**ORIGINAL**

# Mathematical Model to Evaluate the Effect of Information Quality, and Management Capability on Hospital Performance

## Modelo matemático para evaluar el efecto de la calidad de la información y la capacidad de gestión en el desempeño hospitalario

Main Naser Alolayyan[1] ✉, Khaleel Ibrahim Al- Daoud[2] ✉, Badrea Al Oraini[3] ✉, Mohammad Faleh Ahmmad Hunitie[4] ✉, Asokan Vasudevan[5] ✉, Peng Luo[6] ✉, Suleiman Ibrahim Shelash Mohammad[7,8] ✉

[1]Department of health management and policy. Faculty of Medicine. Jordan University of Science and Technology. Jordan.

[2]Department of Accounting– business school Faculties–Al Ahilya Amman University. Amman, Jordan.

[3]Department of Business Administration, Collage of Business and Economics, Qassim University. Qassim, Saudi Arabia.

[4]Department of Public Administration, School of Business, University of Jordan. Jordan.

[5]Faculty of Business and Communications, INTI International University. 71800 Negeri Sembilan.

[6]Faculty of Liberal Arts, Shinawatra University. Thailand.

[7]Department of Business Administration, Business School, Al al-Bayt University. Jordan.

[8]Research follower, INTI International University. 71800 Negeri Sembilan, Malaysia.

**Corresponding Author:** Main Naser Alolayyan ✉

**ABSTRACT**

**Introduction:** the objective of this study is to make active interaction among actual and theoretical outcomes of the view of 100 medical staff and medical supervisors of the university hospital and to study and analyze the effect of important parameters (quality information, employee trust, employee engagement, and management capability) on the hospital performance using the proposed mathematical model.

**Method:** primary data were collected from the highest-level medical job position in a hospital (medical doctors, head of the medical department, and medical supervisors). Using convenient sampling, the proposed mathematical model represents the input parameters as information quality, employee trust, employee engagement, and management capability, and output parameters for hospital performance dimensions as output.

**Results:** the identification system depends on the actual outcomes to evaluate the effects of information quality (IQ), employee trust (ET), employee engagement (EM), and management capability (MC) against hospital performance were 60,032 %, 43,428 %, 78,186 %, and 62,817 %, respectively.

**Conclusions:** the derived mathematical model has a high accuracy to represent all the active parameters of the system and optimize the conditions to produce high outcomes.

**Keywords:** Mathematical Model; Information Quality; Employee Trust and Engagement; Management Capability.

**RESUMEN**

**Introducción:** el objetivo de este estudio es generar una interacción activa entre los resultados reales y teóricos de la opinión de 100 miembros del personal médico y supervisores médicos del hospital universitario y estudiar y analizar el efecto de parámetros importantes (calidad de la información, confianza de los empleados, compromiso de los empleados y capacidad de gestión) en el desempeño del hospital utilizando el modelo matemático propuesto.

**Método:** se recopilaron datos primarios de los puestos médicos de más alto nivel en un hospital (médicos, jefe del departamento médico y supervisores médicos). Utilizando un muestreo conveniente, el modelo matemático propuesto representa los parámetros de entrada como calidad de la información, confianza de los empleados, compromiso de los empleados y capacidad de gestión, y los parámetros de salida para las dimensiones de desempeño del hospital como salida.

**Resultados:** el sistema de identificación depende de los resultados reales para evaluar los efectos de la calidad de la información (CI), la confianza de los empleados (TE), el compromiso de los empleados (EM) y la capacidad de gestión (MC) sobre el desempeño del hospital fueron 60,032 %; 43,428 %; 78,186 %; 62,817 %, respectivamente.

**Conclusiones:** el modelo matemático derivado tiene una alta precisión para representar todos los parámetros activos del sistema y optimizar las condiciones para producir altos resultados.

**Palabras clave:** Modelo Matemático; Calidad de la Información; Confianza y Compromiso de los Empleados; Capacidad de Gestión; Rendimiento Hospitalario.

## INTRODUCTION

This is a time of high competitiveness in medical sector around the world, especially with increasing emphasis on health quality issues, such as decreasing medical services cost, preventing the medical errors, with a high level of productivity in all medical service processes, and achieving a high level of satisfaction from patients and their families. The philosophy of continuous improvement is one of the issues that has received great attention in the medical sector, which is reflected in the nature of scientific research which seeks to identify the most influential points on the performance of the hospital, which gives the hospital points of excellence in the competitiveness of the medical market.

Management issues and their impact on the overall performance of the hospital has an important priority in scientific research today that is interested in the topics of health service management. In this research, the researchers attempt to highlight three very important dimensions in the health management dimensions of hospitals. First: the dimension of human capital, which consists of two main dimensions that effect on the competitive environment of the hospital; these dimensions are employee trust and employee engagement. Second, it is very well known that the medical procedure depends on the correct medical diagnosis in terms of treatments, medications, or medical procedures.

Hence, the importance of the quality of medical and non-medical information (Information Quality) within the hospital lies in the development and improvement of the hospital's outputs. Since this research is concerned with the study or identification of some important dimensions affecting the competitive position of the hospital, management capability is one of the most important dimensions because it is concerned with creating an effective capacity to deal with the dynamic and ongoing market changes and seeks to maintain a high level of market competitiveness for a longer time. This could be achieved through strategic planning for the use of all components of the hospital as efficiently as possible and for the longest term.

### Theoretical framework
*Information Quality*

Information quality is defined as the value capable of producing outputs that meet the expectations of customers and is the quality of information produced by operational systems at all stages of service building.[1] The quality of information can be classified into four categories, which are summarized as follows: essence quality, context quality, representation quality, and accessibility quality.[2]

From another side, quality of information is one of the most important measures to build productive value in the health sector and is provided by the hospital's health information systems to the medical service provider, patients, and patient families. The quality of information varies between the abilities and skills of users and the uses of the underlying information.

