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PAPER

Examining the Relation of Transformational Leadership in Clinical Engineering on the Performance of Medical Equipment: A Neural Network Approach

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ABSTRACT

In the realm of healthcare administration, heightened expectations can lead to stress, therefore impacting working conditions. Specifically, studies on leadership styles have provided a valuable understanding of the factors that hinder performance, particularly in relation to the implementation of transactional leadership. Despite its crucial significance, there is a dearth of research on the management styles employed in clinical engineering. This study examines the impact of leadership styles on the functioning of medical equipment. We assess leadership styles and the performance of medical equipment from the perspective of end-users using a cross-sectional survey and questionnaires that consider many significant criteria. A neural network model is employed to classify the leadership styles exhibited by the Clinical Engineering Department (CED) and to analyze the correlation between these styles and the equipment's performance. The results suggest a significant correlation between the leadership styles of those in charge of CED and the functioning of medical equipment. A strong and favorable correlation exists between transformative leadership and equipment performance (r = 0.856**, P = 0.000). The data suggests that transformative leadership is highly significant, with a mean score of 3.07 ± 0.817.

KEYWORDS

leadership styles, medical equipment performance, multifactorial questionnaire, clinical engineering department

1 INTRODUCTION

In today's rapidly advancing healthcare landscape, the field of clinical engineering plays a pivotal role in ensuring the efficient functioning of medical equipment within hospitals. Clinical engineering (CE) encompasses the management, maintenance, and optimization of medical devices and equipment to support high-quality patient care [1–3]. With the increasing reliance on technology in healthcare

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delivery, the effective management of medical equipment has become more critical than ever before. It has been discovered that the output of health technology management (HTM) is dependent on the input. The clinical engineering department of the Health Care Delivery Organization (HCDO) is responsible for 70% of the HTM input. CE, on the other hand, accounts for 52% of HTM. That is, the CE is responsible for 52 percent of the CED's performance out of a total of 70% [4–6]. In the 1980s, clinical engineers also began to evaluate metrics for their effectiveness within hospitals. Yadin and Rohe presented a model for measuring effectiveness through productivity measurements in 1986 [7]. They identified key factors that contribute to effectiveness, such as decision-making input for technology acquisition, employee training, and integration into the facility management process [7]. The life cycle of medical equipment must be managed effectively as part of the healthcare organization's CE duty. Better health care may be provided to patients by managing the clinical engineering life cycle [8–10]. However, healthcare organizations often face significant challenges in managing the performance of medical equipment. Issues such as equipment downtime, maintenance delays, and suboptimal utilization can have detrimental effects on patient care outcomes, operational efficiency, and overall healthcare delivery. Addressing these challenges requires proactive management strategies and effective leadership within clinical engineering departments. Leadership is essential for organizational success, and its understanding has evolved over time [11]. It shifted from innate traits to observable skills. Leadership is significant across various fields and has adapted from traditional to transformative styles, especially visionary leadership [11]. Recent interest lies in the connection between leadership and high-performing organizations, emphasizing the need for research on leadership styles linked to high performance. Leadership has evolved from one-dimensional personality traits to encompass the entire organization, recognizing its complexity and the influence of diverse styles on behavior and outcomes. This study delves into specific leadership styles like laissez-faire, transactional, and transformational and their effects. Laissez-faire management gives workers little oversight. Leaders avoid decision-making, delegate task group leadership, and provide knowledge and connections. However, this strategy usually fails, resulting in poor work quality, clarity, efficiency, disorganization, and employee unhappiness, which can hinder organizational performance [12–14]. Initiative-taking and self-starting teams may benefit from laissez-faire leadership because leader involvement may impair efficacy. Some term this "non-leadership" [11–12]. Transactional leadership seeks organization, monitoring, compliance, and performance. Stability is maintained by rewarding and punishing high and low achievers. This leadership style encourages leader-follower economic and social exchanges [14–15]. Leaders motivate followers to attain organizational goals. It includes contract-based remuneration, exception-based management, and crisis intervention [16]. A recent study shows that transactional and transformative leadership can coexist [17]. Leadership that communicates a clear vision and boosts morale, awareness, and motivation transforms organizations. Our shared goals enhance ethical standards. It predicts organizational performance and is a good quality management tool, say experts. It beats transactional and laissez-faire leadership. Transformational leaders are change agents with intuition, visionary thinking, clarity in expressing beliefs, intelligence, empathy, adaptability, and learning. They shape business culture to suit social requirements and inspire employees to perform better. Transformational leaders promote organizational goals using high-performance tactics [13] [18–20]. Leadership today fosters company purpose, values, and ethics. Language fosters creativity and community in transformational leaders' workplaces. Language and renewal enhance the organization's mission and vision, boosting health, productivity, and performance. The 2001 information explosion changed the 21st century. Modern leaders promote creative problem-solving and adaptability for long-term success. Learning about change improves workplace and individual development. Science informs leaders' tactics and technologies. For long-term global competitiveness, they aspire to develop learning firms that encourage diverse thinking and organized problem solving. Modern leaders use ethics to foster community and efficiency, touching team members deeply [21–22]. Transformational leadership inspires, shares ideals, and holds people accountable [23], using language to promote employee well-being [24]. When leaders give their mission meaning and demonstrate renewal, language impacts outcomes [25–26]. Flexible and responsive leadership is needed in modern settings [13] [27–28]. Due to social changes, collaboration, empathy, communication, and transformative leadership are necessary [29]. Leaders give symbols, events, and branding meaning to form organizational culture [13]. The 2006 American Hospital Association Leadership Summit addressed leadership commitment to quality care, considering quality as a business strategy, enhancing patient care through technology, integrating physicians in quality care efforts, and strengthening service culture. In a complicated and competitive market, healthcare CEOs should employ transformative leadership to improve performance, learning, and risk-taking. Too often, healthcare leaders lack training and succession planning [30]. Leadership styles have a significant impact on healthcare performance. Transactional and transformational leadership styles were found to have a positive relationship with employee safety behavior and employee performance in healthcare institutions [31–32]. Ambidextrous leadership, a relatively new leadership style, was found to facilitate frontline health professionals' capacity to think and act innovatively, leading to better creative performance [33]. Additionally, participative leadership was found to encourage employees to give their input in decision-making and the formulation of plans, resulting in better healthcare outcomes [34]. It is important for healthcare management to invest in employee well-being and create a work environment that promotes safety measures and balance between management and workers [35]. In this context, the application of neural networks offers a promising approach to understanding the intricate relationship between transformational leadership in clinical engineering and the performance of medical equipment. Neural networks, a form of artificial intelligence, excel at processing and analyzing complex datasets to uncover patterns, correlations, and insights that may not be readily apparent through traditional analytical methods. By leveraging the power of neural networks, researchers can gain deeper insights into the multifaceted dynamics at play within clinical engineering departments and their impact on medical equipment performance. Against this backdrop, the objective of this study is to examine the relationship between leadership styles in clinical engineering and the performance of medical equipment using a neural network approach. By investigating how leadership styles influence medical equipment performance and employing advanced computational techniques, the main hypothesis in this research is that the null hypothesis (H0) posits that there is no significant relationship between leadership styles in Saudi clinical engineering department management and medical equipment performance. In other words, under the null hypothesis, we assume that different leadership styles within clinical engineering departments have no discernible impact on the performance of medical equipment. This hypothesis serves as the default position to be tested against alternative hypotheses. Conversely, the alternative hypothesis (Ha) suggests that there is indeed a meaningful relationship between leadership styles in Saudi clinical engineering department management and medical equipment performance. Under this hypothesis, we propose that specific leadership styles, particularly transformational leadership, exert a major influence on the effectiveness and efficiency of medical equipment management within healthcare settings. This research aims to provide valuable insights for enhancing leadership practices and optimizing the management of medical equipment within healthcare organizations. The findings of this study have the potential to inform strategic decision-making and drive improvements in patient care delivery, contributing to the advancement of healthcare quality and efficiency.

