Analyzing the Efficiency of Health Care in Pakistan: An Application of Data Envelopment Analysis to Rural Health Centers in Punjab

Sadia Farooq
Muhammad Ramzan
Fouzia Hadi Ali
Hafiz Abdur Rashid

This study analyzes the efficiency of 261 public sector Rural Health Centers (RHC's) in Pakistan through application of Data Envelopment Analysis (DEA). The public health care system in Pakistan is faced with a number of challenges involving inadequacy of funds and improper utilization of available resources. The current ranking of Pakistan in terms of health care, according to World Health Organization (WHO), is at 122 out of a total of 190 countries. While, a minimum amount of 44 USD per capita is required for essential health services; in Pakistan, only 37 USD per capita are allocated for this purpose (Ministry of Finance, 2016). These problems, in conjunction with lack of appropriate policies, have resulted in serious repercussions for the general public; such as high infant and maternal mortality rates, low life expectancy and inability of the public health sector to deal efficiently with general epidemics. Data for this study is collected from District Health Information System office of Director General Health Services (Punjab, Pakistan). The findings of the study reveal serious inefficiencies in the performance of selected RHCs. Based on the insights about efficient and inefficient RHCs, the study concludes that there is a pressing need for introducing policy reforms in the public health sector to ensure better facilities for the rapidly expanding population.

Keywords: Efficiency, Data Envelopment Analysis (DEA), Rural Health Centers (RHCs)

Dr. Sadia Farooq, Assistant Professor,
Dr. Muhammad Ramzan, Assistant Professor
Dr. Fouzia Hadi Ali, Assistant Professor
Dr. Hafiz Abdul Rashid, Assistant Professor

Hailey College of Commerce, Punjab University , Lahore

Introduction

Since 1980s, implementation of various managerial and organizational reforms has been observed in the public sector health care systems around the world. Hospitals, particularly those in the public sector, are known to consume a major portion of the health care resources which are quite limited (Lorenz, Khalid & Akhtar, 2011). As a result, ensuring efficiency in usage of these resources has become a major concern (McKee & Healy, 2002). Rapid rise in medical expenses as well as concerns to ensure patients' safety and smoother operations of service providers further legitimize greater regulation of this sector. Other common reasons for regulatory reforms are believed to be inefficiency, corruption, inability to offer services to poor people, dissatisfaction of users, emigration and transfer to the private health sector of skilled personnel, and wastage of resources (El-Seoud, 2013). The present day health care system is also restricted due to resource scarcity in the form of shortage of personnel, medical equipment, and necessary facilities (Aksezer, 2016). In these circumstances, improvement of transactional efficiency is considered to be an important objective calling for establishment of certain standards and rules formulated by law and to be followed by health care providers (Iossifova & Meyer-Goldstein, 2013).

Public health care system in Pakistan is plagued with many challenges, including; shortage of administrative capacity, lack of accountability, inefficient allocation of resources, unskilled and underpaid health care professionals, and inadequate infrastructure (Meghani, Sehar, & Punjani, 2014). While, per capita, a minimum of 44 USD is deemed necessary for provision of essential health services; in Pakistan, the amount allocated for this purpose is only 37 USD (Pakistan Economic Survey, 2015-16). These challenges, concurrent with lack of appropriate policies, have resulted in serious consequences for the general public including; high mortality rates for infants, babies and mothers, the inability to deal with general epidemics and low life expectancy. As a result, Pakistan is ranked at 122 out of a total of 190 countries in terms of health care, according to World Health Organization (WHO).

With a rapidly increasing population, a majority of which remains below poverty line, it is imperative to ensure efficient working of the existing public health care system so as to effectively reach a greater number of people. Bwana (2015) pointed out that given the scarcity of resources available for health care, it is important to evaluate efficiency in performance of hospitals to ensure efficient use of such resources. Mashhadi, Hamid, Roshan, and Fawad (2016), also stress the importance of enhancing efficiency, accessibility, effectiveness and response of public health care system in Pakistan.