The high degree of quality of information increases the validity and objectivity of decisions in all its forms, especially if this information is medical, diagnostic, and therapeutic and if the patient's condition needs constant follow-up. Accuracy of health information is one of the elements of intelligence applications to make a significant difference in health care outcomes. Quality is usually seen as a self-motivation. Most of the time information is required and has an effect in improving output not only by the amount of information but also by the quality of the information.[3]

The information quality usually depends on the quality of primary data collection methods and the quality of raw data to build information used to implement effective decisions at both the clinical and health care

levels and thus build a comprehensive strategy that determines the future of the health system in general. In one study, 42 percent of official interviews indicated poor quality of data in health care, which reflected on health care outcomes and constituted a major impediment to important decision-making, whether therapeutic or administrative.[4]

The same study found that access to health information is a cumbersome and difficult process to obtain because there is no clear policy to control the quality of health data collection and documentation. There are no standards for practical measures to control the quality of basic operations, and there is a clear lack of understanding of information needs, as well as effective management of time-intensive and intensive processes to obtain a clear value of data; often data is manipulated manually in tables, which negatively affects the true value of the data and its role in the performance of the hospital or health provider.

Attention should be given to the quality of health information as the most important factor in the wider context of information quality and an important influence on the overall performance of health services. This quality of information has been studied extensively for its applications in several areas, including commercial, service, and manufacturing, but the interest in the quality of health information in the medical sector is still minor and is the most important sector for the quality of information because it is related to the nature of the service is mostly imperceptible based on psychological dimensions and communication skills.[5]

Clearly, the assessment of the quality of health information for consumers can be described as highly relevant and correlated with the importance of the sequence of quality of information for medical care recipients, which is sometimes misleading. This study calls for further studies and research on how different user groups can assess different types of health information from different sources, for example online and customized approach building to educate and motivate users about health information quality assessment.[6]

## Employee trust

Meyer (1995) defined trust as the willingness of the first party to be subject to the actions of another (second) party based on the expectation and confidence that the other party (second) would carry out a particular act of significant influence to the donor, irrespective of the ability to object the other.[7] Simons (1999) predicted that in order to build trust between two parties or several parties, the perception of behavioral integrity may be a prerequisite for creating an impactful expectation with the listener that the actions of the speaker will broadly correspond to his words.[8]

They pointed out that conceiving safety and advising someone else is one of the main precedents for building trust. As such, research suggests that behavioral integrity is strongly linked to trust in leaders and institutional commitment, creating an effective trust environment, which influences the customer community, organizational competitiveness, and organizational profitability.[9] In his research model, Simons and Parks (2000) also described trust as an intermediate variable between behavioral integrity and customer and several productivity factors that reflected positively on the employee's desire to implement change and retain employee change performance.[9]

Trust between people, organizations, or people and events in work environments is an important basis for enhancing productivity, "Building trust between people and work environments is only voluntary work based on the expectations of others and how you will behave in a relationship to yourself in the future, with the clear support of healthy environments in Organizations.[10] Yu (2018) said that building trust is an essential element in supporting the effectiveness of productive and social processes. In an organizational context, trust is an effective indicator for assessing and supporting positive attitudes and behaviors of employees, such as organizational citizenship behavior, cooperative behavior, organizational commitment, employee loyalty, and other behaviors that reflect positively on the reality of the organization's environment and business process.[11]

Enhancing employee confidence in their organization is an ideal goal for all departments and employers, but how to foster the establishment of organizational trust among organizational departments remains a challenge for organizations and an important research topic. Employees in hospitals positively associated with both patient care and operational effectiveness through their impact on employee organizational commitment.[12] Many studies indicated the roles of employee trust on performance.[13,14,15,16,17]

## Engagement of the employee

Employee engagement is an important force that motivates employees to raise performance levels in organizations. This desirable capacity can be assessed as being similar to commitment to the organization's rules, sincerity, pride, and appreciated efforts, and is most closely related to passion, excitement, and commitment to execution. It can be described as a "combination of commitment, loyalty, productivity, and ownership".[18]

Employee engagement is defined as the mechanism by which an employee communicates separately with his company and how the same employee communicates with each individual with the company's internal and external customers.[19]

The high and advanced level of employee engagement is an important strategic goal for many organizations in the service sector and industries today, particularly health care. It depends on the commitment of employees

working with the employer to share and be satisfied with their work and their willingness to make every extra effort to achieve the goals of the organization and to implement the strategies appropriately. There is much evidence that employee engagement affects other key HR goals, such as retention, job performance, and absenteeism (indirectly through employer reputation).[20,21]

A high level of integration with professionalism is one of the strategic objectives of healthy growth in many organizations in general, particularly in health care organizations. Engagement employees mean to commit to their own work process and to engage with their colleagues in a productive work environment, making them want to make an extra effort to achieve the organization's vision. There is a lot of evidence which suggest that employee engagement should be a key and central objective of human resources management.[20,21]

Through employee engagement, the participant understands the importance of participation and works with his colleagues in the same range to improve performance within the job for the benefit of the organization.[22] According to Shantz, Alfes, Truss, & Soane (2013), many employees have positive attitudes and have a vibrant, dedicated, and enjoyable state of mind the employees if they are properly engaged to improve performance; engagement make employees more psychologically active in the work environment, reducing the likelihood of making big mistakes that are maybe led to stopped work.[23]