2 MATERIALS AND METHODS

This study used a descriptive correlation research design, and the survey approach was effective for gathering unobservable data about leadership qualities. The study used two research instruments to assess leadership skills and traits. The first was the Multi-factor Leadership Questionnaire (MLQ), which is widely recognized and has 36 items reflecting various leadership styles. It has a high internal consistency with a Cronbach's alpha of 0.96 and takes approximately 15 minutes to complete. The MLQ, a reliable and widely used leadership assessment tool, will be employed in this study to assess leadership styles and outcomes. It assesses both transactional and transformative leadership styles, as well as their impact on performance and satisfaction. The MLQ includes forty-five question statements, making it well-suited for our investigation. Other instruments, like the Managerial Practice Survey (MPS), did not effectively measure the required leadership concepts [36]. The MLQ's validity and reliability have been supported by numerous studies, making it an accurate tool for measuring leadership traits. The second instrument targeted medical equipment users, gathering information about the hospital and conducting a qualitative evaluation of Clinical Engineering Department (CED) services, including administration, training, and technical skills [6].

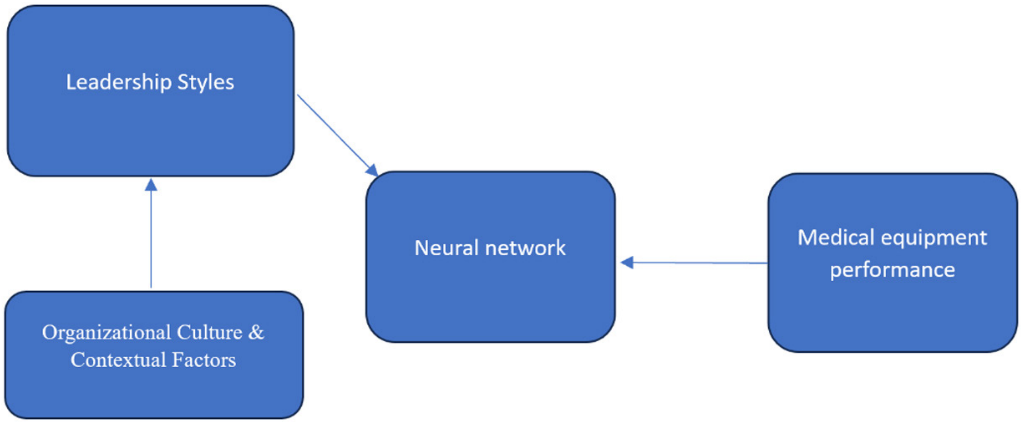

Fig. 1. The conceptual framework

As shown in the Figure 1, Neural Networking is introduced as an additional construct, positioned between Leadership Styles and Medical Equipment Performance, representing the incorporation of neural networking techniques in analyzing the relationship between leadership styles and equipment performance. The arrows from Leadership Styles and Contextual Factors towards Neural Networking indicate that neural networking techniques are influenced by both leadership styles and contextual factors. These techniques analyze data related to leadership styles, contextual factors, and medical equipment performance to uncover patterns and relationships, ultimately contributing to a deeper understanding of how leadership impacts equipment performance. The output from neural networking contributes to the assessment of Medical Equipment Performance, highlighting its role in informing decisions related to equipment availability, reliability, maintenance efficiency, and overall performance. The study's framework assesses how Clinical Engineering Department (CED) management styles affect medical equipment performance. It employs a cross-sectional approach with two questionnaires: one (MLQ) to gauge CED management styles and another to evaluate medical equipment performance by end users. Variables such as hospital size, device numbers, and personnel education impact clinical engineer performance, categorized as "lowest," "low," "moderate," "good," and "highest." Statistical tests confirm hypotheses, and a neural network model uses questionnaire inputs to classify leadership styles and assess medical equipment performance, identifying key factors. Data is analyzed using IBM SPSS Statistics Version 27, a popular software for data analysis. The analysis included a Spearman test to assess the relationship between leadership style among medical equipment maintenance managers and medical equipment performance. It compared the predetermined significance level (alpha) with the calculated value from the data. Data mining is essential as data volumes grow beyond traditional methods. Artificial neural networks (ANN) mimic neuron processes, managing diverse data types. Common models like Multilayer Perceptron (MLP) and Radial Basis Function (RBF) networks have input, hidden, and output layers for data transformation and response, ANN will explore the relationship between leadership styles (input) and medical equipment performance (output), supervised learning is well-suited. In supervised learning, the model is trained on a labeled dataset, where it learns the mapping between input features (like transformational leadership characteristics) and output labels (medical equipment performance). IBM SPSS Statistics 27v used for model construction and assessment.

The research will collect data from three equally sized (government, private, and military) hospital categories in Riyadh. The process comprises three stages: questionnaire validation, sample size calculation, and data analysis. The sample size is determined using the equation:

$$n_0 = (Z^2 \sigma^2) / e^2 \quad (1)\ [37].$$

Where n_0 represents the sample size, Z is the normal curve's abscissa that cuts off an area σ at the tails, e is the desired level of precision, and σ^2 is the population's attribute variance. The study collected data through Google Forms questionnaires from three hundred responses, equally distributed between the Multifactor Leadership Questionnaire and the CED evaluation questionnaire, following a cross-sectional survey design.

3 RESULTS

3.1 Demographic profile

As shown in Table 1, 150 health care employees participated in MLQ, including 135 (90.0%) males and 15 (10%) females. More than half, 88 (58.67%), were aged between 25–34 years old, while 53 (35.33%) were between 35–44 years old. They were well experienced; 60 (40%) had more than 10 years of experience, followed by 37 (24.67%) having 4–6 years. Moreover, 85 (56.67%) held a bachelor's in medical equipment technology, 47 (31.33%) received a diploma. Overall, the respondents had 6.9 average years of working in the hospital. Most of the participants, were Saudi personnel 147 (98%), working in governmental hospitals 117 (78%) and in hospitals with more than 150 beds 95 (63.33%).

Table 1. Demographic profile (n = 150) for MLQ

Factor	Group	N	%
Gender	Male	135	90.00
	Female	15	10.00
Age	less than 25	6	4.00
	from 25 to 34 years old	88	58.67
	from 35 to 44 years old	53	35.33
	from 45 to 54 years old	1	0.67
	more than or equal 55 years old	2	1.33
Total years of experience	less than one year	8	5.33
	from 1 to 3 years	12	8.00
	from 4 to 6 years	37	24.67
	from 7 to 9 years	33	22.00
	more than or equal 10 years	60	40.00
Educational attainment	Diploma	47	31.33
	BSc	85	56.67
	Master	18	12.00
Job title	Technician	53	35.33
	Specialist	88	58.67
	senior specialist	9	6.00
Nationality	Saudi	147	98.00
	Non-Saudi	3	2.00
Hospital type	Governmental	117	78.00
	Military	11	7.33
	Private	22	14.67
Hospital size	less than or equal 50 beds	13	8.67
	from 50–100 beds	23	15.33
	from 100–150 beds	19	12.67
	more than 150 beds	95	63.33

Table 2 shows 150 health care employees participating in the medical equipment performance questionnaire. More than half, 77 (51.33%), were specialists, while 51(34%) were technician. They were well experienced; 64 (42.67%) had more than 10 years of experience, followed by 31 (20.67%) having 1–3 years.

Table 2. Demographic profile (n = 150) for medical equipment performance evaluation

Factor	Group	N	%
Job title	Technician	51	34.00
	specialist	77	51.33
	senior specialist	22	14.67
Total years of experience	less than one year	18	12.00
	from 1 to 3 years	31	20.67
	from 4 to 6 years	29	19.33
	from 7 to 9 years	8	5.33
	more than or equal 10 years	64	42.67
Hospital type	Governmental	117	78.00
	Military	11	7.33
	Private	22	14.67
Hospital size	less than or equal 50 beds	13	8.67
	from 50–100 beds	23	15.33
	from 100–150 beds	19	12.67
	more than 150 beds	95	63.33

3.2 The descriptive analysis

As shown in Table 3, the transformational leadership styles were measured by five dimensions/styles scales using a 5-point Likert scale (frequently, if not always = 4 to not at all = 0). The overall was (3.07 ± 0.817, high level). Idealized Attributes (IA) and Individual Consideration (IC) achieved the highest mean (M = 3.15 ± 0.89, high level), (M = 3.15 ± 0.93, high level) respectively, while Inspirational Motivation (IM) earned second place, with a mean score of (M = 3.13 ± 0.89, high level) followed by Idealized Behaviors (IB), with a mean score of (M = 3.12 ± 0.82, high level), and then Intellectual Stimulation (IS) with a mean score (M = 2.84 ± 0.77, high level).

Table 4 shows the transactional leadership styles were measured by two dimensions/style scales using a 5-point Likert scale (frequently, if not always = 4 to not at all = 0). The overall was (2.89 ± 0.74, high level). Contingent rewards achieved the highest mean (CR) (3.15 ± 0.85, high level), followed by management-by-exception (active) (MBEA), which received a mean score of (2.62 ± 0.83, high level).

Table 5 shows the passive avoidant leadership styles were measured by two dimensions/style scales using a 5-point Likert scale (frequently, if not always = 4 to not at all = 0). The overall was (2.28 ± 0.9, moderate level). Laissez-Faire achieved the highest mean (2.49 ± 0.84, high level), followed by management-by-exception (passive) (MBEP) (2.08 ± 1.1, Moderate level). However, the difference was minimal.

