P-ISSN: 2790-6795	Annals of Human and Social Sciences	Apr-June 2024,Vol. 5, No. 2
O-ISSN:2790-6809	http://doi.org/10.35484/ahss.2024(5-II)50	[541-554]

Annals of Human and Social Sciences
www.ahss.org.pk

RESEARCH PAPER

Efficiency and Productivity of Public Hospitals in Pakistan

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ABSTRACT

This study aims to measure efficiency and productivity of public hospitals in Pakistan. The efficiency and productivity of public hospitals remains focus of researchers because large amount of public money is spent on them. This research examined 12 DHQ hospitals over the period of 2020–2022 using data envelopment analysis (DEA) and the Malmquist Productivity Index to evaluate efficiency and productivity. Results indicate an average technical efficiency (TE) of 0.926 and scale efficiency (SE) 0.95 with slight improvement during the study period. Overall productivity remained 0.943. Only 5 hospitals showed productivity of 1 while the productivity of the rest of the hospitals remained below 1. Notably, hospitals in Northern Punjab exhibit higher efficiency compared to the Southern and Central Punjab, challenging conventional assumptions linking hospital efficiency solely to economic development levels. The study suggests customized resource allocation and reforms for each hospital's needs to improve efficieny and productivity.

Keywords: Data Envelopment Analysis, Efficiency, Malmquist Productivity Index, Productivity, Public Hospitals

Introduction

The foundational pillar and catalyst for advancing the progression of a healthcare system lie in the efficiency of hospitals. It is imperative for a medical institution to uphold a standard of excellence in delivering healthcare services while simultaneously achieving optimal production efficiency at the most economical cost (Garg et al., 2024). Hospital efficiency, a multifaceted economic construct, hinges on variables susceptible to modification, thereby distinguishing the operational and effective performance of the hospital (Kaydos, 2020). This differentiation arises from the unique demands arising from the relentless pursuit of well-being.

The issue of inefficiency pervades health systems on a global scale. According to the World Health Organization (WHO), an estimated 30%-35% of the total overall health spending around the globe is squandered. In the context of Pakistan, it estimated that the annual cost of inefficiency to the healthcare system ranged from 19% to 36% of the total health spending (Gupta & Mondal, 2014).

The escalating growth in health expense, fueled by factors such as rapid increase in population, advancements in health technology, and heightened expectations of the masses, has brought about an intensified focus on enhancing the efficiency of health systems. This heightened attention is propelled by the realization that a significant portion of resources allocated to health is not optimally utilized, posing a substantial challenge to the sustainability and effectiveness of healthcare services. Efforts to curtail inefficiency are imperative to ensure that healthcare resources are judiciously allocated, contributing to improved overall health outcomes and the prudent management of healthcare budgets (Nicol, 2018).

Hospitals constitute a substantial share of the overall health expense, making their efficient management a critical aspect of healthcare systems (Vilcahuamán & Rivas, 2017). Within the member countries of South Asia, hospitals accounted for an average of approximately 36% of the total health expense in the year 2023.

This heightened allocation of resources to hospitals underscores the pivotal role these institutions play in the healthcare landscape. Consequently, policymakers and managers have directed significant attention toward evaluating the efficiency of hospitals. The rationale behind this emphasis lies in the understanding that efficient hospital operations are tantamount to the overall effectiveness of health systems (Devolites & Hatcher, 1983). Recognizing the economic significance of hospital expense, the scrutiny of efficiency becomes imperative for ensuring optimal resource utilization and, consequently, the enhancement of overall healthcare outcomes.

Numerous investigations have underscored the prevalence of technical inefficiency within hospitals, spanning countries at diverse levels of economic development. The global impact of hospital-related inefficiencies amounts to approximately US$ 300 billion each year, signifying a substantial economic loss. In light of this, it becomes paramount to delve into the factors that contribute to hospital inefficiency and to devise interventions aimed at enhancing both hospital efficiency and the overall performance of the healthcare system.

The imperative to identify and address these factors arises from the significant economic ramifications associated with inefficient hospital practices. The annual loss of such a substantial financial magnitude not only underscores the urgency of the issue but also emphasizes the critical need for proactive measures. By gaining insights into the determinants of hospital inefficiency and implementing targeted interventions, there exists the potential to mitigate economic losses, thereby fostering improvements in both hospital efficiency and the broader effectiveness of the healthcare system as a whole.