Gichohi (2014) demonstrates a positive relationship between employee interaction and employee performance and its reflection on increased commitment and wider thinking, leading to increased effectiveness and commitment to improvement in their work.[24] Employee engagement has been defined in a variety of ways. Men (2015), for instance, claims that it is the employees' favorable attitude toward the firm and its ideals. According to Selvarasu and Sastry (2014), an employee's dedication to their organization and values has a major role in determining their performance level. Men (2015) state that energy, absorption, involvement, effectiveness, vitality, dedication, and excitement, together with a good attitude, are characteristics of participation and serve as incentives to boost employee performance.[25,26]

Rana and Chopra (2019) said employee engagement is of great importance and effectiveness in a business environment where competitiveness and dynamism are high today and there is a positive impact directly on the total organizational performance. The workforce engaged in business constitutes a vital and important asset for the organization, which reflects positively on its efforts for the benefit of the organization.[27]

## Management capability

Eisenhardt and Martin (2000) recommended that companies require and need to employ their managers for their ability to design business and organizational strategies that lead organizations properly and innovatively to get more distinctive performance, which reflects on the growth in performance and competitiveness of the organization. In the same vein, managers with unique business empowerment capabilities are in a much better position than other managers to build, develop, and integrate the organization's resources and competencies.[28,29]

The management capacity defines the effectiveness and ability of the management in applying its skills to deal with threats, changes, and opportunities to develop and motivate employees while optimizing the use of organized resources to work on innovation and achieving the highest levels of performance).[30] In the same vein, these capabilities, which rely on high-level management skills, give diverse senior management teams' face and greater opportunities for a dynamic environment, creating a sound environment capable of maintaining competitive advantages to improve organizational performance.[31]

Administrative capacity has a significant impact on all parts of the organization, particularly on the qualities and performance of organizational management related to logistics systems with high efficiency, continuous monitoring , follow-up of costs, and strengthens the financial management skills of staff, which increases the ability to exploit opportunities and manage human resources in a productive and effective way, which reflects on the ability to properly employ human capital, accurate profitability, as well as predictability of revenue and current and future market planning process.[32]

There are many studies that indicate and say that important operational processes in organizations need specialized teams of senior management that uses their management capabilities and skills to identify, operate, and distribute the resources of the company and human capital in the organization properly based on high-quality standards, which improve its competitive position and enhances overall performance.[33] Goswami and Torre (2019) said our research work reinforces that capable management practices are clearly linked to the company's superior performance.[34]

Companies with management capability practices are more organized and have higher productivity, profitability, and growth. This result is extremely powerful because it depends on many controls. Among the most important types of management practices, our results indicate that those related to management capability are supported by performance-driven, data monitoring supported by performance-driven data monitoring. Finally, the correlation of management capability in influencing company performance is particularly linked to that of externally linked companies.

**Hospital Performance**

Because of the many fundamental differences between many countries and hospitals in West Asia, many hospitals in the region suffer from common long-term challenges as healthcare quality, healthcare costs, and access to health care. These challenges can be fragmented into the following challenges and difficulties as well: fragmented strong, capable, and positive management (one of this research objectives was to measure the impact of management capability on hospital performance), Insufficient strategic thinking, ineffective leadership, insufficient knowledge and expertise in change management, limited availability of medical supplies that require specialized diagnosis and care, such as medications, pharmaceuticals, or personal hygiene items, fair distribution of resources, effective resource utilization, ineffective control strategies, poor health information systems (one of the objectives of this research was to measure the impact of quality information on hospital performance), and human resource management productivity and skills (employee trust and engagement and the direct impact of all these variables on hospital performance, another objective of this research was look at the direct impact of all these variables on hospital performance ).[35,36]

Holistic health plans in Iran intended for by 2025 speak of the importance of integrating international scientists, together with leading national experts, to develop basic curricula in seven important areas, in order to serve the development of health sector performance, especially that of hospitals: governance, leadership, strategic management, hospital finance, human resources management, hospital emergencies, hospital supplies, disaster management, supportive and quality improvement, health information management, and patient services safety.[37]

## METHOD

### Study objective and design

This study is based on the study and analysis of the relationship and calculation of the impact of the following independent variables or input dimensions (as in the mathematical model design) on a cumulative hospital performance, through an advanced mathematical model of analysis: information quality, employee trust, employee engagement, and management capability.

### Materials and participants

Participants in this research are a key pillar of the success of medical care and have a clear role in enhancing performance. They are also involved in the dimensions of the study, such as inputs and outputs of the analytical process. The quality information, employee trust, employee engagement, and management capability have a direct impact on the performance of the hospital.

This study relies on data collection through a valid, reliable questionnaire developed based on previous studies. Data were collected on face-to-face interviews with physicians (specialists and residents), heads of medical departments, and key medical supervisors in King Abdullah University Hospital, one of the biggest teaching hospitals in Jordan.

### Innovation in research methods

In this research, some research methods in the social sciences have been merged with high-precision mathematical methods of analysis with a high accuracy level. Questionnaire and interview techniques were used to obtain a high-level of accurate data, this data is important input for a sophisticated mathematical model to get a strong results and evidence for the mathematical model output. Limited studies in the world have used this technique.

### Mathematical models components

There were two types of components in the study:

1. System input as Independent variables (Information Quality, Employee (Trust and Engagement), and Management Capability).

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—all measured as a cumulative dimension).

### Questionnaire of the study

The study instrument was divided into six sections: the first examined demographics including gender, age, professional training, and prior hospital experience; the second part included three items and focused on the employee trust dimension; permission was obtained from the authors for this section[38] the third part focused on employee engagement dimension and included twelve items; To measure employee engagement, permission was taken to use the Q12 benchmark questionnaire (https://q12.gallup.com/Public/en-us/Features) which is one of an important measure in this area.

