group for each (health Region), the peer weights and the peer count — the number of times this Heath Region appears in the peer group of other Heath Regions (excluding itself).

When Health Region Population is considered, Riyadh Health Region obtains an efficiency score of (0.91) or (91) per cent (see Table 3). That means it appears that it could be able to reduce its number of nurses and Physicians by (9%) per cent and still produce its (180376) inpatients and (3118390) outpatients to operate at observed best practice. In practical terms, this means that Riyadh Health Region would have to reduce its number of nurses by (1507) to a new total of (15235) and its number of Physicians by (571) to a new total of (5775). The peer group and peer weights columns indicate that the best practice for Riyadh Health Region is given by a weighted average of (26) per cent of Jeddah Health Region and (74) per cent of AseerHeath Region. However, as evident from the input slack columns, as well as reducing both nurses and Physicians by (9) per cent, Riyadh Health Region has an additional (1243) Nurses. That means to remove all the apparent waste and inefficiency relative to Health Regions Jeddah and Aseer, Riyadh Health Region would appear to have to reduce its number of Nurses to a new total of (13992). Overall, Six Health Regions achieve efficiency scores of 100 per cent (Jeddah, Aseer, Bishah, Al-Bahah, Al-Jouf, and Qurayyat). It is evident from the peer count column

that all of the apparently efficient Heath Regions appear in peer groups for other Heath Regions (and thus, none are efficient by default). However, it is far more likely that all Heath Regions Bishah, Al-Bahah, and Qurayyat are truly efficient because they are peers for other Heath Regions in the sample except Qurayyat Health Region it is efficient but not peer to any other (13) inefficient Heath Regions.

Table 3: Constant return to scale DEA Results for the (20) Health Sectors

No.	DMU	Efficiency Score	Rank	Physician slacks	Nurses Slacks	Peer Group	Peer weight	Peer count
1	Riyadh	0.906238	8	0	1243	3, 10	0.84, 2.35	0
2	Makkah	0.791356	13	0	0	3, 10, 17	0.11, 0.97.0.005	0
3	Jeddah	1	1	0	0	3	1	8
4	Taif	0.706619	17	0	456	3, 10	0.075, 0.52	0
5	Medinah	0.707048	16	29	0	3, 11	0.25, 2.49	0
6	Qaseem	0.947682	7	0	2096	11, 17, 19	3.04, 0.38, 0.31	0
7	Eastern	0.896134	9	19	0	3, 17	0.51, 1.78	0
8	Al-Ahsa	0.800501	12	0	0	3, 10	0.02, 0.62	0
9	Hafr Al-Baten	0.668399	19	0	0	10, 17	0.23, 0.04	0
10	Aseer	1	1	0	0	10	1	8
11	Bishah	1	1	0	0	11	1	7
12	Tabouk	0.69007	18	0	0	10, 11	0.39, 0.50	0
13	Hail	0.83434	10	0	0	10, 11	0.33, 0.24	0
14	Northern	0.541795	20	0	0	11, 19	0.82, 0.28	0
15	Jazan	0.802363	11	35	0	3, 10, 17	0.12, 0.49, 0.23	0
16	Najran	0.763553	15	0	0	11, 19	1.20, 0.66	0
17	Al-Bahah	1	1	0	0	17	1	5
18	Al-Jouf	1	1	0	0	18	1	3
19	Qurayyat	1	1	0	0	19	1	0
20	Qunfudah	0.785006	14	73	0	3, 11	0.03, 0.41	0

8. Conclusion and Recommendations

The results revealed in table (4) appendix (A) shows that there is an excess of (4653) Physicians and (15408) nurses in the Kingdom of Saudi Arabia. This results prove that Saudia Arabia is not like other poor countries Kenya (Kiambat, 2013) and Zimbabwe (Mudyarabikwa, 2006) who are face the problem and challenge for equity in health and shortages in physicians and nurses, but in the opposite direction Ministry of health in Saudi Arabia faces the problem of excesses of physicians and nurses and tell us that decision making policies of increasing the Physicians (including dentists) by 28.3 % and Nurses by (57%) when comparing the year (2015) to the a year (2016) is seemed to be a waste of human resource. Therefore, we recommend that all these excesses of physicians and nurses in the inefficient Health Regions must be redeployed to the efficient areas or to be replaced by Saudi (physicians and nurses) citizens if and only if there is non- saudi whom the decisions makers think that they can terminate their contracts without sensivity of high level needs. Moreover, we advice Saudi health leaders to adopt the methodology of Data Envelopment with a population as a controlling variable in recruitmenting health human resource, and in planning and setting policies in order to avoid the waste of health human resources potential. If this happens, we can gangrantee enhancement of Health human resource effiency and productivity all over the Kingdom of saudi Arabia Health regions. Therefore in details, health strategies must be adopted to redeploy or replace (4653) Physicians and (15408) nurses in the inefficient health regions, and consider all other variables from their experience that might affect the deployment and replacement as follows:

1. Riyadh to deploy or replace (571) Physicians and (2750) nurses.
2. Makkah to deploy or replace (537) Physicians and (1156) nurses.
3. Taif to deploy or replace (406) Physicians and (1646) nurses.
4. Madinah to deploy or replace (726) Physicians and (1614) nurses.
5. Qassim to deploy or replace (86) Physicians and (2328) nurses.
6. Eastern to deploy or replace (324) Physicians and (2750) nurses.
7. Al-Ahsa to deploy or replace (250) Physicians and (686) nurses.
8. Hafr Al-Baten to deploy or replace (192) Physicians and (671) nurses.
9. Tabouk to deploy or replace (361) Physicians and (968) nurses.
10. Hail to deploy or replace (123) Physicians and (378) nurses.
11. Northern to deploy or replace (351) Physicians and (1020) nurses.
12. Jazan to deploy or replace (353) Physicians and (745) nurses.
13. Najran to deploy or replace (213) Physicians and (602) nurses.
14. Qunfudah to deploy or replace (160) Physicians and (160) nurses.
15. No more request of Physicians and nurses to be accepted from the inefficient regions for the very soon coming budget (2018).
16. Request of more Physicians and nurses from the efficient (6) health regions can be accepted without employing new comers, but to redeploy from

inefficient regions during the very soon coming budget (2018).

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Appendix (A):

Table 4: Redistribution or Replacement of Physician and nurses of Health Regions in the Kingdom of Saudi Arabia (2016)

No.	DMU	(I) physicians	(I) Nursing	Excess Physicians	Excess Nurses
1.	Riyadh	6346	16742	571	2750
2.	Makkah	2559	5504	537	1156
3.	Jeddah	2575	5926	0	0
4.	Taif	1401	4105	406	1646
5.	Medinah	2403	5566	726	1614
6.	Qaseem	1724	4645	86	2328
7.	Eastern	3051	6839	324	684
8.	Al-Ahsa	1248	3430	250	686
9.	Hafr Al-Baten	583	2034	192	671
10.	Aseer	1522	3798	0	0
11.	Bishah	412	985	0	0
12.	Tabouk	1165	3124	361	968
13.	Hail	725	2225	123	378
14.	Northern	764	2218	351	1020
15.	Jazan	1591	3724	353	745
16.	Najran	886	2507	213	602
17.	Al-Bahah	784	1737	0	0
18.	Al-Jouf	686	2545	0	0
19.	Qurayyat	272	947	0	0
20.	Qunfudah	415	760	160	160
To amount to be redeployed				4653	15408