Hospital inefficiencies manifest in diverse forms, encompassing technical, allocative, scale, scope, and cost inefficiency (Nicol, 2018). Technical efficiency in a hospital is achieved when it maximizes outputs given a certain level of inputs or resources, or conversely, when it minimizes inputs for a given level and choice of outputs. Allocative efficiency comes into play when a hospital strategically allocates and utilizes the least costly combination of inputs in the production of outputs, ensuring that hospital resources are committed to producing outputs that align with societal priorities (García-Prieto, 2004).

Scale efficiency materializes when the size of hospital operations reaches an optimal level, and any alteration in size would compromise the hospital's overall efficiency. On the other hand, scope efficiency is realized when a hospital reduces its average cost through the advantageous production of various outputs, indicating a capacity to diversify services without increasing costs disproportionately (Madzamba et al., 2022). Cost efficiencies, in turn, gauge the average cost employed in producing outputs in comparison to a predetermined standard or the costs incurred by other providers (Kresimon et al., 2010).

Understanding and addressing these different facets of inefficiency within hospitals are essential for comprehensive improvement strategies. By delineating and targeting specific areas such as technical, allocative, scale, scope, and cost inefficiency, healthcare institutions can streamline their operations, enhance resource allocation, and ultimately contribute to a more effective and economically sustainable healthcare system (Herr et al., 2009).

In terms of operations of a healthcare institute, a hospital is an institution designed to offer not only beds, meals, and continuous nursing care but also medical therapy administered by physicians, all with the overarching goal of restoring patients to health (Nicol, 2018). While this definition encapsulates the fundamental characteristics of a hospital, it is crucial to acknowledge the vast diversity that exists among these institutions in terms of structure and organization. In public sector, hospitals range from modest Basic Health Facility (BHU) providing essential services, to expansive Teaching hospitals equipped with cutting-edge technology and a highly skilled workforce (Madzamba et al., 2022).

The essential functions of hospitals encompass patient care, education, research, and support for the broader health system. However, the execution of these functions varies based on the organizational and classification frameworks adopted by different hospitals. The diversity in organizational structures and classifications is anticipated to significantly impact hospital efficiency and the influencing factors (Ilfandy Imran, 2019). Various criteria, such as size, specialization, and geographic location, contribute to the categorization of hospitals into distinct types, each with its unique attributes and roles.

By recognizing and understanding the diversity inherent in the hospital landscape, policymakers and healthcare professionals can tailor strategies and interventions to address the specific needs and challenges faced by different categories of hospitals. This nuanced approach is pivotal for optimizing the efficiency of hospitals and, consequently, enhancing the overall effectiveness of healthcare delivery systems. This research paper will measure efficiency and productivity of non-teaching DHQ hospitals of Pakistan (Albejaidi, 2021).

Literature Review

Measurement of hospital efficiency

In most of the studies involving the determination of efficiency factors, a prevalent approach involves a two-stage method. Initially, efficiency scores are computed, followed by a regression analysis against hypothesized explanatory variables. This two-stage methodology serves to evaluate the impact of these variables on the efficiency (or inefficiency) of hospital operations. By adopting such comprehensive methodologies, researchers aim to capture the nuanced intricacies of hospital efficiency, accounting for both quantitative and qualitative aspects, and paving the way for a more insightful understanding of the factors influencing the effectiveness of healthcare institutions (Archbold & Cram, 2024).

Inputs and Outputs of Hospitals

Hospitals are complex entities that utilize various inputs, including human resources, pharmaceuticals, and equipment, to generate valued outputs such as outpatient visits and surgical operations. The evaluation of hospital efficiency is centered on gauging the effectiveness with which these inputs are transformed into valuable outputs. The efficiency of hospitals encompasses two key dimensions: technical (production) efficiency and allocative efficiency (Godbole, 2017).

