Mathematical Model to Estimate The Effect of Authentic Leadership Components on Hospital Performance

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Abstract: This study's objective is developing and creating an active interaction between real and theoretical results of the opinion of 100 advanced level of clinical leader against the hospital performance by using high advanced mathematical model. Primary data were collected by one of the most famous and global questionnaires for the authentic leadership with systematic interview, from the top level of clinical leaders in one of the most important university hospitals in Jordan, from August– October 2019. The system represents the input variable, Transparency, Moral/Ethical, Balanced Processing, Self-Awareness, and hospital performance as production. identification system basis on the actual results to estimate the effects of Transparency (tr), Moral/Ethical (et), Balanced Processing (bp), Self-Awareness (sa) on the hospital performance were 69.25%, 82.05%, 67.65% and 99.35%, respectively. The proposed mathematical model has a high accuracy to represent all the active parameters of the system and optimize the conditions to produce high outcomes. The proposed mathematical model depends on experimental results have a real state to optimize the active input variables of tr, et, bp and sa to be equal 89.77%, 83.01%, 91% and 81.05% respectively to have optimum results 93.7%. Scientific studies are needed to satisfy the results of this survey using this dynamic technique.

Keywords: Authentic Leadership; Transparency, Moral/Ethical, Balanced Processing, Self-Awareness, Hospital Performance, Advanced mathematical model and Optimization.

1 Introduction

Authentic Leadership has a clear impact on the development of service facilities, in addition to sustaining development in all facilities of the facility, which positively reflects on the outputs of the facility's departments, including those related to internal operational operations or financial affairs, or from what relates to direct services to customers.

Research has shown that involving health care practitioners in leadership roles varies from country to country. In the US, out of 6500 hospitals only 235 organizations are led by doctors [1]. Evidence also shows that greater involvement of health care practitioners especially at strategic level give benefits to hospitals. Doctors who are CEOs of hospitals bring unique skills

and expertise to their organizations because they understand the challenges of the health care system. They can communicate very well with their employees, which helps them to implement their plans [1].

1.1 Authentic Leadership Components

The four used components of authentic leadership are listed in the Authentic Leadership Questionnaire (ALQ). The first component is the associative transparency perspective, which refers to the leader's ability to express and address their values and ideas with their subordinates, resulting in a mutually trustful and trusting relationship. The second major component is the internal moral perspective, which represents the leader's evolving values

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that guide their actions through an internal control position, regardless of external pressure. The third fundamental component of authentic leadership is self-awareness, which is an individual's knowledge and awareness of themselves, including cognitive, moral development, and emotional. The fourth fundamental component of effective leadership is balanced processing, which reveals a leader's capacity to analyze information objectively and critically consider tasks as well as circumstances before making any choices [2,3,4,5].

1.1.1 Transparency

It is the amount of available information about the organization and its performance which allows for external actors to monitor the internal processes, this interaction between the organization and its stakeholders will ultimately lead to create public value [6]. In addition, to foster psychological safety in term of feeling secured in sharing ideas and criticism, also it will reduce unbalanced contribution of group's members [7,8].

According to [9], the maximum effect of transparency will be achieved by keeping a few if any secrets between the leader and his followers thus will enhance greater trust and positive interaction. For instance, transparent leaders have to introduce openness in giving and receiving feedback, clarify the reasoning behind decisions, and display alignment between words and behaviors.

1.1.2 Moral-Ethics

This dimension is about achieving integrity, trust, and moral rectitude in terms of goods and services, society, supplier, employees and the entire system in which they operate and then they have to spread these healthy manners among employees to imitate it and build a robust culture [10,11].

According to [11], moral leaders characterized by having the master key of social skills so they can build consensus and navigate diversity, more effectively than others, on the other hand, if followers reveal that there is inconsistency between leaders' values and behaviors, they will lose their trust and commitment, which in turn will restrict any intent to lunch future positive changes [9].

1.1.3 Self-Awareness

It is defined by the similarities between the leader's own description and his followers' description about his behaviors [12]. It is considered an evaluative process to make self-standards compared with the goal of better self-knowledge and improvement, furthermore, leader who possess self-awareness have the ability to admit their feelings whether positive or negative ones, alongside with concern of other appraisal [13]. Add to that

self-awareness property allows leaders to accept the effect of their emotions, so they control and modify it, which, in turn, will strengthen the relationship with followers via inspire and motivate them and help in achieving organization objectives. Subsequently, higher self-awareness is associated with higher levels of trust, commitment, usage of influence techniques and more effective performance management [14].