The public health care sector in Pakistan includes Primary Health Care (PHC) which is further comprised of Rural Health Centers (RHCs) and Basic Health Units

(BHUs). Given the importance attached to the achievement of efficiency in performance of public health care system, this study aims to evaluate the performance of 261 public sector Rural Health Centers (RHS) from nine divisions of the most densely populated provinces of Pakistan namely; Punjab. The performance evaluation is conducted through calculating efficiency scores through Data Envelopment Analysis (DEA) technique. DEA is a benchmarking efficiency measurement tool that has widespread usage in the hospitals and health care evaluation (El-Seoud, 2013). Despite the popularity of this technique, there are only a few studies from Pakistan that make use of this tool for measuring efficiency of health care sector (Meghani et al., 2014; Mashhadi et al., 2016). This study thus intends to fill this gap in the literature on efficiency evaluation of public health care system in Pakistan.

1. Literature review

Evaluating efficiency of health care providers is imperative for monitoring their performance (Applanaidu, Samsudin, Ali, Dash and Chik, 2014). Such performance evaluation is important given the concerns related to rising costs in health care sector and budget constraints that necessitate most efficient allocation of resources (Guardazi, et al., 2014). Many studies aimed towards evaluating hospital efficiency tend to focus on the goal of achieving maximum output from the limited available resources (Sorkis & Talloru, 2002). Through measuring efficiency in utilization of resources, it may be possible to enhance the ability to control expenses and make better use of the available resources. Such analysis can also prove beneficial for policy making and budget planning.

Within health sector evaluation, DEA is considered as an invaluable tool that can help assess service reliability of operating units (Aksezer, 2016). DEA is a popular method for calculating relative efficiency of similar decision making units (DMUs); while considering a number of different inputs and outputs. Cobb and Douglas (1928) first introduced the use of production function as a means of productivity measurement. Efficiency measurement modelling introduced by Farrell (1957), was another step in this direction which set up the stage for later work leading to DEA, as a tool for efficiency evaluation. The two subsequent stages in the field of efficiency measurement resulted in development of the CCR model by Charnes et al. (1978), which considered constant returns to scale (CRS); and the BCC model by Banker et al. (1984), which assumed variable returns to scale (VRS). DEA does not make any assumptions about data distribution and, unlike other techniques, is able to incorporate a number of input and output variables simultaneously.

The literature on hospital efficiency reveals a number of studies that have been conducted by using DEA. Two of the earlier studies in this regard

were conducted in United States of America in 1980s by Nunamaker (1983) and Sherman (1984). Vivian (1990) also used DEA for analyzing hospital efficiency and concluded that non-profit public sector hospitals were more efficient, as compared to the non-profit private sector hospitals. However, the study by Ozcan, Luke, and Haksever (1992), found that no distinction between non-profit and government hospitals could be exhibited with respect to efficiency scores.

Other studies in this area were conducted that explored various impacts on efficiency of hospitals. For example, DEA was used to demonstrate that some of the main factors affecting hospital efficiency included competition levels, regional or local labor market, and demographic features of the area in which these hospitals were offering their services (Dittman, Capettinit, & Morey, 1991). The church-ownership angle was explored as a possible impact on performance of hospitals and it was concluded that religious hospitals were more efficient than non-religious or secular hospitals (White and Ozcan, 1996). Similarly, mergers' effects on efficiency of hospitals were studied; however, no significant impact of merger activity on efficiency of merged hospitals could be confirmed (Ferrier and Valdmanis, 2004).

The studies focused on evaluating performance have come up with mixed findings regarding efficiencies prevailing in the health sector in different parts of the world. For example, Al-Shayea (2011) used DEA for evaluating the efficiency of a teaching hospital's departments in Saudi Arabia and observed high inefficiency, with only two out of the nine departments being found fully efficient. A study of hospitals in Turkey proved that introduction of reforms in the state owned hospitals had resulted in increased efficiency; while the reverse was found to be true for private hospitals which showed an average decrease in efficiency in the same period (Sahin & Bulent, 2011). Dimas, Goula, and Soulis (2012) studied the public general hospitals in Greece and found high inefficiency in their performance. Their study concluded that an extreme rise in expenditure was mostly responsible for the inefficiency observed in the selected hospitals' performance.

