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RESEARCH ARTICLE

EVALUATION OF SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY BASED ON DATA ENVELOPMENT ANALYSIS (DEA)

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ABSTRACT

BACKGROUND:

This study introduced a service-oriented nursing supervisor strategy to increase the performance efficiency of different hospital wards. The efficiency of this strategy, in 12 wards under the supervision of 12 supervisors, was evaluated using Data Envelopment Analysis (DEA).

MATERIALS AND METHODS:

The efficiency of the service-oriented nursing supervisor strategy was evaluated using DEA. This study aims to evaluate the relative efficiency of hospital wards before and after implementing the service-oriented nursing supervisor strategy at Milad hospital. Data were evaluated using two basic models of data envelopment analysis technique, i.e., CCR and BCC output-oriented methods. Then, the relative performance efficiencies of 12 wards in 2 periods, including the first half of 2020 (before service-oriented nursing supervisor strategy) and the second half of 2020 (after service-oriented nursing supervisor strategy) were analyzed. Finally, efficient wards were ranked using the Anderson-Peterson method based on the results.

RESULTS:

According to the CCR output-oriented method, after implementing service-oriented nursing supervisor strategy, Urology, Gastroenterology, and Neurosurgery wards, as well as ENT, had the highest and lowest efficiency rates, respectively. Based on the BCC output-oriented method, Urology, Renal Transplant, Neurosurgery, and Gynecology wards had the highest efficiency in performance, while ENT had the lowest efficiency.

CONCLUSION:

In conclusion, the findings of this study offer a service-oriented nursing supervisor strategy that improves the efficiency of different wards of the hospital.