1.1.4 Balanced Processing

It is a self-regulatory behavior taken from Aristotle virtue behavior [15]. It is also mean as being open -hearted, by investigating different opinions, with fair consideration for all perspectives, and by treating all viewpoints objectively [16].

According to [17], balanced processing minimizes the influence of eco defensive mechanism. And this will be achieved by reflect analyzed information on task and circumstances before making decisions [18].

Doctors are actually playing hybrid management roles where they arise forming clinical duties as well as management responsibilities [19,20]. There is perception developing in health care field that both professional and managerial knowledge is necessary to improve performance [21]. There are more evidence that doctors who are performing professional and managerial role will improve clinical as well as managerial performance [22].

Authors studied a case of clinical directorate(CDs) where doctors have an opportunity to play the role of doctor as well as managers [22]. Clinical directorates are organizational structures designed to deliver care. Senior consultants are the in charge of these directorate "Correia and Denis". So in Portugal, CDs are considered as innovation in public hospital which deliver care to the patient efficiently. Doctors introduced various good initiatives while heading CDs in Portuguese. They introduced flexible human resource management to improve merit in hospitals and appraisal system. Performance-based funding was also introduced where incentives were given to those who perform well. In order to check the malpractices in hospitals, technological tools were continuously checked for safety and internal and external audit system was implemented.But problem is still whether or not authentic clinical leadership improves performance of hospital. There is some evidence that authentic clinical leadership improves financial performance but still the impact of authentic clinical leadership on performance of hospital is inconclusive and up till now there is no quantitative evidence regarding this. The aim of our research is to bridge this gap and provide concrete mathematical quantitative model evidence about this phenomenon.

1.2 Hospital Performance

Hospital performance measurement provides an important indicator of the overall results of hospital quality of care and the level of internal and external satisfaction [23,24,25,26]. Minvielle et al. mentioned that there is an urgent pursuit by hospitals and health institutions to improve the reality of hospital performance [27]. To achieve many goals such as high clinical performance, increased productivity with a lack of financial flows [28,29,30,31,32].

2 Methodology

2.1 Instrument of the Study

The study tool is divided into three sections: The first section focuses on demographic data such as leadership positions in the hospital, gender, age, professional education, and hospital experience. The second section focused on the four dimensions of Authentic Leadership, and it includes 1- Transparency and it is included five items, 2- Moral / Ethical and it is including four items, 3- Balanced Processing and it is included three items, and Self Awareness and it is included four items. The research permission to use the instrument was obtained from [33]. Instrument: Authentic Leadership Questionnaire (ALQ): Copyright. The third part focused on hospital performance and included six dimensions (Clinical quality (four items), Process orientation (nine items), Workforce conditions (three items), Patient satisfaction (four items), Financial performance (three items), and Operational efficiency (four items) [34,35,36,37,38,39, 40,41].

2.2 Validity of the Questionnaire

The validity of the questionnaire was coming from the types of both types of questionnaires, which measured, reliable and validated by many research paper, which published in many strong and famous journal around worlds.

2.3 Sample Size and Type

The sample size for this study consists of one hundred from high level position of clinical leadership (medical doctors and clinical high-level supervisors). The questionnaire and systematic interview was conducted at King Abdullah University Hospital (KAUH), by using the convenience sample techniques.

Table 1: Survey Result after Converting the Results to Percentages

No.	Dimensions of the Study	Percentage of all Respondents
1	Transparency	73.84%
2	Moral/Ethical	72.75%
3	Balanced Processing	77.00%
4	Self-Awareness	73.37%
5	Total Hospital Performance	64.72%

2.4 Convert the Instrument Results from Likert Scale to Percentage

Authentic leadership questionnaire using Likert scale consist of five scale as following: 0- Not at all up to 4- Frequently, if not always. Hospital performance questionnaire using Liker scale consist of five scale as following: 1- Strongly disagree up to 5- Strongly agree. All the Likert scale values were converted to percentage values to be appropriate for the mathematical model run, by dividing the average answer of every participant on LIKERT scale value and multiplying by 100 percent. Next, the mean for each element was calculated, as shown in Table 1.