While the outcomes of leadership styles shown in Table 6 were measured by three dimensions/style scales using a 5-point Likert scale (frequently, if not always = 4 to not at all = 0). The overall mean score of leadership outcomes was (M = 3.2 ± 0.95, high level). Effectiveness (EFF) achieved the highest mean score (M = 3.21 ± 0.96, higher level), extra effort received a mean score of (EE) (M = 3.2 ± 1.01), followed by satisfaction (SAT), which attained a mean score of (M = 3.19 ± 0.95, high level). As shown in Table 7, the outcomes of leadership styles were measured by three dimensions/style scales using a 5-point Likert scale (frequently, Excellent = 5 to Low Level = 1). The overall mean score of evaluation of medical equipment performance was (M = 4.23 ± 0.877, higher level). CED Attitude achieved the highest mean score (M = 4.39 ± 0.91, higher level), followed by Medical Equipment Efficiency, Repair, End User Training, then Maintenance, respectively.

Table 3. The descriptive analysis of transformational leadership styles (n = 150)

Style	No	N/%	Not at All	Once in a While	Sometimes	Fairly Often	Frequently, if Not Always	Mean ± SD	Mean ± SD (Overall)
Idealized Attributes (IA)	1	N	3	10	17	47	73	3.18 ± 1.01	3.15 ± 0.89
		%	2.00	6.67	11.33	31.33	48.67		
	2	N	3	12	29	40	66	3.03 ± 1.07	
		%	2.00	8.00	19.33	26.67	44.00		
	3	N	3	4	20	53	70	3.22 ± 0.92	
		%	2.00	2.67	13.33	35.33	46.67		
	4	N	6	5	22	43	74	3.16 ± 1.06	
		%	4.00	3.33	14.67	28.67	49.33		
Idealized Behaviors (IB)	1	N	9	6	31	56	48	2.85 ± 1.1	3.12 ± 0.82
		%	6.00	4.00	20.67	37.33	32.00		
	2	N	3	7	21	48	71	3.18 ± 0.98	
		%	2.00	4.67	14.00	32.00	47.33		
	3	N	5	8	25	54	58	3.01 ± 1.04	
		%	3.33	5.33	16.67	36.00	38.67		
	4	N	3	3	16	35	93	3.41 ± 0.91	
		%	2.00	2.00	10.67	23.33	62.00		
Inspirational Motivation (IM)	1	N	5	12	13	40	80	3.19 ± 1.1	3.13 ± 0.89
		%	3.33	8.00	8.67	26.67	53.33		
	2	N	3	10	16	47	74	3.19 ± 1.01	
		%	2.00	6.67	10.67	31.33	49.33		
	3	N	8	9	33	46	54	2.86 ± 1.14	
		%	5.33	6.00	22.00	30.67	36.00		
	4	N	4	7	16	37	86	3.29 ± 1.01	
		%	2.67	4.67	10.67	24.67	57.33		

(Continued)

Table 3. The descriptive analysis of transformational leadership styles (n = 150) *(Continued)*

Style	No	N/%	Not at All	Once in a While	Sometimes	Fairly Often	Frequently, if Not Always	Mean ± SD	Mean ± SD (Overall)
Intellectual Stimulation (IS)	1	N	5	7	28	49	61	3.03 ± 1.04	2.84 ± 0.77
		%	3.33	4.67	18.67	32.67	40.67		
	2	N	3	9	15	52	71	3.19 ± 0.98	
		%	2.00	6.00	10.00	34.67	47.33		
	3	N	3	9	24	36	78	3.18 ± 1.04	
		%	2.00	6.00	16.00	24.00	52.00		
	4	N	26	34	37	27	26	1.95 ± 1.34	
		%	17.33	22.67	24.67	18.00	17.33		
Individual Consideration (IC)	1	N	3	10	17	42	78	3.21 ± 1.02	3.15 ± 0.93
		%	2.00	6.67	11.33	28.00	52.00		
	2	N	4	13	21	43	69	3.07 ± 1.09	
		%	2.67	8.67	14.00	28.67	46.00		
	3	N	5	9	22	48	66	3.07 ± 1.06	
		%	3.33	6.00	14.67	32.00	44.00		
	4	N	4	5	18	44	79	3.26 ± 0.98	
		%	2.67	3.33	12.00	29.33	52.67		
Transformational Leadership Styles (Mean ± SD)									3.07 ± 0.817

Table 4. The descriptive analysis of transactional leadership styles (n = 150)

Style	No	N/%	Not at All	Once in a While	Sometimes	Fairly Often	Frequently, if Not Always	Mean ± SD	Mean ± SD
Contingent Reward (CR)	1	N	5	3	31	45	66	3.09 ± 1.01	3.15 ± 0.85
		%	3.33	2.00	20.67	30.00	44.00		
	2	N	3	8	23	41	75	3.18 ± 1.01	
		%	2.00	5.33	15.33	27.33	50.00		
	3	N	4	9	29	46	62	3.02 ± 1.05	
		%	2.67	6.00	19.33	30.67	41.33		
	4	N	3	6	12	48	81	3.32 ± 0.93	
		%	2.00	4.00	8.00	32.00	54.00		
Management-by-Exception (Active) (MBEA)	1	N	17	31	29	42	31	2.26 ± 1.31	2.62 ± 0.83
		%	11.33	20.67	19.33	28.00	20.67		
	2	N	5	10	29	46	60	2.97 ± 1.08	
		%	3.33	6.67	19.33	30.67	40.00		
	3	N	7	14	15	45	69	3.03 ± 1.17	
		%	4.67	9.33	10.00	30.00	46.00		
	4	N	18	33	34	30	35	2.21 ± 1.34	
		%	12.00	22.00	22.67	20.00	23.33		
Transactional Leadership Styles (Mean ± SD)									2.89 ± 0.74