Orientation of Efficiency

Technical efficiency is characterized by both input and output orientations. In the input-oriented perspective, a hospital is deemed technically efficient when it minimizes the utilization of inputs to produce its selected outputs. Conversely, in the output-oriented definition, which is equivalent yet distinct, a hospital is considered technically efficient when it maximizes its outputs given a predetermined level of inputs. Further, technical efficiency is dissected into pure technical (operational) efficiency and scale efficiency (Lee, 2009). When a hospital operates outside constant returns to scale, it experiences inefficiencies stemming from both economies and diseconomies of scale.

The second facet of hospital efficiency, allocative efficiency, delves into the strategic allocation of hospital outputs or inputs. From an input-oriented allocative efficiency standpoint, the focus is on whether a hospital employs the optimal combination of inputs (factors of production) to generate its chosen outputs, taking into account prevailing input prices. On the output side, allocative efficiency scrutinizes whether a hospital utilizes scarce resources to produce the correct mix of outputs that maximizes societal health gains in the aggregate (Archbold & Cram, 2024).

Considering that in institutions like hospitals, it is easier to control inputs rather outputs and outputs can be improved by efficiently using inputs, the input-oriented DEA method was selected as the most suitable approach for this analysis (Jahanshahloo & Khodabakhshi, 2004).

Assessment of Hospital Efficiency

The assessment of hospital efficiency involves the application of diverse methodologies, including ratios and frontier techniques rooted in the microeconomic theory of production. Ratios, while useful, present a partial picture by focusing on measures of capacity utilization and unit costs, neglecting the intricate multiple-input, multiple-output dynamics inherent in hospital production. This limitation is addressed by frontier techniques, which offer a more comprehensive evaluation. Two prominent approaches are data envelopment analysis, a non-parametric, data-driven technique utilizing mathematical programming, and parametric stochastic frontier techniques employing econometric methods, encompassing both production and cost functions (Roshani et al., 2021).

Data Envelopment Analysis (DEA)

DEA is the most widely used technique. it is an innovative technique incorporating mathematical planning, such as linear programming, to assess the relative efficiency of a decision-making unit (DMU). This assessment involves multiple input and output variables within the framework of a DMU. Initially applied to assess the efficiency of public sector only, DEA gradually extended its reach to encompass finance, economics, project evaluation, and, notably, health service efficiency evaluation on a global scale (ATILGAN, 2016).

The methodology employs measured data from each DMU to ascertain its eligibility for DEA analysis, evaluating whether the DMU resides on the "production frontier" of the production function. DEA introduces two fundamental models, Charnes, Cooper, Rhodes (CCR), and Banker, Charnes, Cooper (BCC), based on assumptions of constant returns to scale and variable returns to scale respectively. In the former model a DMU can be scaled up proportionally by equal investments while in the latter a DEA model assumes disproportionate expansion of the scale output concerning the invested scale (Archbold & Cram, 2024). Both models can be categorized as input-oriented or output-oriented, with the former focusing on constant outputs relative to least possible inputs and the latter emphasizing constant input relative to maximum outputs when assessing DMU effectiveness.

Malmquist Index

The Malmquist index, initially conceived for consumption analysis, it was adapted by Caves et al. for production analysis. This index is basically calculated by diving distance function with the productivity index (Jianguo & Qamruzzaman, 2017). It is further divided into TC and TE where TC stands for technological change while TE stands for technical efficiency change, with TE change comprising pure TE change (PTEC) and scale efficiency change (SEC). These subdivisions reflect improvements in production and operational behavior, technological progress, variable-scale remuneration assumptions, and changes in economies of scale within DMUs (Klofsten et al., 2020).

Defined through the proposed distance function, the Malmquist index serves as a reflection of efficiency changes from time t to t + 1. It is a dynamic, nonparametric method reflecting total factor productivity (TFP) changes. The total factor productivity changes (TFPC) over a period of time provides a metric for assessing the TFP index. A Malmquist index >1 signifies improved TFP levels and increased productivity, while an index <1 indicates a decline in TFP levels and regression in productivity during the specified period (Jianguo & Qamruzzaman, 2017).