KEYWORDS

Supervisor, DEA, Nurse, Hospital, Efficiency, strategy

INTRODUCTION

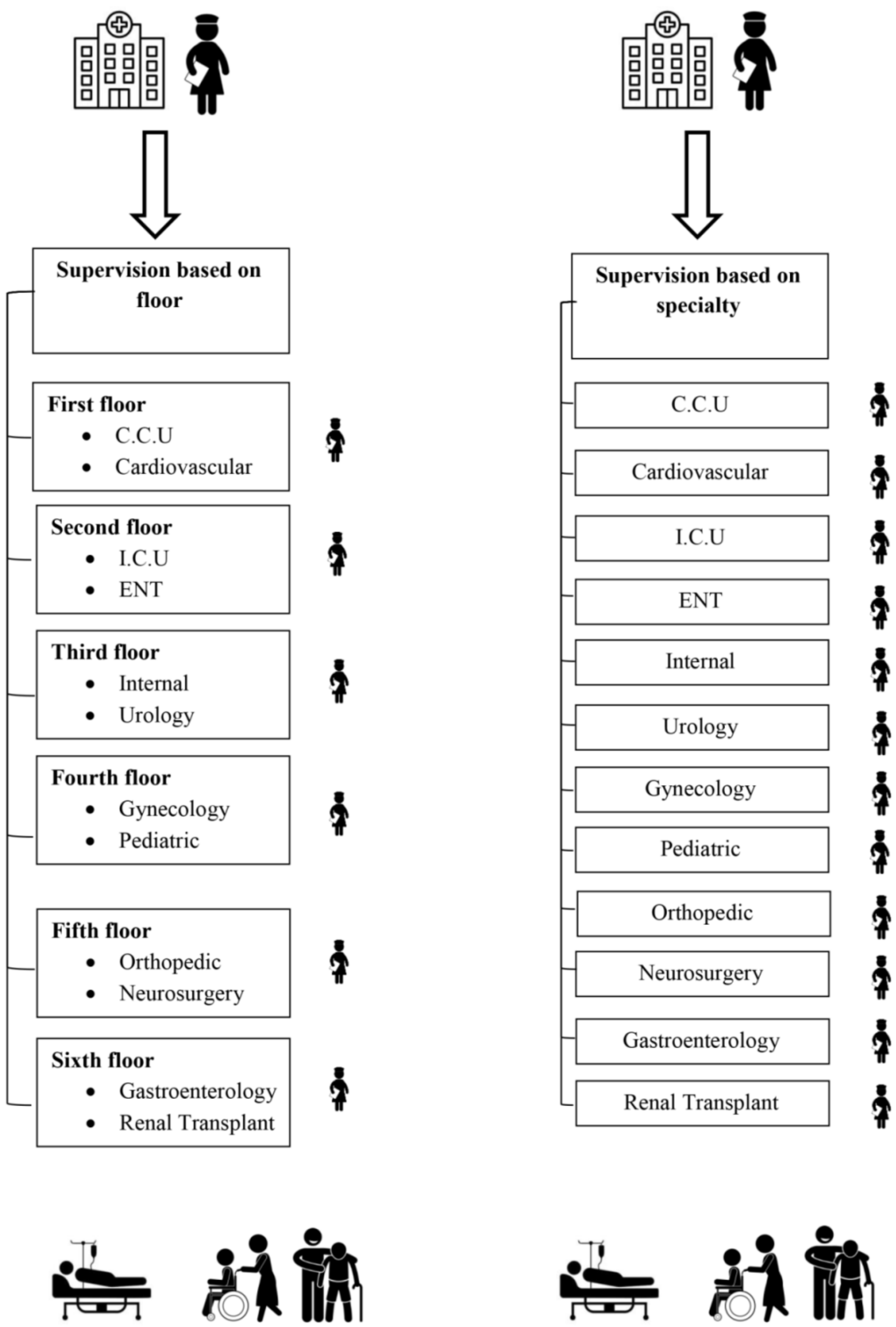
Hospitals can be understood as institutions that have the mission to provide health improvements, both at a broader level, such as the communities in which they are located and, more specifically, for patients to whom they directly offer assistance [1]. The quality of health care and the nursing care management reflect the hospital's image. For the success of health services, scientific and systematic activities are needed. Accordingly, the participation of all staff and understanding the perceptions and expectations of patients is necessary to increase productivity and improve and improve healthcare processes. Nursing services are one of the essential components of hospital services that play an influential role in meeting the nursing needs of the community [2]. The clinical supervisor plays a critical role in guaranteeing the quality of treatment while improving patient care and efficiency. The nurse supervisor's duty is still mostly unknown. Depending on the organization, the nurse supervisor may be referred to as a shift supervisor, clinical coordinator, administrative coordinator, shift administrator, or patient care coordinator[3]. Some nurse supervisor tasks include staffing, clinical quality, patient safety, executive presence, emergency response, customer satisfaction, census management, throughput, and nursing resource [4]. Thus, establishing a proper process is vital for implementing hospital management, which leads to the identification and scope of organizational effectiveness [5]. Accordingly, in the clinical or medical environment, performance management can be translated into the systematic development and constant monitoring of the standards applied to this specific environment to guarantee particular outcomes [6]. One of performance management's crucial challenges in hospital organizations is to avoid mismatching wards workload. Consequently, once hospitals investigate extending care quality while reducing costs [7], it also looks for an optimal balance between resource planning and the necessary resources, represented by beds, ward staff, outpatient clinics, etc.. Consequently, hospitals seek to optimize resource planning and the necessary resources, represented by beds, ward staff, outpatient clinics, etc. In other words, it is up to the hospital performance management to ensure the best allocation to the specialties, according to the available budget and resources[1]. In recent years, healthcare providers have attempted to improve the quality of nursing services; however, instead of facing numerous obstacles, they have been practically unsuccessful. Based on the fierce competition rampant in healthcare, attention to the quality and services provided to patients can be considered an influential factor in the success of healthcare institutions. In this study, to increase the efficiency of Milad Hospital wards, a different strategy was presented to promote the services of supervisors. The opinions of health managers and medical staff opinions were employed to design a service-oriented nursing supervisor strategy. In general, at Milad Hospital, each floor was managed by one supervisor. In the new strategic plan, to improve the efficiency of the hospital wards, the number of supervisors increased. For each specialty, a trained and experienced supervisor was assigned in the same specialty. Then, the DEA method was used to evaluate the efficiency of the wards before and after implementing the supervisor strategy.

SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY

Supervision is staff observation during work and providing formal guidance. In health care sectors, protecting life, human health, and nullifying clients' needs are the main goals; hence, much complexity has been observed in health sectors that duplicate the importance of supervision[3]. Supervision has been introduced as clinical supervision in health care organizations. The Department of Health's clinical supervision has been defined as "a formal process for supporting, training, and professional learning." It provides a safe and confidential environment for the staff to reflect on and discuss their work, enhancing their awareness and clinical skills and improving competency. The supervisee should accept responsibility for their performance[8]. In nursing, clinical supervision is a process in which between two or more professionals (novice nurse and practitioner nurse), the focus is to provide a basis for monitoring, assessing, examining practice, and receiving feedback at work, which could lead to the development of professional skills[3]. Clinical supervision is done in hospitals by clinical supervisors. A clinical supervisor is a nurse responsible for supervising nursing services directly and helps reach the organization's goals by supporting and expanding knowledge, skills, commitment, and performance[9]. Supervision is helpful in the identification of clinical problems, and supervisors may help nurses in the admission of new roles[10]. Experts and fully trained clinical supervisor/s can inform nurses what and when to do while supervising and bringing development to the organization;

they support and strengthen the supervised nurse and maintain and enhance the quality of care[11]. Milad Hospital is the largest specialized and subspecialized hospital in Iran. This hospital is a complementary health service provider in Iran's Social Security organization (SSO) hospitals. Supervisors at Milad Hospital were based on floor-oriented, and a supervisor managed each floor. In order to elevate the efficiency and reduce the number of accommodations and the rate of bed employment (increasing the patients' discharge from the hospital), a service-oriented nursing supervisor strategy is performed experimentally in the case of 6 floors and 12 specialties at the hospital.

FIGURE 1. SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY



According to Figure 1, there are two specialties on each floor which are normally managed by one supervisor, and a total of 12 wards are managed by 6 supervisors. After the implementation of the service-oriented nursing supervisor strategy, 2 supervisors are hired on each floor so that each specialty is managed by a trained and experienced supervisor. Overall the number of supervisors is doubled.

DATA ENVELOPMENT ANALYSIS (DEA)

Data envelopment analysis (DEA) measures the efficiency of homogeneous decision-making units (DMUs) with multiple inputs and outputs. The DMUs may be companies, schools, hospitals, shops, bank branches, etc. Efficiency is a management concept with a long management science history[12]. Efficiency shows that an organization has used its resources well to produce the best performance at some point in time. If the DMU has an input and an output, its efficiency is defined $\frac{Output}{Input}$ as the same unit. In 1975, Farrell introduced a method for measuring efficiency based on economic theories in an article referring to the problems of measuring the efficiency of units with multiple inputs and outputs[13]. Farrell considered the measure of relative efficiency when there are numerous and incomparable data and outputs and suggested that an efficient hypothetical department be constructed based on the weighted average of the efficient unit to be used as a comparative basis for using an inefficient unit. The ordinary equation for measuring the relative efficiency of DMUs despite multiple data and outputs is as follows:

$$Efficiency : \frac{\text{Total output weights}}{\text{Total input weights}}$$

Which function is as follows:

$$Efficiency\ \ of\ \ unit_j = \frac{u_1 y_{1j} + u_2 y_{2j} + \ldots}{v_1 x_{1j} + v_2 x_{2j} + \ldots}$$

Where in:

U_1 Weight given to output number 1, Y_{1j} the output of number 1 from unit j, V_1 Weight given to input number 1, X_{1j} is the input value of number 1 to unit j. In the term relative efficiency, the resulting efficiency is the result of comparing units. In the term relative efficiency, the resulting efficiency is the result of comparing units with each other, which efficiency of each DMU to be numerically between[14]. Usually, the maximum value can be considered after calculating efficiency, and all values can be divided. In this case, the change range is between [0 1]. Relative efficiency for unit k:

$$\mathrm{RE}_k : \frac{y_k / x_k}{Max\,\{y_j / x_j : j = 1, \ldots, n\}}$$

Due to the limitations of the Farrell method, in terms of constant efficiency compared to scale, this method did not find much practical application. Over time, practical methods for measuring efficiency were provided. [15] later proposed a practical method for determining the efficiency of a set of DMUs with multiple data and outputs, known as data envelopment analysis. Bunker, Charans, and Cooper (1984) developed the concepts and models of data envelopment analysis and introduced the BCC model for determining performance without assuming constant returns to scale (RTS) [16]. Charnes and Cooper (1985) introduced the collective model as another model for data envelopment analysis that simultaneously considers reducing inputs and the increase of outputs [17]. Suppose the unit under evaluation consists of n DMUs as $(j = 1, \ldots, n)$ and DMU_j, which consumes m input $(x_{1j}, \ldots, x_{mj})$ to produce s output $(y_{1j}, \ldots, x_{mj})$. In addition, suppose that the inputs and outputs of each DMU are all negative and that each DMU has at least one positive input and one positive output. Also, in most organizations, managers of the organization must examine the performance of DMUs consistent with similar inputs and outputs and compare their performance. One of the principles of DEA models is the relationship between the number of inputs, outputs, and DMU. Usually, restrictions such as $n \geq 3(m+s)$ or $n \geq 2m+s$ are applied in the DEA, where n, m, and s are the number of units, inputs, and outputs, respectively. This problem can be solved by controlling the weights. Managers must follow the principle of the correct selection of inputs and outputs. In other words, inputs and outputs must be selected to include all the factors that affect the efficiency or inefficiency. For example, comparing two hospitals regardless of where they are located makes the evaluation results unrealistic. Determining the efficiency or inefficiency and ranking of each DMU, is one of the strengths of data envelopment analysis models compared to the other methods.

MATERIAL AND METHOD

This research is descriptive and analytical in terms of purpose, quantitative in terms of method, and practical for results. For this study, the efficiency of 12 different wards (Data were collected through Milad Hospital Information System H.I.S) of Milad Hospital was evaluated based on the data envelopment analysis (DEA) method. The ethical approval for the publication of this study was obtained by Milad hospital.

The primary data envelopment analysis models are divided into CCR and BCC. These methods can be examined in two ways: input-oriented and output-oriented. The difference between the two models, CCR and BCC, is assumed to be a constant or variable return on the scale. The CCR model assumes a constant return and the BCC model assumes a variable return on the scale. Constant return on the scale means that outputs change relative to inputs; for example, if inputs double, outputs double. However, the meaning of variable returns to scale is that the outputs do not change in proportion to the inputs. The constant return to scale assumption is only valid if units operate at an optimal scale. In evaluating DMUs by data envelopment analysis, efficiency scores were assigned between [0 1], and if the efficiency value is 1, this DMU is efficient. Several methods have been proposed for ranking efficient DMU in data envelopment analysis. In this research, for ranking DMUs, Anderson and Peterson's model have been used. One of the reasons for using this method is that the computational process of this method is low. The technology of ranking production does not change concerning efficiency. The exact ratio as the performance score obtained is calculated with the same ranking pattern. The A&P model does not accurately assess the nature of the input for the DMU with data close to 0, so using this model with the nature of the output solves this problem. The indicators essential to evaluating the performance of hospital wards based on the literature are as follow:

TABLE 1: INPUT / OUTPUT INDICATORS

input	Fall	Bedsore	Medical Errors
output	Bed Occupancy Rate	Average Stay	

The service-oriented nursing supervisor was first implemented in the second half of 2020 by assigning a supervisor separately for each ward specialty (Table 2).