Table 5. The descriptive analysis of passive avoidant leadership styles (n = 150)

Style	No	N/%	Not at All	Once in a While	Sometimes	Fairly Often	Frequently, if Not Always	Mean ± SD	Mean ± SD (Average)
Management-by-Exception (Passive) (MBEP)	1	N	28	41	31	25	25	1.85 ± 1.36	2.08 ± 1.1
		%	18.67	27.33	20.67	16.67	16.67		
	2	N	32	41	25	22	30	1.85 ± 1.44	
		%	21.33	27.33	16.67	14.67	20.00		
	3	N	19	25	30	36	40	2.35 ± 1.37	
		%	12.67	16.67	20.00	24.00	26.67		
	4	N	16	33	32	33	36	2.27 ± 1.33	
		%	10.67	22.00	21.33	22.00	24.00		
Laissez-Faire (LF)	1	N	23	27	30	41	29	2.17 ± 1.35	2.49 ± 0.84
		%	15.33	18.00	20.00	27.33	19.33		
	2	N	46	35	21	23	25	1.64±1.47	
		%	30.67	23.33	14.00	15.33	16.67		
	3	N	5	6	26	56	57	3.03 ± 1.01	
		%	3.33	4.00	17.33	37.33	38.00		
	4	N	3	7	28	45	67	3.11 ± 1	
		%	2.00	4.67	18.67	30.00	44.67		
Avoidant Leadership Styles (Mean ± SD)									2.28 ± 0.9

Table 6. The descriptive analysis of leadership outcomes (n = 150)

Style	No	N/%	Not at All	Once in a while	Sometimes	Fairly Often	Frequently, if Not always	Mean ± SD	Mean ± SD (Average)
Extra Effort (EE)	1	N	7	7	16	40	80	3.19 ± 1.1	3.2 ± 1.01
		%	4.67	4.67	10.67	26.67	53.33		
	2	N	4	11	19	35	81	3.19 ± 1.08	
		%	2.67	7.33	12.67	23.33	54.00		
	3	N	4	9	19	38	80	3.21 ± 1.05	
		%	2.67	6.00	12.67	25.33	53.33		
Effectiveness (EFF)	1	N	5	10	16	41	78	3.18 ± 1.08	3.21 ± 0.96
		%	3.33	6.67	10.67	27.33	52.00		
	2	N	3	7	18	46	76	3.23 ± 0.97	
		%	2.00	4.67	12.00	30.67	50.67		
	3	N	5	7	15	48	75	3.21 ± 1.03	
		%	3.33	4.67	10.00	32.00	50.00		
	4	N	4	9	19	38	80	3.21 ± 1.05	
		%	2.67	6.00	12.67	25.33	53.33		
Satisfaction (SAT)	1	N	3	10	21	37	79	3.19 ± 1.04	3.19 ± 0.95
		%	2.00	6.67	14.00	24.67	52.67		
	2	N	3	12	13	47	75	3.19 ± 1.03	
		%	2.00	8.00	8.67	31.33	50.00		
Outcomes of Leadership (Mean ± SD)									3.2 ± 0.95

Table 7. The descriptive analysis of medical equipment performance evaluation indicators (n = 150)

Style	No	N/%	Low Level	Acceptable	Good	Very Good	Excellent	Mean ± SD	Mean ± SD (Overall)
Repair	1	N	8	4	16	51	71	4.15 ± 1.07	4.21 ± 0.95
		%	5.33	2.67	10.67	34.00	47.33		
	2	N	2	5	22	33	88	4.33 ± 0.94	
		%	1.33	3.33	14.67	22.00	58.67		
	3	N	2	17	13	42	76	4.15 ± 1.07	
		%	1.33	11.33	8.67	28.00	50.67		
Maintenance	1	N	5	5	17	36	87	4.3 ± 1.02	4.18 ± 0.95
		%	3.33	3.33	11.33	24.00	58.00		
	2	N	1	13	21	34	81	4.21 ± 1.03	
		%	0.67	8.67	14.00	22.67	54.00		
	3	N	4	13	23	43	67	4.04 ± 1.09	
		%	2.67	8.67	15.33	28.67	44.67		
End User Training	1	N	7	5	28	36	74	4.1 ± 1.11	4.21 ± 0.91
		%	4.67	3.33	18.67	24.00	49.33		
	2	N	2	10	12	45	81	4.29 ± 0.96	
		%	1.33	6.67	8.00	30.00	54.00		
	3	N	2	11	13	46	78	4.25 ± 0.98	
		%	1.33	7.33	8.67	30.67	52.00		
Medical Equipment Efficiency	1	N	6	4	17	49	74	4.21 ± 1.02	4.22 ± 0.93
		%	4.00	2.67	11.33	32.67	49.33		
	2	N	5	3	15	38	89	4.35 ± 0.98	
		%	3.33	2.00	10.00	25.33	59.33		
	3	N	6	7	13	50	74	4.19 ± 1.05	
		%	4.00	4.67	8.67	33.33	49.33		
	4	N	5	5	22	54	64	4.11 ± 1	
		%	3.33	3.33	14.67	36.00	42.67		
CED Attitude	1	N	4	9	9	38	90	4.34 ± 1.02	4.39 ± 0.91
		%	2.67	6.00	6.00	25.33	60.00		
	2	N	2	6	18	21	103	4.45 ± 0.95	
		%	1.33	4.00	12.00	14.00	68.67		
Overall evaluation of medical equipment performance (Mean ± SD)									4.23 ± 0.877

Figure 2 shows the classification of medical equipment performance evaluation based on scoring system. Most medical equipment had high performance with a percentage of 66%, 25% of medical equipment had "good performance" followed by 8% for moderated performance and 1% for low performance.