District Head Quarter (DHQ) hospitals in Pakistan cater to populations ranging from 2 to 4 million. These hospitals offer various healthcare services including promotion, prevention, diagnosis, treatment, inpatient care, and referrals (Gilchrist & Collier, 2020). This study examines the efficiency and productivity of these hospitals from 2020 to 2022. Assessing economic efficiency and cost productivity is crucial for improving hospital performance and optimizing resource allocation. This analysis aims to identify factors influencing the economic efficiency and productivity of DHQ hospitals to guide healthcare resource allocation effectively. Recognizing Punjab's pivotal role in Pakistan being the most populated province, the author has chosen to focus on Punjab Province, conducting a meticulous assembling and analysis of research data from a sample of 12 DHQ hospitals within Punjab. The objective is to assess the efficiency of DHQ hospital development, thereby furnishing valuable evidence for future endeavors in this realm.

In line with the principles and models of Data Envelopment Analysis (DEA), each non-teaching DHQ hospital within Punjab Province is treated as a Decision-Making Unit (DMU) and 12 hospitals were selected as sample by Stratified Random Sampling technique. The healthcare services are envisioned as an economic framework that combines human and financial resources to generate service outcomes. By utilizing the data extracted from different reports related to healthcare services, the research conducts an empirical study to assess the efficiency of the mentioned 12 DHQ hospitals using DEA models and theories. This analytical approach seeks to provide detailed insights into the effectiveness of these healthcare institutions, thereby supporting evidence-based decision-making for future developmental plans (Lee, 2009).

Material and Methods

Variables

Drawing on an assessment of public hospitals and drawing from insights provided by earlier studies such as by Majid Ali, the experts engaged in a comprehensive deliberation. The experts judiciously selected input indicators to gauge the hospital's dynamics (Majid Ali et al., 2023). These include (I1) the actual count of doctors, (I2) the count of actual nurses, (I3) the actual count of beds, and (I4) the total expense. On the output side, variables were chosen to reflect the hospital's service capacity, encompassing (O1) the count of emergency visits, (O2) the count of discharges, and (O3) the count of hospitalized patients (Roshani et al., 2021).

Input Variables

The healthcare system is conceptualized as an economic system that combines different resources to produce healthcare services. This research conducts an empirical investigation into the efficiency of the mentioned 12 DHQ hospitals using DEA models and theories. This analytical approach aims to offer nuanced insights into the efficiency of these healthcare institutions, facilitating evidence-based decision-making for future developmental strategies (Gilchrist & Collier, 2020).

Output Variables

In terms of service capacity, certain variables play a crucial role. The volume of outpatient and emergency visits, along with the tally of discharged and hospitalized patients, collectively serve as robust indicators of a hospital's effectiveness in providing healthcare services. This thoughtful selection of indicators reflects a comprehensive approach, recognizing the multifaceted nature of hospital operations and ensuring that the evaluation encompasses essential aspects related to human capital, economic investment, and service capacity (Majid Ali et al., 2023).

Statistical analysis

For data entry, Microsoft Excel 2021 was employed, and subsequent analysis involved SPSS software for calculating the median and variance of both input and output variables. DEAP software facilitated the analysis of integrated efficiency, encompassing Technical Efficiency (TE), Pure Technology Efficiency (PTE), and Scale Efficiency (SE) (Majid Ali et al., 2023).

Measurement of Technical Efficiency (TE)

TE serves as a comprehensive measure of production efficiency for DMUs, considering specific input factors. It evaluates the capacity for allocation of resources allocation and their efficient utilization within each DMU (Roshani et al., 2021). TE is calculated using the CCR model under the assumption of fixed scale payments, representing the cutting edge of existing production conditions when hospital operates at its peak efficiency. Additionally, dissecting TE into two components provides further insights:

Pure Technical Efficiency (PTE): This component reflects the efficiency related to hospital systems and management.

Scale Efficiency (SE): SE highlights the difference between the existing scale and the optimal scale under the current system and management level.

The relationship between these components is encapsulated by the formula TE = PTE × SE

Measurement of Productivity

Malmquist productivity index based on DEA was utilized to assess the efficiency of TFP. When the Total Factor Productivity Change (TFPC) exceeds 1, it indicates enhanced TFP levels, implying cost reduction and increased productivity over the specified period. Conversely, if TFPC is less than 1, it signifies a decline in TFP levels, indicating a regression in productivity (Gilchrist & Collier, 2020).