3 Data Analysis and Mathematical Model Results

3.1 Mathematical Models Components

The study contained two types of components:

1. System inputs as independent variables (Transparency, Moral/Ethical, Balanced Processing and Self-Awareness).
2. System output as Dependent variables (hospital performance consists of six dimensions (Financial performance, Workforce conditions, Clinical quality, Operational efficiency, Process orientation, and Patient satisfaction), measured as a cumulative dimension).

3.2 System Results Identification

This arrangement consists of four input variables: transparency, ethical, balance processing and self-awareness and one output hospital performance (HP) as illustrated in Figure 1 and Table 2. Tables 3, 4, 5 and 6 represent identification systems for transparency, ethical, balance processing and self-awareness, respectively. The identification scheme can be presented in the steps below [42].

1. Step (1) is represented by raising or lowering the amount of transparency, ethical, balance processing, and self-awareness inputs based on the specified step change.
2. The input variables represent the organize outcomes of each step.
3. Inputs and outputs calculation for each change in the input and output steps.
4. Determine the average slope and the average angle θ that signifies the overall effects of the input variables, the (k) average must be calculated.
5. Steps (1) to (4) must be repeated for all input variables.

The results of the identification analysis system, as demonstrated in Figure 1, are presented as follows:

1. Self-awareness effects represent the greatest effects on the output about 99.38% compared to interaction effects represents the lowest effects about 0.62%.
2. Ethical, balance processing and transparency have an active effect on the variable of output about 82.05%, 67.65% and 69.25%, respectively.
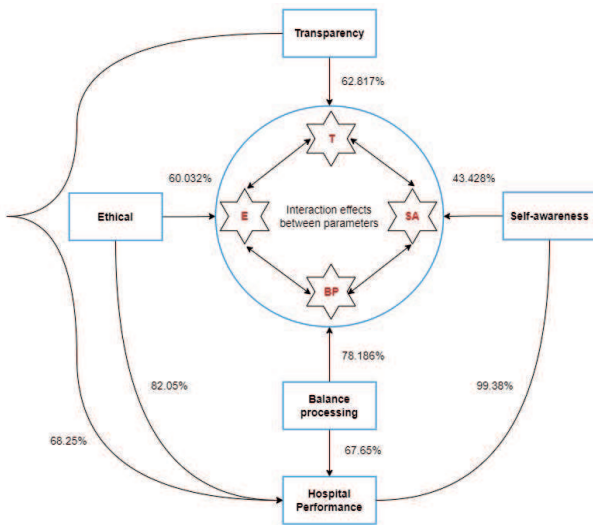

Fig. 1: Identification System Illustration

$$\theta = tan^{-1}AverageSlope = tan^{-1}1.907 = \theta = 69.25° \quad (1)$$

$$\%effect = \frac{\theta}{90°} = \frac{69.25}{90} \times 100 = 69.25\%$$

$$\theta = tan^{-1}AverageSlope = tan^{-1}3.4542 = \theta = 73.85°$$
$$\quad (2)$$
$$\%effect = \frac{\theta}{90°} = \frac{73.85}{90} \times 100 = 82.05\%$$

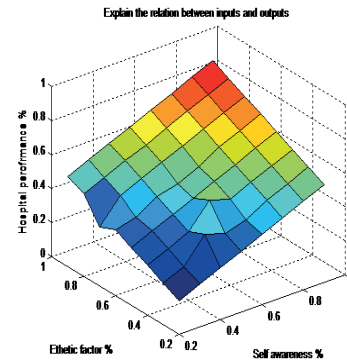$$\theta = tan^{-1}AverageSlope = tan^{-1}1.796 = \theta = 60.89° \quad (3)$$

Fig. 2: The Mathematical Relation between Inputs Parameters and Hospital Performance

$$\%effect = \frac{\theta}{90°} = \frac{60.89}{90} \times 100 = 67.65\%$$

$$\theta = tan^{-1}AverageSlope = tan^{-1}10.383 = \theta = 60.89°$$
$$\quad (4)$$
$$\%effect = \frac{\theta}{90°} = \frac{10.383}{90} \times 100 = 99.38\%$$