This tool was developed by identifying it through the elements used by Gallup and used in hundreds of surveys; the fourth part focused on quality information and included eight items[39] the fifth part focused on management capability and include six items[32] the sixth 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)). [40,41,42,43,44,45,46,47,48,49,50,51,52]

**Validity of the questionnaire**

The validity of the questionnaire was measured by work on a prospective exploratory study, in which 15 preliminary interviews were conducted with parts of the study population; all observations were taken from the target sample considered, and some parts of the questionnaire were modified based on feedback.

**Sample size**

This study's sample size can be regarded as appropriate and appropriate for the mathematical model ran. At King Abdullah University Hospital (KAUH), 140 questionnaires were distributed; 112 of them were returned; and 100 of the respondents were deemed suitable for study. Data collection took place between April 22, 2023, and August 15, 2023.

**Switching from LIKERT scale to percentage value**

Data were collected by a questionnaire in a university hospital containing more than 650 beds. A suitable sample and questionnaire were used to achieve the study objectives. All the values of LIKERT scale 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 (average) for each element was calculated, as shown in table 1.

| Table 1. The survey result after converting the results to percentages | | |
|---|---|---|
| **No.** | **Study Dimensions** | **Percentage of all respondents (Change from Likert scale to percentage)** |
| 1 | Information Quality | 72,079 |
| 2 | Employee Trust | 62,720 |
| 3 | Employee Engagement | 72,146 |
| 4 | Management Capability | 66,609 |
| 5 | The average for all hospital performance dimensions (Total Hospital Performance) | 64,725 |

**Identification System Outcomes**

In this project, there are four input variables: communication quality (IQ), employee trust (ET), employee engagement (EM) and management control (MC), as well as an output value: performance hospital (HP), shown in figure 1 and table 2. Tables 3, 4, 5 and 6 show the information quality scoring system, employee trust, participation and management
ability. The identification plan can be modeled as follows. [53,54]

   a. Phase (1) is characterized by the rise and fall of information quality, employee trust,
employee participation and control inputs according to the change in phase. select.

   b. The arrangement of the results is different for each step of the input variables.

   c. For each event cycle for the input and output event cycles, calculate the other sides for the inputs and outputs.

   d. Determine the average slope and average angle θ representing all the effects of the
input variables. Let's calculate the mean k.

   e. Repeat steps (1) to (4) for all input variables.

What is related to the results of the identification analysis system, such as figure 1, is shown as follows:

   1. The effects of employee participation show the effects high to produce and approx 78,186 %.

   2. Employee trust shows the least effect on the internal, proximal parameters 43,428 %.

   3. The quality of information and management ability have a strong influence on the near-term output index. 60,032 % and 62,817 %.
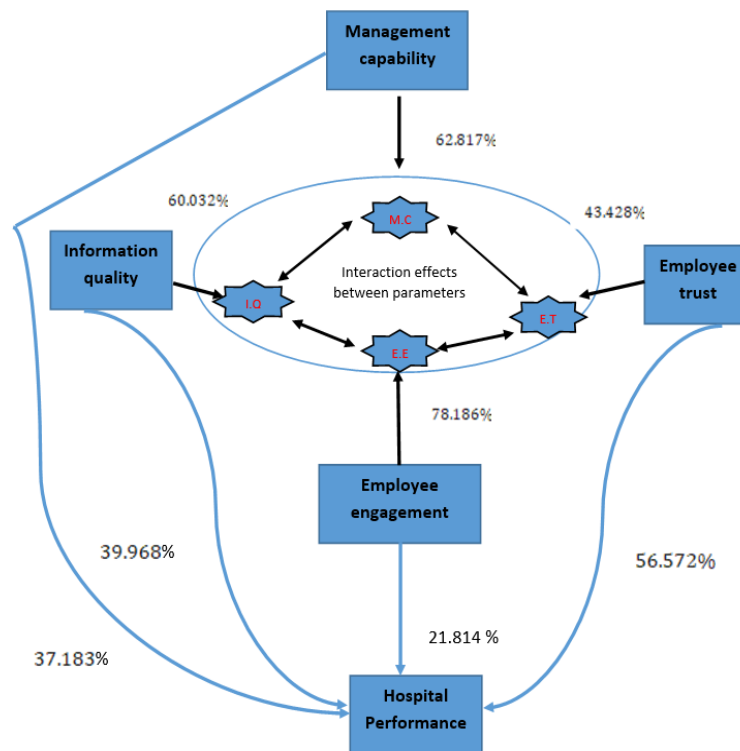
**Figure 1.** An illustration of the identification system

| Table 2. Represents the average data that represents the system | | | | |
|---|---|---|---|---|
| **Information Quality** | **Employee Trust** | **Employee Engagement** | **Management Capability** | **Hospital Performance** |
| 0,83929 | 0,26667 | 0,36667 | 0,35714 | 0,31825 |
| 0,87500 | 0,33333 | 0,56667 | 0,52381 | 0,45238 |
| 0,37500 | 0,60000 | 0,70000 | 0,23810 | 0,46111 |
| 0,92857 | 0,46667 | 0,61667 | 0,57143 | 0,54841 |
| 0,62500 | 0,53333 | 0,65000 | 0,66667 | 0,58810 |
| 0,78571 | 0,53333 | 0,71667 | 0,59524 | 0,62222 |
| 0,55357 | 0,73333 | 0,73333 | 0,73810 | 0,68651 |
| 0,98214 | 0,73333 | 0,80000 | 0,92857 | 0,73413 |
| 0,99854 | 0,80000 | 0,80000 | 0,57143 | 0,77143 |
| 0,35714 | 0,53333 | 0,75000 | 0,83333 | 0,82460 |
| 0,21429 | 0,93333 | 0,91667 | 0,92857 | 0,88333 |