Applanaidu et al. (2014), studied public hospital in Kedah (Malaysia) and found that 74% of the DMUs were efficient technically. Contrary to these results, in a study conducted by Bwana (2015) that looked at Tanzanian private teaching hospitals for evaluating their technical efficiency through DEA, only 22.3 % of the selected DMUs obtained efficiency scores between 92-98%. While comparing public hospitals with those in the private sector; Davey, Raghav, Singh, Davey and Singh (2015) observed overall high efficiency scores. Cheng et al (2015) evaluated 114 county hospital for the period from 2010 to 2012 in Henan (China). In addition to DEA, they also used Malmquist index for calculating the productivity for the period and regressed different environmental and institutional factors affecting technical efficiency, through Tobit regression.

It was concluded that the selected hospitals were experiencing significant technical inefficiency.

Kaitelidou et al (2016) studied 90 general hospitals in Greece for the years 2010 and 2011 through DEA and bootstrapping techniques. They concluded that despite a small increase in overall efficiency, resulting from injection of additional funds; there was a strong need for better administering the allocation and utilization of available health care resources. In a study of hospitals based in Tehran, Kalhor et al. (2016) also suggested the need for better policy making and planning to improve inefficient performance of hospitals. In a more recent study, Farzianpour, Emami, Foroushani, and Ghiasi (2017) focused on hospitals in the city of Tabriz (Iran) for the period ranging from 2013 to 2014. Based on the findings of the study, the researchers suggested bringing improvement in financial and human resources' management, as well as modelling of efficient reference peers by the inefficient hospitals, as means of improving performance.

Based on the review of literature as discussed in this section, it can be safely concluded that health care systems in general are plagued with various challenges; of which, inefficiencies in performance and inadequate allocation of limited resources occupy a prominent place. The literature further suggests the need to ensure better performing and more efficient health care units through various avenues, such as better policy making as well as identification and emulation of more efficient units. This study is conducted in response to these needs through focusing on a group of Rural Health Centers (RHCs) located in Punjab province of Pakistan. The study aims to identify efficient and inefficient units and offer some policy related insights for the health care system in Pakistan.

2. Research Design and Methodology

Data

Data for the study was obtained from District Health Information System office of Director General Health Services (Punjab, Pakistan) for the year 2016. A total of 261 RHCs located in nine divisions of the Punjab province in Pakistan are included in the study. The nine divisions include: Bahawalpur, D.G. Khan, Faisalabad, Gujranwala, Lahore, Multan, Sahiwal, Rawalpindi and Sargodha.

DEA Model Specification

For measuring relative efficiency of RHCs, DEA is used, which is a non-parametric technique based on linear programming. In DEA, a pair of mutually dual linear programming models are used for calculating the efficiency scores. The envelopment DEA models measure efficiency scores by considering

efficient frontiers. The multiplier models, on the other hand, measure efficiency through ratio of total input variables to total output variables. The formulations of primal envelopment models and their dual multiplier models can be explained as follows

VRS envelopment model with input orientation

Min θ_0

Subject to

$\sum_{j=1}^{N} \lambda_j x_{ij} \leq \theta_0 x_{ij_0}$ (i =1..... m)

$\sum_{j=1}^{N} \lambda_j y_{rj} \geq y_{rj_0}$ (r = 1..... s)

$\sum_{j=1}^{N} \lambda_j = 1$ (J = 1,.....,N)

$\lambda_j \geq 0$

θ_0 sign free

In the above model, x and y are used to denote inputs and outputs of the study respectively. Notation N is used to depict the number of decision making units. The number of outputs is denoted by s and number of inputs in denoted by m; while DMU j0 is one of the N DMUs being evaluated. For DMU j, level of i^{th} input is represented by x_{ij} and level of r^{th} output is represented by y_{rj}.