CCR OUTPUT-ORIENTED

This model has a return to constant scale. Output-based models seek to increase or maximize outputs as long as there is no increase (without change or decrease) in the number of inputs. Suppose there are n DMUs, each of which uses the input m to generate the output s. X_{ik} is the input value i $(i = 1,2,\ldots, m)$, which is used by $(k = 1,2, .., n\ DMU_k)$ and y_{rk} is the output value r produced by $(k = 1, 2, .., n)$ DMU$_k$ The variables u_r and v_i are the weights of output indices and input indices, respectively. The technical efficiency of DMU$_j$ is calculated according to the multiplicative model as follows:

$$minE_j = \sum_{i=1}^{m} v_i x_{ij}$$

$$\sum_{i=1}^{s} u_r y_{rj} = 1$$

$$\sum_{r=1}^{s} u_r y_{rk} - \sum_{i=1}^{m} v_i x_{ik} \le 0$$

$$ur, v_i \ge 0; k = 1,2,\ldots,n; r = 1,2,\ldots,s; i = 1,2,\ldots,m$$

BCC OUTPUT-ORIENTED

In 1984, Bunker, Charans, and Cooper introduced a vital factor called "return to scale" and added it to the CCR model. With this change, they created the BCC model, whose mathematical model was quite similar to the CCR model, except that the efficiency factor was added to the W scale to the objective function and the unequal constraint of the CCR model [16].

$$minE_j = \sum_{i=1}^{m} v_i x_{ij} + W$$

$$S.t \sum_{i=1}^{s} u_r y_{rj} = 1$$

$$\sum_{r=1}^{s} u_r y_{rk} - \sum_{i=1}^{m} v_i x_{ik} + W \le 0$$

$$\text{W free}, U_r \ge 0, V_i \ge 0$$

RTS means that if we multiply our input by x, our output by y. If $y > x$, the RTS is incremental; if $y = x$, the return to the scale is constant; if $y < x$, the RTS is declining [18].

ANDERSON-PATTERSON OUTPUT-ORIENTED MODEL

In this method, in the linear programming model related to performance DMU, $(j \le 0)$ is removed. This constraint causes the maximum value of the objective function to be 1. The efficiency is > 1 after removing this limitation. Thus, the most efficient unit has higher efficiency.

$$Maxy_j = \theta$$

$$St\sum_{k=1}^{n}\lambda_r y_{ik} + S_s^- = X_{ij}$$

$$\text{i}=1,2,...,n; k \neq j$$

$$s\theta\sum_{k=1}^{n}\lambda_r y_{rk} + S_s^+ = y_{rj}$$

$$\text{r}=1,2,...,n; k \neq j$$

$$\sum_{k=1}^{n}\lambda_k = 1$$

$$\text{k}=1,2,...,n; k \neq j$$

SCALE EFFICIENCY

[16] showed that the performance score obtained by the CCR method indicates total technical efficiency and the performance score obtained by the BCC method indicates the pure technical efficiency.

$$SEj = \frac{\theta_{CCR}}{\theta_{BCC}}$$

In an envelopment analysis model, the output-oriented $(SE = 1)$ indicates deductive efficiency and $(SE > 1)$ indicates deductive inefficiency. In other words, if the DMU operates under efficiency conditions relative to the scale of increase or decrease, it is deductive inefficiency [19].

RESULTS

Selecting the best set of inputs and outputs is one of the most critical steps in calculating performance using data envelopment analysis. According to inputs and outputs (Table 1), envelopment analysis methods were adopted, and their relative efficiency was determined. After forming the desired models based on the data associated with wards, they were evaluated using DEA Solver Pro software. The performance of each ward and its ranking were obtained. In the next step, the Anderson-Peterson model was implemented in Lingo software for the wards with an efficiency coefficient of 1. The problem-solving results based on two data envelopment analysis models are presented in Tables 2 and 3 based on the CCR and BCC output-oriented methods. Selecting the best set of inputs and outputs is one of the most critical steps in calculating performance using data envelopment analysis. The indicators essential to evaluating the performance of hospital wards based on the literature were Fall, Bedsore, and Medical Errors as input factors along with Bed Occupancy Rate and Average Stay as output factors. According to inputs and outputs, envelopment analysis methods were adopted, and their relative efficiency was determined. After forming the desired models based on the data associated with wards, they were evaluated using DEA Solver Pro software, and the performance of each ward and its ranking were obtained. In the next step, the Anderson-Peterson model was implemented in Lingo software for the wards with an efficiency coefficient of 1. The problem-solving results based on two data envelopment analysis models are presented in Tables 2 and 3 based on the CCR and BCC output-oriented methods.