| Table 3. Identification system of information quality effects | | | | |
|---|---|---|---|---|
| $X_i$ (information quality) % | $|(X_i-X_n) / X_n|$ | $Y_i$ (efficiency) % | $|(Y_i-Y_n) / Y_n|$ | Slope |
| 0,83929 | 0,068 | 0,31825 | 0,488 | 7,176 |
| 0,87500 | 0,113 | 0,45238 | 0,272 | 2,407 |
| 0,37500 | 0,522 | 0,46111 | 0,258 | 0,494 |
| 0,92857 | 0,181 | 0,54841 | 0,118 | 0,651 |
| 0,62500 | 0,204 | 0,58810 | 0,054 | 0,264 |
| 0,78571 | 0 | 0,62222 | 0 | 0 |
| 0,55357 | 0,295 | 0,68651 | 0,103 | 0,349 |
| 0,98214 | 0,25 | 0,73413 | 0,179 | 0,716 |
| 0,99854 | 0,27 | 0,77143 | 0,239 | 0,885 |
| 0,35714 | 0,545 | 0,82460 | 0,142 | 0,26 |
| 0,21429 | 0,727 | 0,88333 | 0,419 | 0,576 |
| Average slope=1,3778 | | | | |

$$\theta = tan^{-1} Average\ slope = tan^{-1} 1.3778 = \theta = 54.028^o \quad \textbf{(1)}$$

$$\%\ effect = \frac{\theta}{90^o} = \frac{54.028}{90} \times 100 = 60.032\%$$

| Table 4. Identification system of employee trust effects | | | | |
|---|---|---|---|---|
| $X_i$ (employee trust) % | $\|(X_i-X_n)\ /\ X_n\|$ | $Y_i$ (efficiency) % | $\|(Y_i-Y_n)\ /\ Y_n\|$ | Slope |
| 0,26667 | 0,499 | 0,31825 | 0,488 | 0,977 |
| 0,33333 | 0,375 | 0,45238 | 0,272 | 0,725 |
| 0,60000 | 0,125 | 0,46111 | 0,258 | 20,064 |
| 0,46667 | 0,124 | 0,54841 | 0,118 | 0,944 |
| 0,53333 | 0 | 0,58810 | 0,054 | - |
| 0,53333 | 0 | 0,62222 | 0 | - |
| 0,73333 | 0,375 | 0,68651 | 0,103 | 0,274 |
| 0,73333 | 0,375 | 0,73413 | 0,179 | 0,477 |
| 0,80000 | 0,5 | 0,77143 | 0,239 | 0,478 |
| 0,53333 | 0 | 0,82460 | 0,142 | - |
| 0,93333 | 0,749 | 0,88333 | 0,419 | 0,559 |
| Average slope=.81225 | | | | |

$$\theta = tan^{-1} Average\ slope = tan^{-1} 0.81225 = \theta = 39.085^o \quad (2)$$

$$\%\ effect = \frac{\theta}{90^o} = \frac{39.085}{90} \times 100 = 43.428\ \%$$

| Table 5. Identification system of employee engagement effects | | | | |
|---|---|---|---|---|
| $X_i$ (employee engagement) % | $\|(X_i-X_n)\ /\ X_n\|$ | $Y_i$ (efficiency) % | $\|(Y_i-Y_n)\ /\ Y_n\|$ | Slope |
| 0,36667 | 0,488 | 0,31825 | 0,488 | 1 |
| 0,56667 | 0,209 | 0,45238 | 0,272 | 1,301 |
| 0,70000 | 0,022 | 0,46111 | 0,258 | 11,727 |
| 0,61667 | 0,139 | 0,54841 | 0,118 | 0,848 |
| 0,65000 | 0,092 | 0,58810 | 0,054 | 0,586 |
| 0,71667 | 0 | 0,62222 | 0 | 0 |
| 0,73333 | 0,023 | 0,68651 | 0,103 | 4,478 |
| 0,80000 | 0,117 | 0,73413 | 0,179 | 1,529 |
| 0,80000 | 0,117 | 0,77143 | 0,239 | 2,042 |
| 0,75000 | 0,047 | 0,82460 | 0,142 | 3,021 |
| 0,91667 | 0,279 | 0,88333 | 0,419 | 1,501 |
| Average slope=2,803 | | | | |

$$\theta = tan^{-1} Average\ slope = tan^{-1} 2.803 = \theta = 70.368^o \quad (3)$$

$$\%\ effect = \frac{\theta}{90^o} = \frac{70.368}{90} \times 100 = 78.186\%$$

| Table 6. Identification system of management capability effects | | | | |
|---|---|---|---|---|
| $X_i$ (management capability) % | $\|(X_i-X_n)/X_n\|$ | $Y_i$ (efficiency) % | $\|(Y_i-Y_n)/Y_n\|$ | Slope |
| 0,36667 | 0,4 | 0,31825 | 0,488 | 1,22 |
| 0,56667 | 0,121 | 0,45238 | 0,272 | 2,247 |
| 0,70000 | 0,6 | 0,46111 | 0,258 | 0,43 |
| 0,61667 | 0,04 | 0,54841 | 0,118 | 2,95 |
| 0,65000 | 0,119 | 0,58810 | 0,054 | 0,453 |
| 0,71667 | 0 | 0,62222 | 0 | 0 |
| 0,73333 | 0,24 | 0,68651 | 0,103 | 0,43 |
| 0,80000 | 0,559 | 0,73413 | 0,179 | 0,32 |
| 0,80000 | 0,04 | 0,77143 | 0,239 | 5,975 |
| 0,75000 | 0,4 | 0,82460 | 0,142 | 0,355 |
| 0,91667 | 0,559 | 0,88333 | 0,419 | 0,75 |
| Average slope=1,5129 | | | | |