For multiplier model, v_i and u_r denote the weights assigned by a DMU being evaluated to its ith input and rth output respectively in such a way that its efficiency may be maximized. ω0 is used to represent the dual variable for the convexity constraint in the corresponding envelopment model.

Selection of Orientation

This study uses input orientation for the DEA model in line with the reasoning offered by Cheng et al (2015). They propose that input orientation is more suitable for studying health care institutions, due to their underlying objective of meeting health care demands of their patients, through minimizing the use of input resources. The technical efficiency scores obtained under input orientation helps explain that how much reduction in the selected inputs is possible with existing levels of outputs.

Selection of Suitable Returns to Scale

This study has used the approach suggested by Avkiran (2001) for making decision about returns to scale assumption for DEA models. Following this approach, the DEA model was run with both the constant returns to scale (CRS) and variable returns to scale (VRS) assumptions. The resulting efficiency scores were having significant difference, suggesting suitability of VRS assumption for the data set.

Variables of the Study

The proposed model takes into account the importance of including all relevant inputs and outputs related to hospital efficiency. The selected variables are measured through both the monetary and non-monetary units and details of these are provided in Table 1.

Table 1 Units of Measurement and Classification of Selected Variables

Serial No.	Variables	Classification	Unit of Measurement
1	Number of doctors	Input	Number
2	Number of nurses	Input	Number
3	Operating expenses	Input	Pakistani Rupee
4	Outdoor patients	Output	Number
5	Indoor patients	Output	Number
6	Revenue generated	Output	Pakistani Rupee
7	Number of laboratory tests	Output	Number

3. Results and Discussion

The descriptive statistics for inputs and outputs used to analyze the efficiency of RHCs in Punjab are provided in Table 2, while Table 3 offers the descriptive statistics for efficiency scores obtained from running the proposed DEA model for different divisions in Punjab.

Table 2 Descriptive Analysis of Input and Output Variables

Variables	Mean	Minimum	Maximum	Standard Deviation
Inputs				
Number of doctors	28.85	2	60	9.64
Number of nurses	56.55	2	129	19.01
Operating expenses	4987068.20	837844	14809953	2656249.98
Outputs				
Outdoor patients	57051.47	13276	161003	24241.94
Indoor patients	2403.25	76	12146	1475.98
Revenue generated	158718.02	14	622153	109887.51
Number of laboratory tests	5745.42	411	36516	5627.47

Researcher has conducted descriptive analysis to check the characteristics of different variables by calculating their mean, minimum, maximum, and standard deviation. The value of standard deviation is showing the dispersion of data across its mean. Table 2 further shows that the average number of doctors in the RHCs of Punjab is 29. The minimum number of doctors is selected RHCs are 2 and maximum number of doctors in any RHC is 60. The number of nurses has mean score of 57. The minimum and maximum number of nurses Punjab based RHCs have is 2 and 129 respectively. Operating expenses, on the other hand has an average amount of Rs. 4987068 which shows that RHCs in Punjab, on average, spend Rs. 4,987,068 to operate their functions smoothly. The minimum and maximum amount of operating expenses is Rs. 837844 and Rs. 14,809,953 respectively. The mean number of outdoor patients in RHCs is 2403 with minimum and maximum value of 13276 and 161003 respectively. Whereas the average number of indoor patients, in any RHCs, is 2403. The minimum number of indoor patients is 76 and maximum number of indoor patients is 12146.

The average revenue generated by RHCs in Punjab is Rs. 158718 approximately. The minimum and maximum revenue generated is Rs. 14 and Rs. 622153 respectively. Number of laboratory test has an average of 5745. The minimum and maximum number of laboratory tests is 411 and 36516 respectively.