TABLE 2: EFFICIENCY COEFFICIENT AND RANK OF WARDS BASED ON OUTPUT CCR AND AP MODEL

	FIRST HALF OF 2020 (BEFORE SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY)				SECOND HALF OF 2020 (AFTER SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY)			
Wards	Efficiency in the CCR method	Rank based on CCR method	Efficiency in the AP method	Rank based on AP method	Efficiency in the CCR method	Rank based on CCR method	Efficiency in the AP method	Rank based on AP method
C.C.U	0.853	5		5	0.646	5		5
Cardiovascular	0.891	3		3	0.756	4		4
ENT	0.092	11		11	0.143	11		11
Gynecology	0.432	8		8	0.575	6		6
I.C.U	0.614	6		6	0.515	9		9

Internal	.0254	10		10	0.133	12		12
Neurosurgery	0.086	12		12	0.212	10		10
Gastroenterology	0.999	2	1.193	2	1	1	1.028	2
Orthopedic	0.394	9		9	0.518	8		8
Pediatric	0.443	7		7	0.521	7		7
Renal Transplant	0.873	4		4	0.936	3		3
Urology	1	1	1.667	1	1	1	1.629	1

Following the implementation of the service-oriented nursing supervisor strategy based on the CCR method, Urology and Gastroenterology wards had the highest efficiency. Cardiovascular, I.C.U, and Internal wards followed a downward trend for efficiency; however, C.C.U, ENT, Pediatric wards and Renal Transplant, Neurosurgery, Orthopedics, and Gynecology wards had a constant and increasing efficiency rate.

According to the BCC method, Urology, Renal Transplant, Neurosurgery, and Gynecology wards had the highest efficiency rate, while ENT had the lowest efficiency. C.C.U, I.C.U, and Internal wards and Cardiovascular, Neurosurgery, Orthopedic, and Pediatric wards had lower and higher efficiency rates, respectively. Based on the total technical efficiency coefficient and pure technical efficiency, the scale efficiency coefficient can be calculated for each period using Equation 3. The scale efficiency coefficient for the desired period for each ward is given in Table 4

TABLE 3: EFFICIENCY COEFFICIENT AND RANK OF WARDS BASED ON OUTPUT BCC AND AP MODEL

Wards	FIRST HALF OF 2020 (BEFORE SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY)				SECOND HALF OF 2020 (AFTER SERVICE-ORIENTED NURSING SUPERVISOR STRATEGY)			
	Efficiency in the BCC method	Rank based on BCC method	Efficiency in the AP method	Returns to scale (RTS)	Efficiency in the BCC method	Rank based on BCC method	Efficiency in the AP method	Returns to scale (RTS)
C.C.U	1	1	1.059	Decrease	0.746	7		Decrease
Cardiovascular	0.942	7		Decrease	0.789	6		Decrease
ENT	0.104	12		Increase	0.164	12		Increase
Gynecology	1	1	1.74	Increase	1	1	1.3	Increase
I.C.U	0.776	8		Decrease	0.535	10		Increase
Internal	1	1	1.32	Increase	0.199	11		Increase
Neurosurgery	0.467	10		Increase	1	1	1.105	Increase
Gastroenterology	1	1	1.539	Constant	1	1	1.4	Constant
Orthopedic	0.6	9		Decrease	0.629	8		Decrease
Pediatric	0.453	11		Decrease	0.538	9		Increase
Renal Transplant	1	1	3.043	Decrease	1	1	2.990	Decrease
Urology	1	1	1.816	Constant	1	1	1.728	Constant