## RESULTS

Counting test days provides a strong understanding and clear understanding of the status of the audit to managers and decision makers in the hospital. Interpolation method is one of the powerful numerical methods used to create a mathematical model of experimental data to achieve perfect accuracy and independent behavior between input and output variables. Figure 2 and Table 7 represent the effects of information quality, employee trust, employee engagement, and management capability as input parameters against hospital performance. The identification scheme is applied to determine the weights of interaction between input parameters against output, to make mesh date generation to establish an interpolation mathematical model that has high accuracy due to its depending on the actual date to hold a clear perspective about all the system, as presented in equation 5.

$$Hospital\ performance(HP) = \sum_{i=1}^{n}\sum_{j\neq i}^{n} L_{IQ}x_i L_{ET}x_j\ L_{EE}x_i L_{MC}x_i w_{i,j,i,j} \qquad (5)$$

| Table 7. Shows the input parameters change with the hospital performance | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Information quality | | | | | | | | |
| Employee trust | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | Management capability |
| 0,2 | 0,199 | 0,256 | 0,312 | 0,369 | 0,425 | 0,482 | 0,538 | 0,595 | 0,2 |
| 0,3 | 0,242 | 0,299 | 0,355 | 0,412 | 0,468 | 0,525 | 0,581 | 0,638 | 0,3 |
| 0,4 | 0,286 | 0,37 | 0,399 | 0,43 | 0,512 | 0,568 | 0,625 | 0,681 | 0,4 |
| 0,5 | 0,33 | 0,386 | 0,442 | 0,499 | 0,555 | 0,611 | 0,668 | 0,724 | 0,5 |
| 0,6 | 0,372 | 0,43 | 0,485 | 0,542 | 0,598 | 0,655 | 0,711 | 0,768 | 0,6 |
| 0,7 | 0,416 | 0,47 | 0,53 | 0,585 | 0,642 | 0,698 | 0,755 | 0,811 | 0,7 |
| 0,8 | 0,46 | 0,515 | 0,572 | 0,628 | 0,685 | 0,74 | 0,798 | 0,854 | 0,8 |
| 0,9 | 0,502 | 0,559 | 0,615 | 0,672 | 0,728 | 0,785 | 0,841 | 0,898 | 0,9 |
| | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | |
| Employee engagement | | | | | | | | | |

Mathematical models can give energetic optimization conditions, as shown in equations 6–9, and let all derivative equations be equal to zero, as shown in equation 10, for the variables input information quality, employee trust, employee engagement, and management capability, respectively, to estimate the optimum input parameters of hospital performance as shown in table 8 and figure 3.
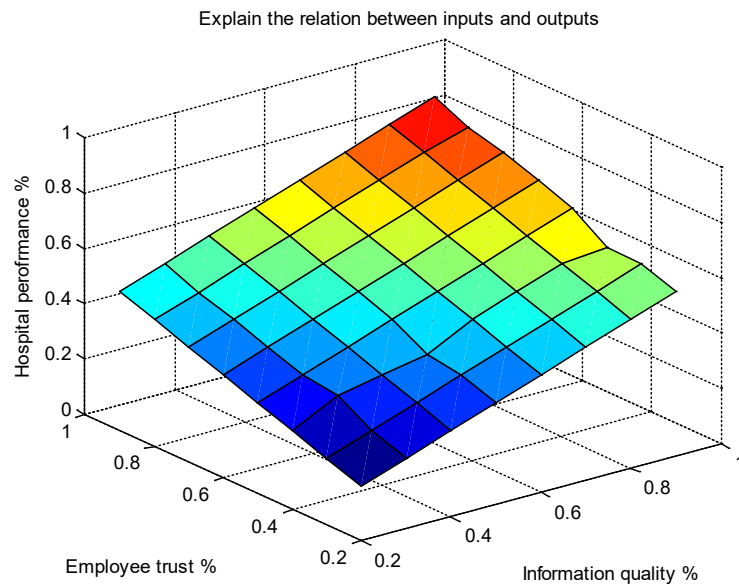
**Figure 2.** Explains the effects of input variables on the hospital performance

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

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

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

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

$$\frac{d\,HP}{dL_{IQ}} = \frac{d\,HP}{dL_{ET}} = \frac{d\,HP}{dL_{EE}} = \frac{d\,HP}{dL_{MC}} = 0 \qquad (10)$$

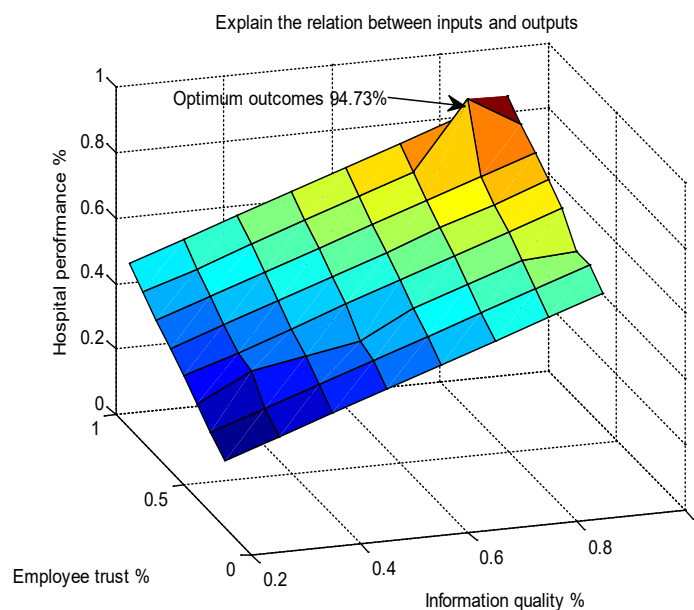| Table 8. Shows the optimum of inputs and outputs results | | |
|---|---|---|
| **Variables** | **Value of inputs variables in %** | **Hospital performance %** |
| IQ | 86,103 | 94,734 |
| ET | 83,247 | |
| EE | 90 | |
| MC | 88,58 | |