Table 3 Descriptive Analysis of Efficiency scores

Division wise Segregation of Punjab	Mean	Minimum	Maximum	Standard Deviation
Bahawalpur	68.3718	40.44	100.00	16.50185
D.G Khan	59.6868	37.33	100.00	19.22885
Faisalabad	59.1993	40.53	100.00	18.24280
Gujranwala	78.3923	43.33	100.00	16.55262
Lahore	65.2063	37.13	100.00	20.03717
Multan	70.7252	47.97	100.00	17.25800
Sahiwal	71.1258	42.11	100.00	17.36319
Rawalpindi	77.5964	42.31	100.00	17.98031
Sargodha	57.9622	34.35	100.00	18.29129

Table 3 shows the descriptive analysis of the efficiency scores calculated by DEA across the nine divisions of Punjab. The mean score of the RHCs located in Bahawalpur division is 68.37%. The minimum and maximum efficiency scores of RHCs in this division are 40.44% and 100% respectively. The RHCs working in the next division D.G. Khan, on the other hand, have average efficiency score of 69% approximately. The smallest score for this division is 37.44% which indicates very poor performance. The highest score of in this division is 100% which indicates that at least one RHC of D.G. Khan is fully efficient. The average efficiency score of Faisalabad based RHCs is 59.19% which indicates overall poor performance of health care sector in the said division. The minimum and maximum efficiency scores are 40.53% and 100% respectively. The mean score of Gujranwala division is 78.39% approximately, which indicate slightly better performance of health care sector in this division. The smallest and largest efficiency scores of this division range from 43.33% to 100%.

The average efficiency score for RHCs in the Lahore division is 65.21% approximately, which indicates overall poor performance of hospitals in this division. The minimum and maximum efficiency scores for Lahore division are 37.13% and 100% respectively. RHCS in the Multan division, on the other hand, have an average efficiency score of 70.72% approximately, which shows relatively better performance of health care institutions of this division. The minimum and maximum efficiency scores of this division range from 47.97% to 100%. The mean score of Sahiwal based RHCs is 71.12%, which indicate acceptable performance with minimum and maximum scores of 42% and 100% respectively. Rawalpindi division RHCs have an average efficiency score of 77.59% which shows that hospitals in this city are using their inputs at an acceptable level. The minimum and maximum efficiency scores for Rawalpindi ranges from 42.31% to 100%. The average efficiency score of RHCs in Sargodha division is 57.96% approximately which shows that performance of health care sector is poor in the city. The minimum and maximum efficiency scores are 34% and 100% respectively. Overall, the analysis of descriptive statistics shows that Gujranwala division, on average, has scored highest in the nine divisions of Punjab. Sargodha, on the other hands, has scored lowest in in terms of average efficiency scores.

Figure 1: Performance of RHCs located in Punjab

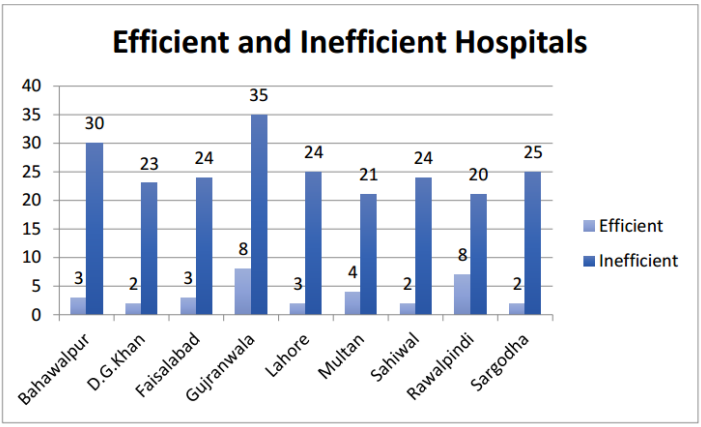

Figure 1 provides a pictorial overview of the number of efficient and inefficient RHCs operating in the nine divisions of Punjab. Researcher has distinguished efficient RHCs from inefficient ones, based on the criterion that all the RHCs having efficiency score of 100 are considered as efficient, and other RHCs having less than 100efficiency score are considered as inefficient. It can be further elaborated that in terms of percentage, Rawalpindi division stands first with 8 of its RHCs scoring 100 % efficiency score, which translates into 28.6% of the RHCs being fully efficient. The second highest percentage of fully efficient RHCs belongs to Gujranwala at 18.60%. On the other hand,

D.G. Khan, Sahiwal and Sargodha divisions have least percentage of fully efficient hospitals at 8%, 7.69% and 7.41%, respectively.