Measurement of Technological Efficiency Change

Technological Efficiency Change (TEC) represents enhancements in production and operational practices. A TEC value greater than 1 indicates improved efficiency. Technological Change (TC) explains the impact of progress in technological on productivity, with a TC value exceeding 1 suggesting cost savings or productivity gains due to technical innovation (Roshani et al., 2021). Pure Technical Efficiency Change (PTEC) relates to variable-scale compensation assumptions within the DMUs' technical context. PTEC values greater than 1 signify superior performance compared to the average level, while PTEC values less than 1 highlight the need for management improvement. Scale Efficiency Change (SEC) pertains to alterations in the DMUs' economies of scale. An SEC value below 1 indicates the necessity for downsizing and adjustment. The relationship between TFPC, EC (Efficiency Change), PTEC, and SEC is mathematically expressed as TFPC = EC × TC, where EC = PTEC × SEC (Jahanshahloo & Khodabakhshi, 2004).

Results and Discussion

Table 1 below presents a comprehensive depiction of descriptive input and output data spanning the years 2020 to 2023. The table encapsulates a detailed overview of various factors, allowing for a thorough examination and analysis of trends and patterns during this three-year timeframe (Gilchrist & Collier, 2020). The inclusion of both input and output details provides a holistic perspective, enabling a nuanced understanding of the dynamics and changes observed over this period. This tabulated information serves as a valuable resource for researchers, policymakers, and analysts seeking to delve into the intricacies of the subject matter within the specified timeframe.

Table 1
Descriptive Data of input and output from 2020 to 2022

Year	Items	Input Variables				Output Variables		
		I1	I2	I3	I4 (PKR '000,000)	O1	O2	O3
2020	Median	188.5	260.5	477.0	15,610.5	301,521.0	19,656.0	4318.0
	Standard Deviation	53.323	52.429	223.334	5324.59	86,754.229	10,009.924	3083.296
2021	Median	185.0	257.5	477.5	14,213.0	29,3450.0	20,389.5	4529.0
	Standard Deviation	59.860	77.431	291.428	7819.730	110,032.431	13,393.232	3515.047
2022	Median	178.0	244.5	450.5	13,119.5	246,285.0	18,472.5	4068.0
	Standard Deviation	63.043	95.549	280.206	9306.520	122,256.676	14,202.955	3921.624

I1 = actual count of doctors, I2 = count of actual nurses, I3 = actual count of beds, I4 = Total expense, O1 = the count of emergency visits, O2 = the count of discharges, O3 = the count of hospitalized patients

Technical efficiency results for data envelopment analysis of sample hospitals

Table 2 below illustrates a noteworthy trend in efficiency of the 12 DHQ hospitals during the period spanning 2020 to 2022. Notably, there is a discernible upward trajectory in the overall efficiency, with hospitals B, J, I, G, and C consistently achieving validity for DEA as reflected in their TE scores equaling 1. Hospital C, however, exhibited an interesting pattern, showing an upward trend until 2022, followed by a subsequent decline in efficiency.

Table 2
Technical efficiency of sample hospitals for the year 2020–2022

Hospital Code	2020	2021	2022	Mean
A	0.985	1	1	0.998
B	1	1	1	1
C	0.753	0.659	0.709	0.755
D	0.906	0.923	1	0.937
E	0.756	0.929	1	0.876
F	0.805	0.887	0.995	0.898
G	1	1	1	1
H	0.658	0.723	0.776	0.732
I	1	1	1	1
J	1	1	1	1

K	0.785	1	1	0.930
L	0.968	1	0.994	0.988
South	0.903	0.896	0.927	0.922
Central	0.816	0.885	0.943	0.877
North	0.949	1	0.999	0.979
Mean	0.889	0.927	0.956	0.926

Over the course of the past 3 years, a notable observation emerges, with a significant majority of the hospitals—nine out of twelve, constituting 75%—attaining a TE score of 1, indicative of optimal efficiency. In contrast, 3 hospitals—specifically, hospitals F, H, and C—never reached a TE of 1 during this period. Examining the annual breakdown, it is evident that the number of hospitals deemed valid for DEA varied each year, with counts of 4, 7, and 8 hospitals meeting the criteria from 2020 to 2022, respectively (Majid Ali et al., 2023).