Relationship between classification medical equipment performance level and Leadership styles:

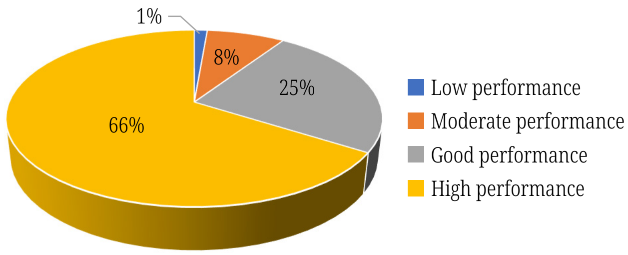

Fig. 2. Classification of medical equipment performance evaluation

Table 8 shows the relationship between classification medical equipment performance level and Leadership styles indicators. Transformational leadership style had significant strongest positive proportional relation with the medical equipment performance level with an average relationship 0.8056 while the Transactional leadership style had significant moderate positive proportional relationship with the medical equipment performance level with an average relation 0.670 and Passive Avoidant had moderate negative relation with an average relationship –0.595.

Table 8. Relationship between classification medical equipment performance level and leadership styles

Leadership Characteristics			Medical Equipment Performance Group
Spearman's	Transformational idealized attributes	Correlation Coefficient	.813**
		Sig. (2-tailed)	0
	Transformational idealized Behavior	Correlation Coefficient	.722**
		Sig. (2-tailed)	0
	Transformational Inspirational Motivation	Correlation Coefficient	.849**
		Sig. (2-tailed)	0
	Transformational Intellectual Stimulation	Correlation Coefficient	.862**
		Sig. (2-tailed)	0
	Transformational Individual Consideration	Correlation Coefficient	.782**
		Sig. (2-tailed)	0
	Transactional Contingent Reward	Correlation Coefficient	.606**
		Sig. (2-tailed)	0
	Transactional Management by Exception Active	Correlation Coefficient	.734**
		Sig. (2-tailed)	0
	Passive Avoidant Management by Exception Passive	Correlation Coefficient	–.557**
		Sig. (2-tailed)	0
	Passive Avoidant Laissez Faire	Correlation Coefficient	–.633**
		Sig. (2-tailed)	0

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Multilayer Perceptron for prediction medical equipment performance level based on Leadership styles indicators:

Neural networks are the preferred option for a wide range of predictive data mining applications because of their power, versatility, and ease of implementation. Neural networks are also used in machine learning applications. When used in conjunction with a complex underlying process, predictive neural networks have the potential to provide significant benefits to the application. In predictive applications, supervised neural networks, such as the Multilayer Perceptron (MLP), is used because it's predictions can be compared to known values of target variables. It is possible to use the Neural Networks option to integrate MLP networks. The models can then be saved and utilized for evaluation. Figure 3, Tables 9 and 10 show the summary of neural network.