3.3 Derive Mathematical Model

Based on the experimental data provides clear knowledge and a deep statement about the evaluation of four important parameters like transparency (tr), ethical (et), balance processing (bp) and self-awareness (sa) effect on the performance of the hospital. The Lagrange interpolation method is one of the active computational techniques used to derive mathematical models depending on observational data to reach high accuracy and show the interaction between inputs and production parameters. Figure 2 and Table 7 explain the effects of the tr, et, bp and sa as input variables towards the hospital performance. The identification action was applied to actual data as indicated in equation 5 to fix the weights of interaction effect between input variables and output to create mesh data generation as demonstrated in Table 2.

$$HospitalPerformance(HP) = \sum_{i=1}^{n}\sum_{j \neq i}^{n} L_{tr}x_i L_{et}x_j L_{bp}x_i L_{sa}x_i w_{i,j,i,j} \quad (5)$$

Proposed model provides active optimize conditions as shown in equations (6-10) and make all derivative equations to be equal to zero as shown in equation 10 for inputs parameters sa, et, bp and tr respectively to calculate the optimum input variables of hospital performance as shown in Table 8 and Figure 3.

$$\frac{dHP}{dL_{sa}} = \sum_{i=1}^{n}\sum_{j \neq i}^{n} L_{IQ}x_i L_{ET}x_j L_{EE}x_i L_{MC}x_i w_{i,j,i,j} \quad (6)$$

Table 2: The Average Data That Represents the System

Transparency (As a leader I...)	Moral/Ethical (As a leader I...)	Balanced Processing (As a leader I...)	Self-Awareness (As a leader I...)	Hospital Performance
0.52000	0.40000	0.60000	0.80000	0.31825
0.60000	0.40000	0.93333	0.80000	0.45238
0.76000	0.95000	0.80000	0.80000	0.46111
0.56000	0.70000	0.46667	0.55000	0.54841
0.64000	0.50000	0.53333	0.55000	0.58810
0.92000	0.85000	0.86667	0.80000	0.60159
0.60000	0.60000	0.60000	0.70000	0.68571
0.80000	0.85000	0.73333	0.80000	0.72381
0.60000	0.80000	0.60000	0.60000	0.77143
0.99540	0.70000	0.60000	0.60000	0.80476
0.84000	0.95000	0.93333	0.75000	0.88333

Table 3: Transparency Effects' Identification System

X_i (Transparency)%	$\lvert(X_i - X_n)/X_n\rvert$	Y_i (efficiency)%	$\lvert(Y_i - Y_n)/Y_n\rvert$	Slope
0.52000	0.108	0.31825	0.471	4.36
0.60000	0.347	0.45238	0.248	0.71
0.76000	0.174	0.46111	0.233	1.34
0.56000	0.391	0.54841	0.088	0.225
0.64000	0.304	0.58810	0.022	0.072
0.92000	0	0.60159	0	0
0.60000	0.347	0.68571	0.14	0.403
0.80000	0.13	0.72381	0.203	1.56
0.60000	0.347	0.77143	0.282	0.81
0.99540	0.082	0.80476	0.337	4.21
0.84000	0.087	0.88333	0.468	5.38
Average Slope				**1.907**

Table 4: Ethical Effects' Identification System

X_i (Ethical)%	$\lvert(X_i - X_n)/X_n\rvert$	Y_i (efficiency)%	$\lvert(Y_i - Y_n)/Y_n\rvert$	Slope
0.40000	0.53	0.31825	0.471	0.88
0.40000	0.53	0.45238	0.248	0.448
0.95000	0.117	0.46111	0.233	1.991
0.70000	0.411	0.54841	0.088	0.50
0.50000	0	0.58810	0.022	0.053
0.85000	0.29	0.60159	0	0
0.60000	0.011	0.68571	0.17	0.48
0.85000	0.058	0.72381	0.203	18.45
0.80000	0.117	0.77143	0.282	4.86
0.70000	0.117	0.80476	0.337	4.86
0.95000	0.117	0.88333	0.468	2.88
Average Slope				**3.4542**

$$\frac{dHP}{dL_{et}} = \sum_{i=1}^{n} \sum_{j \neq i}^{n} L_{IQ} x_i L_{ET} x_j L_{EE} x_i L_{MC} x_i w_{i,j,i,j} \qquad (7)$$

$$\frac{dHP}{dL_{bp}} = \sum_{i=1}^{n} \sum_{j \neq i}^{n} L_{IQ} x_i L_{ET} x_j L_{EE} x_i L_{MC} x_i w_{i,j,i,j} \qquad (8)$$

$$\frac{dHP}{dL_{tr}} = \sum_{i=1}^{n} \sum_{j \neq i}^{n} L_{IQ} x_i L_{ET} x_j L_{EE} x_i L_{MC} x_i w_{i,j,i,j} \qquad (9)$$

$$\frac{dHP}{dL_{sa}} = \frac{dHP}{dL_{et}} = \frac{dHP}{dL_{bp}} = \frac{dHP}{dL_{tr}} = 0 \qquad (10)$$