A regional analysis reveals interesting disparities, with North Punjab exhibiting the highest efficiency levels, closely trailed by South Punjab, while Central Punjab consistently recorded the lowest efficiency (Jahanshahloo & Khodabakhshi, 2004). Notably, in the year 2021, North Punjab maintained an average TE score of 1, further accentuating the regional differentials in hospital efficiency. This nuanced exploration of temporal and regional dynamics provides valuable insights into the performance variations among DHQ hospitals in Punjab Province during the specified period.

Pure technology efficiency results for data envelopment analysis of sample hospitals

As depicted in Table 3 below, spanning the years 2010 to 2015, a select group of hospitals, namely A, I, K, B, L, J, and G, have consistently demonstrated proactive measures in maintaining a Pure Technology Efficiency (PTE) score of 1, signifying optimal utilization of resources. Notably, these hospitals have exhibited commendable efficiency in leveraging resources for the specified period. In contrast, Hospital C has not achieved a PTE of 1 at any point, with its PTE value experiencing a decline post-2013.

Table 3
PTE of sample hospitals

Hospital	2020	2021	2022	Mean
A	1	1	1	1
B	1	1	1	1
C	0.882	0.810	0.785	0.871
D	0.984	1	1	0.997
E	0.770	1	1	0.910
F	0.806	1	1	0.935
G	1	1	1	1
H	0.916	1	0.942	0.975
I	1	1	1	1
J	1	1	1	1
K	1	1	1	1
L	1	1	1	1
Southern	0.979	0.953	0.963	0.964
Central	0.892	1	1	0.953
Northern	1	1	1	1
Mean	0.957	0.984	0.988	0.974

The annual breakdown reveals varying levels of success in achieving an effective Data Envelopment Analysis (DEA) across the hospitals. Specifically, in the years 2020 to 2021, there were 8, 10, and 11 hospitals, respectively, that successfully met the criteria for effective DEA.

Regional Analysis

A regional analysis unveils an interesting trend, with the average PTE in North Punjab consistently standing at 1, surpassing the corresponding averages in South and Central Punjab. This disparity underscores the regional nuances in the application of technology and management practices, positioning North Punjab as a region where hospitals have excelled in optimizing technology efficiency (Majid Ali et al., 2023). The detailed examination of PTE scores and regional differentials enriches our understanding of the varied technological landscapes among hospitals in Punjab Province during the specified period.

Scale efficiency results for data envelopment analysis of sample hospitals

As indicated in Table 4, there is a consistent trend wherein a substantial majority of hospitals—nine out of twelve, constituting 75%—have achieved a Scale Efficiency (SE) score of 1, indicative of optimal scaling in resource utilization. In contrast, 3 hospitals, specifically hospitals H, F, and C, have not reached an SE of 1 throughout the past 6 years, suggesting potential inefficiencies in their scale of operation.

Table 4
SE of sample hospitals

Hospital	2020	2021	2022	Mean
A	0.997	1	1	0.998
B	1	1	1	1
C	0.809	0.840	0.875	0.865
D	0.874	0.923	1	0.939
E	0.982	0.929	1	0.963
F	0.992	0.887	0.995	0.963
G	1	1	1	1
H	0.715	0.767	0.776	0.750
I	1	1	1	1
J	1	1	1	1
K	0.794	1	1	0.930
L	1	1	0.994	0.988
Southern	0.921	0.941	0.969	0.950
Central	0.922	0.900	0.943	0.920
Northern	0.949	1	0.999	0.980
Mean	0.931	0.945	0.970	0.950

Examining the annual breakdown, the number of hospitals meeting the criteria for effective DEA varied each year, with counts of 7, 6, and 8 hospitals successfully achieving an effective DEA for the years 2010 to 2015, respectively.

Regional analysis

A regional analysis reveals intriguing disparities in Scale Efficiency, with North Punjab exhibiting the highest average SE at 0.979. Following this, South Punjab demonstrates a commendable SE, while Central Punjab records the lowest SE. This regional differentiation in scaling efficiency sheds light on the diverse operational landscapes among hospitals in Punjab province. The nuanced examination of SE scores and regional variations contributes valuable insights into the efficiency levels of hospitals and their scaling practices during the specified period.