**Figure 3.** Explain optimum conditions

## CONCLUSIONS

The creativity of this study was integrated among the actual and theoretical results to derive a mathematical model that has a high performance in representing the system and design identification system to handle active results about employee engagement, which has the highest effect on the hospital performance, in contrast to employee trust, which has the lowest effect on the system. The mathematical model employed optimization techniques to find optimum hospital performance outcomes and optimum parameters as specified in the identification system.

## ACKNOWLEDGEMENT

## BIBLIOGRAPHIC REFERENCES

1. DeLone WH, McLean ER. Information systems success: The quest for the dependent variable. Information systems research. 1992 Mar;3(1):60-95.

2. Wang RY, Strong DM. Beyond accuracy: What data quality means to data consumers. Journal of management information systems. 1996 Mar 1;12(4):5-33.

3. Gogan JL, Baxter RJ, Boss SR, Chircu AM. Handoff processes, information quality and patient safety: A trans-disciplinary literature review. Business Process Management Journal. 2013 Feb 1;19(1):70-94.

4. Foshay N, Kuziemsky C. Towards an implementation framework for business intelligence in healthcare. International Journal of Information Management. 2014 Feb 1;34(1):20-7.

5. Al-Jefri M, Evans R, Uchyigit G, Ghezzi P. What is health information quality? Ethical dimension and perception by users. Frontiers in medicine. 2018 Sep 20;5:260.

6. Sun Y, Zhang Y, Gwizdka J, Trace CB. Consumer evaluation of the quality of online health information: systematic literature review of relevant criteria and indicators. Journal of medical Internet research. 2019 May 2;21(5).

7. Mayer RC, Davis JH, Schoorman FD. An integrative model of organizational trust. Academy of management review. 1995 Jul 1;20(3):709-34.

8. Simons TL. Behavioral integrity as a critical ingredient for transformational leadership. Journal of organizational change management. 1999 Apr 1;12(2):89-104.

9. Simons T, Parks JM. The sequential impact of behavioral integrity on trust, commitment, discretionary service behavior, customer satisfaction, and profitability. Cornell University, Center for Hospitality Research; 2000.

10. Gilson L. Trust and the development of health care as a social institution. Social science & medicine. 2003 Apr 1;56(7):1453-68.

11. Yu MC, Mai Q, Tsai SB, Dai Y. An empirical study on the organizational trust, employee-organization relationship and innovative behavior from the integrated perspective of social exchange and organizational sustainability. Sustainability. 2018 Mar 19;10(3):864.

12. Baird KM, Tung A, Yu Y. Employee organizational commitment and hospital performance. Health care management review. 2019 Jul 1;44(3):206-15.

13. Bligh MC. The role of trust in leader-follower relationships.

14. Boies K, Fiset J, Gill H. Communication and trust are key: Unlocking the relationship between leadership and team performance and creativity. The leadership quarterly. 2015 Dec 1;26(6):1080-94.

15. Guinot J, Chiva R. Vertical trust within organizations and performance: a systematic review. Human Resource Development Review. 2019 Jun;18(2):196-227.

16. Koohang A, Paliszkiewicz J, Goluchowski J. The impact of leadership on trust, knowledge management, and organizational performance: A research model. Industrial Management & Data Systems. 2017 Apr 10;117(3):521-37.

17. Mo S, Shi J. Linking ethical leadership to employee burnout, workplace deviance and performance: Testing the mediating roles of trust in leader and surface acting. Journal of Business Ethics. 2017 Aug;144:293-303.

18. Wellins R, Concelman J. Creating a culture for engagement. Workforce performance solutions. 2005;4(1):1-4.

19. Lucey J, Bateman N, Hines P. Why major lean transitions have not been sustained. Management Services. 2005 Jan;49(2):9-13.

20. Gibbons J, Schutt R. A global barometer for measuring employee engagement. Conference Board.

21. Macey WH, Schneider B. The meaning of employee engagement. Industrial and organizational Psychology. 2008 Mar;1(1):3-0.

22. Ologbo AC, Sofian S. Individual and organizational factors of employee engagement on employee work outcomes. International Journal of Business and Behavioral Sciences. 2013 Mar;3(3):498-502.

23. Alfes K, Shantz AD, Truss C, Soane EC. The link between perceived human resource management practices, engagement and employee behaviour: a moderated mediation model. The international journal of human resource management. 2013 Jan 1;24(2):330-51.

24. Gichohi PM. The role of employee engagement in revitalizing creativity and innovation at the workplace: A survey of selected libraries in Meru County-Kenya.

25. Men LR. Employee engagement in relation to employee–organization relationships and internal reputation: effects of leadership communication. Public Relations Journal. 2015;9(2):11-22.

26. Selvarasu A, Sastry SK. A study of impact on performance appraisal on employee's engagement in an organization. International Journal of Managerial Studies and Research (IJMSR). 2014 Dec;2(1):10-22.