4. Conclusion

This study has calculated relative technical efficiency scores of 261 RHCs working in nine division of the province of Punjab, Pakistan. A non-parametric technique known as DEA was used for evaluating performance of selected RHCs. The DEA tool offers insights about how inefficient RHCs can reduce their inefficiencies by following their more efficient peers. The scores are obtained under input orientation which reveal the degree to which all selected inputs need to be reduced for achieving full efficiency.

The scores obtained from DEA show that a greater proportion of the RHCs are not performing well; with the minimum efficiency score falling as low as 34.35 %. Overall, the efficiency scores for the nine divisions tell us that Gujranwala division has highest number of fully efficient RHCs. Our analysis

also revealed that out of 261 RHCs, only 33 are fully efficient with a relative efficiency score of 100%. This means that these 33 RHCs are lying on the efficient frontier and can act as efficient benchmarks for their inefficient peers. The large scale inefficiencies observed in the selected RHCs suggest the need for more intense policy making and other operational changes to ensure better performance. In this regard, the inefficient RHCs can learn to perform better through following their efficient peers' best practices and production processes.

Our analysis offers some important policy implications with reference to RHCs in Punjab in particular, and for the whole of Pakistan in general. Future research may focus on a bigger data set through including other provinces of Pakistan.

End Notes and Bibliography

Aksezer, C. S. (2016). A nonparametric approach for optimal reliability allocation in health services. *International Journal of Quality & Reliability Management*, 33(*2*), 284-294.

Al-Shayea, A. M. (2011). Measuring hospitals' units' efficiency: A data envelopment analysis approach. *International Journal of Engineering & Technology* IJET-IJENS, 11(*6*), 7-19.

Applanaidu, S. D., Samsudin, S., Ali, J., Dash, U., & Chik, A., R. (2014). Technical and scale efficiency of public district hospitals in Kedah, Malaysia: A data envelopment analysis (DEA). *Journal of Health Management. 6*(3), 327-335.

Avkiran, N. K. (2001). Investigating technical and scale efficiencies of Australian Universities through data envelopment analysis. *Socio-Economic Planning Sciences*, *35*(1), 57–80.

Banker, R.D., Charnes, A., Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science, 30*(9), 1078–1092.

Bwana, K. M. (2015). Technical efficiency of Tanzania teaching hospitals: The case of private not for-profit hospitals. *Business Management and Strategy, 6*(1), 2157-2168.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2***,** 429-444.

Cheng, Z., Tao, H., Cai, M., Lin, H., Lin, X., Shu, Q., & Zhang, R. (2015). Technical efficiency and productivity of Chinese county hospitals: An exploratory study in Henan province, China. *BMJ Open*, *5*(9), 1-11.

Cobb, C. W. & Douglas, P. H. (1928). A Theory of Production. *The American Economic Review, 18***,** 139-165.

Davey, S., Raghav, S., Singh, J., Davey, A., & Singh, N. (2015). A comparative evaluation of public health centers with private health training centers on primary healthcare parameters in India: A study by data envelopment analysis technique. *Indian Journal of Community Medicine*, *40*(4), 252-257.

Dimas, G., Goula, A., & Soulis, S. (2012). Productive performance and its components in Greek public hospitals. *Operational Research, 12*(1), 15–27.

Dittman D. A., Capettinit R., & Morey R. C. (1991). Measuring efficiency in acute care hospitals: An application of data envelopment analysis. *Journal of Health and Human Resource Administration, Summer;* 14(1), 89-108.