Scale efficiency and Pure technology efficiency

It is discerned from the above discussion that throughout the period spanning 2020 to 2022, Pure Technology Efficiency (PTE) consistently surpassed Scale Efficiency (SE). This leads to the conclusive inference that, during this timeframe, PTE emerged as the predominant factor influencing Technical Efficiency (TE), with SE playing a secondary role.

The consistent precedence of PTE over SE underscores the significance of technological considerations in determining the overall efficiency of the system. This observation implies that improvements in technological processes and management practices were more instrumental in driving overall efficiency than adjustments in the scale of operations during the specified period. The nuanced interplay between PTE and SE provides valuable insights into the dynamics shaping the technical efficiency landscape over the years under consideration.

Redundant inputs and inadequate output

The investigation into the service efficiency of five DHQ hospitals, identified as exhibiting poor efficiency based on Pure Technology Efficiency (PTE), has brought to light notable findings regarding the allocation of inputs and outputs within these healthcare institutions. A comprehensive analysis, as detailed in Table 5 below, reveals a pattern of redundancy in certain input factors, compared with inadequacies in output.

Table 5
Redundant & Slack values of the sample DHQ hospitals

Hospitals	Years	Inputs				Outputs		
		I1	I2	I3	I4 (PKR '000,000)	O1	O2	O3
C	2020	−37.423	−63.070	−40.512	−1316.922	1663.014	0	0
	2021	−43.423	−14.754	−10.594	−4012.169	0.000	0	0
	2022	−28.365	−42.697	−180.772	−7250.156	48,688.659	0	0
D	2020	0	0	0	0	0	0	0
	2021	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0
E	2020	−78.918	−59.704	−98.074	−3199.561	0	0	0
	2021	−61.325	−39.075	−27.425	−3410.554	0	0	0
	2022	0	0	0	0	0	0	0
F	2020	−68.912	−117.787	−243.263	−2288.110	0	0	0
	2021	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0
H	2020	−9.911	−13.270	−55.998	−654.875	35,837.47	3252.49	0
	2021	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0

In the context of these five hospitals, certain input factors were identified as redundant during the study period. These were the actual count of beds, doctors, nurses and the total expense. Conversely, the primary focus of output centered around the number of emergency visits, with particular emphasis observed in the year 2020. Following this period, positive trends were noted in 2021 and 2022, indicating an overall improvement in efficiency.

However, a closer examination reveals that hospital C consistently exhibited input redundancy and inadequate production from 2020 to 2022. This deficiency was particularly evident in the count of nurses, actual bed count, and total cost. Similar instances of unnecessary inputs and insufficient outputs were also identified in hospitals D and E in 2021, hospitals F in 2022, and hospital H in 2020, 2021, and 2023

For example, considering the 2020 results of hospital C, there exists potential for input optimization in input variable I1 by reducing it bt 37.4, in input variable I2 by reducing it by 63.07, in input variable I3 by reducing it bt 40.5, and in input variable I4 by reducing it by 1316.922, while maintaining the current output. Alternatively, achieving the same result would require increasing the output (O1) by 1663.014 with the existing input levels.

These detailed findings offer a nuanced understanding of the inefficiencies present in these DHQ hospitals, presenting opportunities for targeted improvements in resource allocation and output optimization. The meticulous analysis provided in Table 5 serves as a foundational resource for strategic interventions aimed at enhancing the overall service efficiency of these healthcare institutions.

Productivity change for Malmquist index in the 3 years-period (2020–2022)

Average Total Factor Productivity Change (TFPC) recorded a slight decline, reaching 0.983, indicating a decrease of 1.7%. as illustrated in Table 6 below, the This reduction in average productivity can be attributed to the reduction in Total Cost (TC), with the impact of the increase in Total Efficiency Change (TEC) being less pronounced as compared to TC.

Table 6
Malmquist Productivity index for DHQ hospitals in Punjab (2020-2022)

Years	Total Efficiency Change	Total Cost	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Producti vity Change
2020–2021	1.010	0.922	0.996	1.005	0.931
2021–2022	1.016	0.942	1.011	1.015	0.957
Mean	1.013	0.925	1.003	1.010	0.943

On an annual basis, the Malmquist productivity index exhibited fluctuations, measuring 0.931, and 0.957 for the periods of 2020–2021 and 2021–2022 respectively.