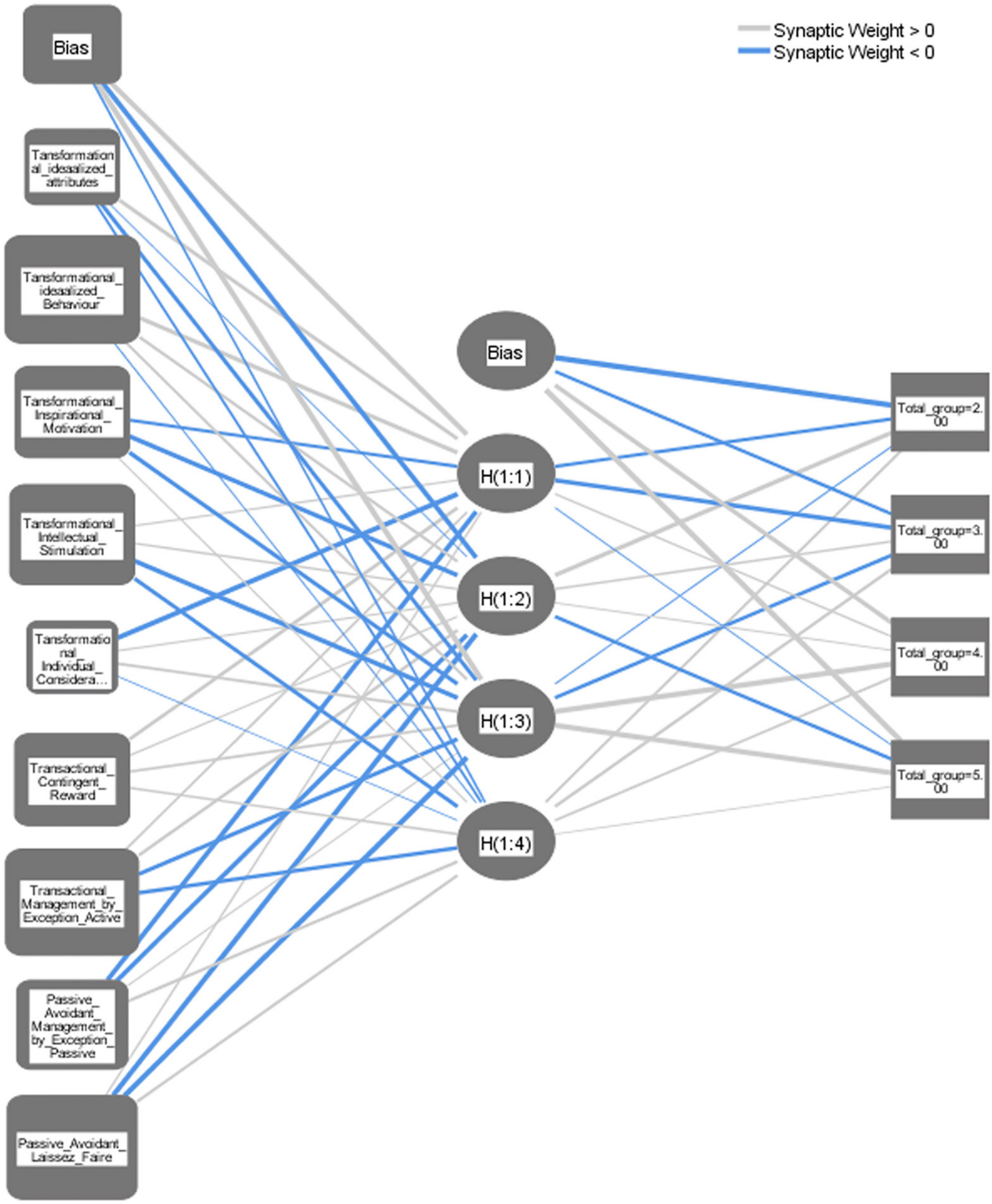

Fig. 3. Neural Network medical equipment performance evaluation

Table 9. Case processing summary

		N	Percent
Sample	**Training**	111	74.0%
	Testing	39	26.0%
Valid		150	100.0%
Excluded		0	
Total		150	

Table 10. Network information

Layer	Number of Nodes
Input Layer	9
Hidden Layer(s)	4
Output Layer	4

MLP for prediction model for medical equipment performance level based on Leadership styles indicators had accuracy during training stage 96.7% and during testing phase 89.1%. Figure 4 shows the Receiver Operating Characteristic Curve (ROC) for medical equipment performance classes, the area of each class was 0.799, 0.743, 0.608 and 0.609 for low, moderate, good, and high-performance class, respectively. Figure 5 shows the normalized importance for input variables (leadership styles indicators) for classification medical equipment performance level.

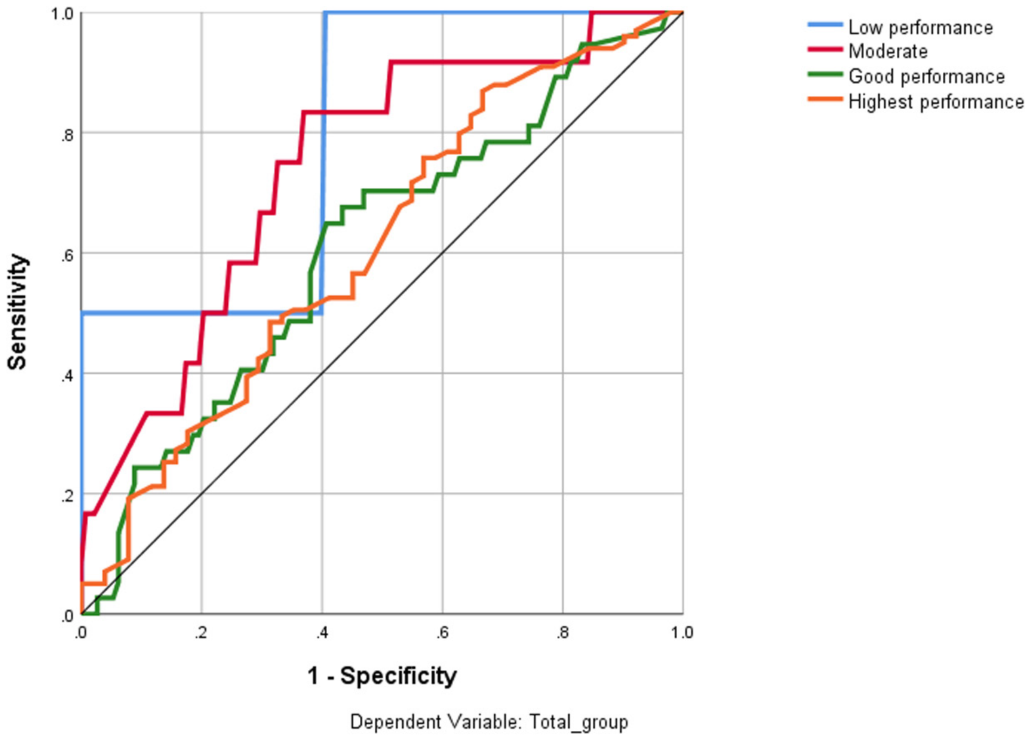

Fig. 4. The ROC curve for medical equipment performance evaluation level classification

Transformational Intellectual Stimulation had the highest percentage with 95.4% and Passive Avoidant Laissez Faire had lowest percentage with 41.0%.

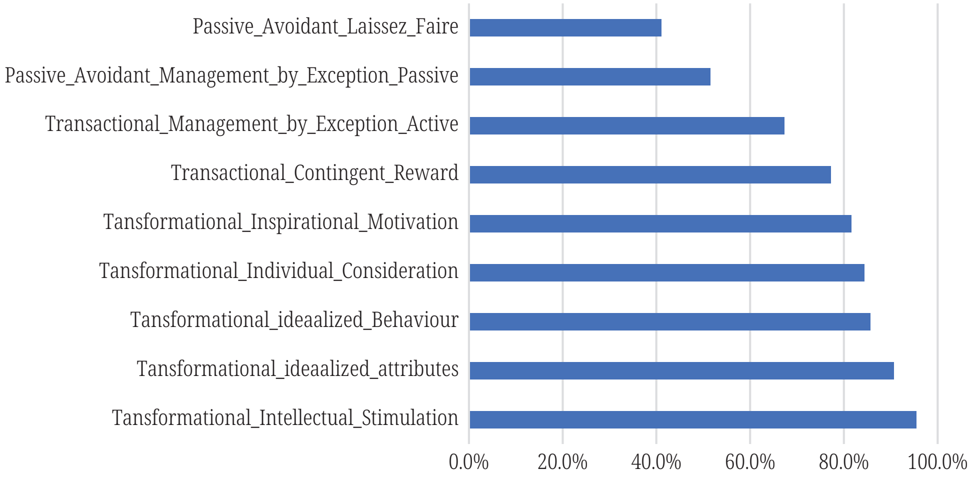

Fig. 5. Input variables importance

From Figures 4 and 5, It was remarkable that 5 variables from transformational leadership style have the most impact for determine the medical performance.