TABLE 4: AVERAGE EFFICIENCY OF THE WARDS SCALE AND RANKING

WARDS	SCALE EFFICIENCY (SE)			RANK BASED ON EFFICIENCY
	First half of 2020	Second half of 2020	Average	
C.C.U	0.583	0.865	0.724	8
Cardiovascular	0.945	0.958	0.951	4
ENT	0.884	0.871	0.877	6
Gynecology	0.432	0.575	0.503	10
I.C.U	0.719	0.962	0.840	7
Internal	0.254	0.668	0.461	11
Neurosurgery	0.184	0.212	0.198	12
Gastroenterology	0.999	1	0.999	2
Orthopedic	0.581	0.823	0.702	9
Pediatric	0.977	0.968	0.972	3
Renal Transplant	0.873	0.936	0.904	5
Urology	1	1	1	1

After implementing the CCR and BCC data envelopment analysis method of the output-oriented, for 12 wards, in two periods (before and after implementing the service-oriented nursing supervisor strategy), It indicates that the number of efficient, inefficient wards is different before after the strategy. For example, in the first half of 2020, when each supervisor was floor-specific and monitored a floor (regardless of departmental expertise), departmental performance was much lower than after strategy execution.

DISCUSSION

There is no doubt that various elements may help supervisors and advanced nursing roles perform better [20]. Tavrow's study implied that supervisors devoted <5% of their time to patient care issues [21]. The study's essential contribution is introducing a new strategy for the work of the nursing supervisor. In recent years, the DEA Model has been widely used in the research field of efficiency, but there have been no studies evaluating the supervisor model. According to Kilmenster et al., supervision should be structured and carried out regularly following the program. Content of supervision should be agreed upon and the aims specified before beginning supervision [22]. Knudsen et al. founded that clinical supervision quality is substantially influenced by autonomy or authority at work [23]. Supervisors must act successfully in their tasks (staffing, clinical quality, patient safety, executive presence, emergency response, and customer satisfaction, census management) to enhance patient care. Several factors have been identified as influencing effective practice in novel nurse roles in acute settings, with opposition to self-directed nursing advances being higher in larger acute/general hospital trusts than in "small enterprises." Feedback, performance evaluation, and reflective practice Feedback from other health care professionals can promote professional development. Performance measurement can also aid personal and professional development[24]. Also, Graduate level education and leadership courses could influence the innovativeness of supervisors, hence making acting better in line with hospital goals [25]. In this study, the service-oriented nursing supervisor strategy was first presented to increase the performance efficiency of wards and the management of each ward by a experienced supervisor. Then, the efficiency of the ward before and after the strategy was evaluated using DEA method. The results demonstrated that based on the CCR output-oriented method after implementing service-oriented nursing supervisor strategy, Urology and Gastroenterology wards and Neurosurgery and ENT had the highest and lowest efficiency rates, respectively. However, according to the BCC output-oriented method, Urology, Renal Transplant, Neurosurgery, and Gynecology wards had the highest efficiency, while ENT had the lowest efficiency.

CONCLUSION

In conclusion, the findings of this study offer a service-oriented nursing supervisor strategy that improves the efficiency of different wards of the hospital. Given the importance of hospitals in providing health services, using data envelopment analysis (DEA) to compare and model can be an essential step for the continuous improvement of different wards efficacy with the new strategy service-oriented nursing supervisor.

LIMITATIONS

Some of our research limitations should be highlighted at this time. Because causal inferences might be challenging to draw from cross-sectional data, relationships between research variables should be carefully studied before drawing any conclusions. Furthermore, the primary data's convenience reduced the generalizability of the findings. Thus, future research should adopt samples from other hospital wards in the long run. Future research should focus on replicating this study in a more extensive and multicenter representative population of nurse supervisors. However, more work is required to optimize the hospital wards' efficiency fully.

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CONFLICTS OF INTEREST

Nothing to declare

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