However, in the period of 2021–2022, a notable upswing in the Malmquist index to 0.957 was observed, reflecting a comparative rise in service efficiency by 6.1%. This positive trend was driven by a rise in TEC & TC, increasing by 2.4% and 4.2%, respectively. The surge in TEC was ascribed to the simultaneous rise in Pure Technical Efficiency Change (PETC) and Scale Efficiency Change (SEC), both registering a 1.2% rise. This intricate pattern underscores the nuanced fluctuations in the overall productivity and efficiency landscape, offering valuable insights into the dynamic evolution of these factors over the specified time frame.

Productivity change for Malmquist index by hospital

Examining the below given Table 7 reveals noteworthy insights into the Malmquist index for the 12 DHQ hospitals. Hospitals A, B, E, F, and G demonstrated Malmquist indices exceeding 1, standing at 1.011, 1.004, 1.069, 1.002, and 1.035, respectively. This indicates that the factor productivity of these five hospitals experienced varied degrees of improvement over the analyzed period.

Table 7
Malmquist Productivity index for DHQ hospitals

Hospitals	Total Efficiency Change	Total Cost	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Change
A	1.043	0.960	1.044	0.999	1.002
B	1.072	0.997	1.058	1.013	1.069
C	1.000	0.950	1.000	1.000	0.950
D	1.000	1.035	1.000	1.000	1.035
E	1.034	0.956	1.018	1.016	0.988
F	1.000	1.004	1.000	1.000	1.004
G	1.020	0.924	1.000	1.020	0.942
H	0.998	0.958	0.983	1.015	0.956
I	1.050	0.952	1.000	1.050	0.999

J	1.000	0.923	1.000	1.000	0.923
K	1.005	0.922	1.000	1.005	0.927
L	1.003	1.008	1.000	1.003	1.011
Mean	1.017	0.974	1.007	1.011	0.979

Conversely, the remaining seven hospitals exhibited Malmquist indices below 1, signifying a reduction in factor productivity. Notably, hospitals D experienced 5.8% decrease, L experienced 7.3% decrease, and J experienced 7.7% decrease, indicating a substantial decline in their overall factor productivity. This divergence in the performance of hospitals underscores the heterogeneity in the efficiency landscape among the DHQ hospitals of Punjab, with some experiencing enhancements while others faced challenges in maintaining or improving their factor productivity. The disparities in Malmquist indices shed light on the diverse trajectories and performance trends exhibited by these healthcare institutions during the specified period.

Conclusion

The performance of DHQ hospitals has shown improvement over time, although there is room to enhance SE. Analysis from 2020 to 2022 indicates that the average comprehensive Technical Efficiency TE of the 12 hospitals was 0.956, with PTE and SE averaging at 0.977 and 0.979, respectively. While overall efficiency exceeded PTE and SE, it fell short of the optimal threshold of 1. Over this period, overall TE generally showed rising trend.

In comparing PTE and SE, SE consistently trailed behind, highlighting the need to address scale-related challenges through organizational optimization. Enhancing personnel strategies, performance evaluation, and promotion methods are crucial for overcoming scale-related issues and countering diminishing returns.

Dynamic analysis using the Malmquist index method revealed that the average service efficiency Malmquist index in DHQ hospitals in Punjab Province declined by 1.7% to 0.983 during this period, largely due to reduced efficiency in technological progress. Regional variations were observed, with North Punjab consistently outperforming South and Central Punjab in efficiency metrics, challenging conventional assumptions about hospital efficiency and economic development correlations.

Recommendations

The study stresses the importance of prudent resource management and effective allocation for hospital development, noting instances of insufficient investment and output in some hospitals which saw improvement following healthcare reform policies. Despite positive impacts, there was a lag in realizing these reforms, as indicated by the Malmquist index decline, emphasizing the need for balanced attention to management improvements and technological advancements.

Certain hospitals (A, B, E, F, G) serve as successful case studies, achieving Malmquist indices above 1. Overall, the study advocates for a comprehensive approach that integrates management enhancements and technological progress for sustainable development.

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