4 Conclusion

The estimation of this work was incorporated between experimental and theoretical consequences in create computational model has high accuracy to represent the

Table 5: Balance Processing Effects' Identification System

X_i (Balanced Processing)%	$|(X_i - X_n)/X_n|$	Y_i (efficiency)%	$|(Y_i - Y_n)/Y_n|$	Slope
0.60000	0.30	0.31825	0.471	1.57
0.93333	0.08	0.45238	0.248	0.31
0.80000	0.07	0.46111	0.233	3.32
0.46667	0.46	0.54841	0.088	0.20
0.53333	0.38	0.58810	0.022	0.05
0.86667	0	0.60159	0	0
0.60000	0.30	0.68571	0.14	0.46
0.73333	0.15	0.72381	0.203	1.35
0.60000	0.30	0.77143	0.282	0.94
0.60000	0.30	0.80476	0.337	1.12
0.93333	0.08	0.88333	0.468	5.85
Average Slope				**1.796**

Table 6: Self-Awareness Effects' Identification System

X_i (Self Awareness)%	$|(X_i - X_n)/X_n|$	Y_i (efficiency)%	$|(Y_i - Y_n)/Y_n|$	Slope
0.80000	0.0125	0.31825	0.471	37.68
0.80000	0.0125	0.45238	0.248	19.84
0.80000	0.0125	0.46111	0.233	18.64
0.55000	0.3125	0.54841	0.088	0.2816
0.55000	0.3125	0.58810	0.022	0.0704
0.80000	0	0.60159	0	0
0.70000	0.125	0.68571	0.14	1.12
0.80000	0.0125	0.72381	0.203	16.24
0.60000	0.282	0.77143	0.282	1.128
0.60000	0.337	0.80476	0.337	1.348
0.75000	0.468	0.88333	0.468	7.488
Average Slope				**10.383**

Table 7: Shows The Input Parameters Change with The Hospital Performance

Ethical	Self-awareness								Balance Processing
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
0.2	0.199	0.253	0.307	0.360	0.413	0.466	0.520	0.573	0.2
0.3	0.246	0.30	0.441	0.406	0.440	0.514	0.567	0.620	0.3
0.4	0.293	0.347	0.401	0.543	0.507	0.561	0.614	0.667	0.4
0.5	0.341	0.394	0.448	0.50	0.554	0.608	0.661	0.714	0.5
0.6	0.388	0.418	0.495	0.526	0.580	0.657	0.708	0.763	0.6
0.7	0.345	0.488	0.542	0.594	0.648	0.702	0.755	0.808	0.7
0.8	0.482	0.535	0.590	0.641	0.696	0.750	0.802	0.855	0.8
0.9	0.53	0.583	0.636	0.688	0.743	0.796	0.850	0.902	0.9
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
	Transparency								

Table 8: Inputs and Outputs Results Optimum

Variables	Value of input variables in percentage %	Hospital performance%
Self-Awareness (sa)	81.05	
Moral/Ethical (et)	83.01	94.734
Balanced Processing (bp)	91	
Transparency (tr)	89.77	

and analysis each parameter's effect on the output. Self-awareness has the highest strength and balance processing has the lowest effect on the output compared to the other variables. Optimization technique was employed to find the optimum conditions with less cost.

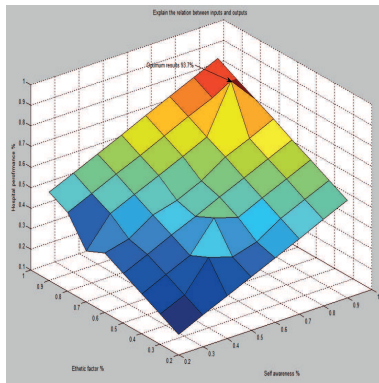organization. The identification system was used to study

Fig. 3: Explain the relation between Inputs Parameters and output (Hospital Performance)

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