4 DISCUSSION

The research encompassed a heterogeneous sample of 150 individuals employed in the healthcare sector, with a predominant representation of males (90%) and a majority falling within the age range of 25–34 years (58.67%). Most of the participants possessed considerable expertise, as indicated by 40% of respondents reporting over a decade of professional experience. Most participants possessed a bachelor's degree in medical equipment technology, accounting for 56.67% of the sample. On average, participants had accumulated 6.9 years of professional experience within a hospital setting. The study found that a considerable proportion of the participants consisted of Saudi people, accounting for 98% of the total sample. These individuals were primarily employed in governmental hospitals, representing 78% of the participants. Furthermore, most of the participants, namely 63.33%, were affiliated with hospitals that had more than 150 beds.

The Multifactor Leadership Questionnaire (MLQ) is utilized to assess the various leadership styles, including transformational, transactional, and passive avoidant types. The results of the study revealed that the transformational leadership style exhibited the highest mean score of 3.07 ± 0.817, suggesting a significant prevalence of transformational leadership within the hospital settings. These findings align with previous studies that have highlighted transformational leadership as a commonly observed style within healthcare environments [38–40]. The transactional leadership style exhibited a high score of 2.89 ± 0.74, with contingent rewards being the most prominent aspect. The leadership style characterized as passive avoidant obtained a moderate total score of 2.28 ± 0.9, with Laissez-Faire being the prevailing style [38–39].

The results of the study indicate that the leadership styles employed exhibited a significant degree of efficacy (M = 3.21, SD = 0.96), as well as eliciting more effort (M = 3.2, SD = 1.01) and satisfaction (M = 3.19, SD = 0.95) among the participants. This observation suggests that the current leadership styles are efficacious, leading to elevated levels of employee engagement and contentment [38–40].

The overall evaluation of the performance of medical equipment was found to be high, with an average score of 4.23 ± 0.877. Among the various aspects evaluated, the Clinical Engineering Department (CED) Attitude had the highest score of 4.39 ± 0.91. This observation implies that the existing leadership styles may have a positive impact on the functioning of medical equipment. This observation is consistent with prior studies that have established a correlation between leadership styles and the provision of high-quality care, encompassing the effectiveness of medical equipment [41].

Most of the medical equipment exhibited high performance, accounting for 66% of the total. Good performance was seen in 25% of the equipment, while moderate performance was found in 8% of the cases. A mere 1% of the equipment showed bad performance. This finding suggests that a significant proportion of the medical equipment utilized in hospitals is operating at a satisfactory level of performance [41].

The correlation between the categorization of medical equipment performance level and leadership styles suggests that the performance of medical equipment may be influenced by different leadership styles to varying degrees. The results of the study indicate that there is a significant positive correlation between the transformational leadership style and the performance level of medical equipment, with an average correlation coefficient of 0.8056. There exists a moderate positive proportional relationship between the transactional leadership style and the performance level of medical equipment, with an average correlation coefficient of 0.670. The Passive Avoidant attachment style had a moderate negative correlation, with an average correlation coefficient of –0.595 [41–44].

The utilization of neural networks was employed to forecast the performance level of medical equipment by leveraging characteristics of leadership styles [45]. The accuracy of the Multilayer Perceptron (MLP) model for prediction was found to be 96.7% during the training phase and 89.1% during the testing phase. The Receiver Operating Characteristic Curve (ROC) was utilized to evaluate the performance classes of medical equipment. The areas under the ROC curve were found to be 0.799, 0.743, 0.608, and 0.609 for the low, moderate, good, and high-performance classes, respectively. The analysis of the normalized importance of input factors, namely the indicators of leadership styles, in classifying the performance level of medical equipment revealed that Transformational Intellectual Stimulation exhibited the highest percentage at 95.4%, while Passive Avoidant Laissez Faire demonstrated the lowest percentage at 41.0%.

5 CONCLUSIONS

Based on the current study on different hospitals in Riyadh, Saudi Arabia, the CED leadership styles play significant role in determination of the medical equipment performance level in the hospital. There are varieties of leadership styles used by clinical engineering managers in different healthcare organizations and they encounter factors that affect medical equipment performance. This study found that the Saudi clinical engineering managers in Riyadh, Saudi Arabia, were transformational types of leadership more often than transactional and passive-avoidant. The transformational, transactional, and passive avoidant are associated with medical equipment performance level. To sum up, leaders in healthcare institutions need to reflect what leadership style best suits their respective healthcare teams and must also find ways to identify and prevent career derailment to promote positive outcomes not only for themselves but for the general staff as well. With the findings revealed in the study, it is therefore recommended that:

1. Clinical engineering managers attend boosting programs to reinforce their leadership skills.
2. Clinical engineering managers may employ transformational or transactional leadership, as it generates positive results.

Our study offers a novel approach by employing a neural network model to classify Clinical Engineering Department (CED) leadership styles and their correlation with medical equipment performance, ensuring a robust assessment. However, limitations exist, including a small sample size, potentially limiting the generalizability of our findings, and the subjective nature of assessments relying on end-users' perceptions, introducing bias. Additionally, the cross-sectional design restricts our ability to establish causality between leadership styles and equipment performance. Despite these limitations, our study provides meaningful insights, revealing a significant relationship between CED leadership styles and medical equipment performance, particularly emphasizing the importance of transformational leadership.

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