El-Seoud, A. (2013). Measuring efficiency of reformed public hospitals in Saudi Arabia: An application of data envelopment analysis. *International Journal of Economics and Management Sciences*, 2(*9*), 44-53.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society Series A (General), 120***,** 253-290.

Farzianpour, F., Emami, A. H., Foroushani, A. R., & Ghiasi, A. (2016). Determining the technical efficiency of hospitals in Tabriz city using data envelopment analysis for 2013- 2014. *Global Journal of Health Science, 9*(5), 42-54.

Ferrier, G. D., & Valdmanis, V. G. (2004). Do mergers improve hospital productivity?*Journal of the operational research society, 55*(10), 1071-1080.

Guardazi, R., Pourreza, A., Shokoohi, A., Skari, R., Mahdavi, M., & Moghri, J. (2014). Technical efficiency of teaching hospitals in Iran: The use of stochastic frontier analysis, 1990-2011. *International Journal of Health Policy Management, 3*(2), 91-97.

Iossifova, A. R., & Meyer-Goldstein, S. (2013). Impact of standards adoption on healthcare transaction performance: The case of HIPAA. *International Journal of Production Economics, 141*(1), 277-285.

Kaitelidou, D, Kalogeropoulou, M., Siskou, O., Tsavalias, K., Katharaki, M., Economou, C., Souliotis, K., & Liaropoulos, l. (2011). The impact of economic crisis to hospital sector and the efficiency of Greek public hospitals. *European Journal of Business and Social Sciences, 4*(10), 111-125.

Kalhor, R., Amini, S., Sokhanvar, M., Lotfi, F., Sharifi, M., & Kakemam, E. (2016). Factors affecting the technical efficiency of general hospitals in Iran: Data envelopment analysis. *Journal of the Egyptian Public Health Association,* 91(1), 20-25.

Lorenz, C., Khalid, M., & Akhtar, N. (2011). Costing structure of public hospitals in Pakistan. *Pakistan Journal of Medical and Health Sciences*. *5*(3), 403-407.

Mashhadi, S. F., Hamid, S., Roshan, R., & Fawad, A. (2016). Healthcare in Pakistan-A systems perspective. *Pakistan Armed Forces Medical Journal*, *66*(*1*), 136-142.

McKee, M., & Healy, J. (2002). *Hospitals in a Changing Europe*. Open University Press, Philadelphia: 1-285.

Meghani, S. T., Sehar, S., & Punjani, N. S. (2014), Comparison and analysis of healthcare delivery system: Pakistan versus China. *International Journal of Endorsing Health Science Research, 2*(1), 46-50.

Ministry of Finance (2016) *Pakistan Economic Survey*. Retrieved from http://www.finance.gov.pk/survey_1516.html

Nunamaker, T. R. (1983). Measuring routine nursing service efficiency: A comparison of cost per patient day and data envelopment analysis models. *Health Services Research, 18*(2 Pt. 1), 183-208.

Ozcan, Y. A, Luke, R. D., & Haksever, C. (1992). Organizational performance – a comparison of technical efficiency across hospital types. *Medical Care*, 3, 781-794.

Sahin, M. G., & Bulent, S. (2011). Analyzing the efficiencies of hospitals: An data envelopment analysis. *Journal of Global Strategic Management, 5*(2) 137-146.

Sherman, H. D. (1984). Hospital efficiency measurement and evaluation: Empirical test of a new technique. *Medical Care, 22*(10), 922-938.

Sorkis J., & Talloru, S. (2002). Efficiency measurement of hospitals: Issues and extensions. *International Journal of Operation and Production Management*, *22*(3), 306- 313.

Vivian G. V. (1990). Ownership and technical efficiency of hospitals. *Medical Care*, *28*(6).

White, K. R., & Ozcan, Y. A. (1996). Church ownership and hospital efficiency. *Hospital and health services administration*, *41*(3)
.