27. Rana S, Chopra P. Developing and sustaining employee engagement: the strategic perspective in telecom company. InManagement Techniques for Employee Engagement in Contemporary Organizations 2019 (pp. 142-164). IGI Global.

28. Eisenhardt KM, Martin JA. Dynamic capabilities: what are they?. Strategic management journal. 2000 Oct;21(10-11):1105-21.

29. Adner R, Helfat CE. Corporate effects and dynamic managerial capabilities. Strategic management journal. 2003 Oct;24(10):1011-25.

30. Matheson D. Management capability: What it really means, Management Magazine.

31. Carmeli A, Tishler A. The relationships between intangible organizational elements and organizational performance. Strategic management journal. 2004 Dec;25(13):1257-78.

32. DeSarbo WS, Anthony Di Benedetto C, Song M, Sinha I. Revisiting the Miles and Snow strategic framework: uncovering interrelationships between strategic types, capabilities, environmental uncertainty, and firm performance. Strategic management journal. 2005 Jan;26(1):47-74.

33. Wolff JA, Pett TL. Small-firm performance: modeling the role of product and process improvements. Journal of small business management. 2006 Apr;44(2):268-84.

34. Grover A, Torre I. Management capabilities and performance of firms in the Russian Federation. World Bank Policy Research Working Paper. 2019 Sep 4(8996).

35. Dadgar E, Janati A, Tabrizi JS, Asghari-Jafarabadi M, Barati O. Iranian expert opinion about necessary criteria for hospitals management performance assessments. Health promotion perspectives. 2012;2(2):223.

36. Shukla M. Impact of a health governance intervention on provincial health system performance in Afghanistan: a quasi-experimental study. Health systems & reform. 2018 Jul 3;4(3):249-66.

37. Doshmangir L, Takian A. Capacity building to improve hospital managers' performance in West Asia. International Journal of Health Policy and Management. 2019 May;8(5):319.

38. Simons T, Friedman R, Liu LA, McLean Parks J. Racial differences in sensitivity to behavioral integrity: attitudinal consequences, in-group effects, and "trickle down" among Black and non-Black employees. Journal of Applied Psychology. 2007 May;92(3):650.

39. Ribière V, LaSalle AJ, Khorramshahgol R, Gousty Y. Hospital information systems quality: a customer satisfaction assessment tool. InProceedings of the 32nd Annual Hawaii International Conference on Systems Sciences. 1999. HICSS-32. Abstracts and CD-ROM of Full Papers 1999 Jan 5 (pp. 7-pp). IEEE.

40. Vera A, Kuntz L. Process-based organization design and hospital efficiency. Health care management review. 2007 Jan 1;32(1):55-65.

41. Gemmel P, Vandaele D, Tambeur W. Hospital Process Orientation (HPO): The development of a measurement tool. Total Quality Management. 2008 Dec 1;19(12):1207-17.

42. Kershaw R, Kershaw S. Developing a Balanced Scorecard to implement strategy at St. Elsewhere hospital. Management accounting quarterly. 2001 Jan 1;2(2).

43. Olden PC, Smith CM. HOSPITALS, COMMUNITY HEALTH, AND BALANCED SCORECARDS. Academy of Health Care Management Journal. 2008 Jan 1;4(1).

44. Walker KB, Dunn LM. Improving hospital performance and productivity with the balanced scorecard. Academy of Health Care Management Journal. 2006 Jan 1;2.

45. Griffith JR, Alexander JA, Jelinek RC, Foster DA, Mecklenburg GA. Is anybody managing the store? National trends in hospital performance. Journal of Healthcare Management. 2006 Nov 1;51(6):392.

46. Zelman WN, Pink GH, Matthias CB. Use of the balanced scorecard in health care. Journal of health care finance. 2003 Jan 1;29(4):1-6.

47. Chen H, Tian Y, Daugherty PJ. Measuring process orientation. The International Journal of Logistics Management. 2009 Aug 14;20(2):213-27.

48. Griffith JR, Alexander JA, Warden GL. Measuring comparative hospital performance/practitioner response. Journal of healthcare management. 2002;47(1):41.

49. Gumbus A, Belthouse DE, Lyons B. A Three Year Journey to Organizational and Financial Health Using the Balanced Scorecard: A Case Study at a Yale New Haven Health System Hospital. Journal of Business & Economic Studies. 2003 Sep 1;9(2).

50. Chow CW, Ganulin D, Haddad K, Williamson J. The balanced scorecard: a potent tool for energizing and focusing healthcare organization management. Journal of Healthcare Management. 1998 May 1;43(3):263-80.

51. Lovaglio PG. Model building and estimation strategies for implementing the Balanced Scorecard in Health sector. Quality & Quantity. 2011 Jan;45:199-212.

52. Meyer SM, Collier DA. An empirical test of the causal relationships in the Baldrige Health Care Pilot Criteria. Journal of operations management. 2001 Jul 1;19(4):403-26.

53. Marley KA, Collier DA, Meyer Goldstein S. The role of clinical and process quality in achieving patient satisfaction in hospitals. Decision Sciences. 2004 Aug;35(3):349-69.

54. Ibrehem AS. System identification for experimental study for polymerization catalyst reaction in fluidized bed. Bulletin of Chemical Reaction Engineeing & Catalysis. 2011 Dec 20;6(2):137-46.

## FINANCING

## CONFLICT OF INTEREST

There is no conflict of interest.

## AUTHORSHIP CONTRIBUTION

*Conceptualization:* Main Naser Alolayyan, Badrea Al Oraini.
*Formal analysis:* Khaleel Ibrahim Al- Daoud, Asokan Vasudevan.
*Research:* Mohammad Faleh Ahmmad Hunitie, Peng Luo.
*Methodology:* Khaleel Ibrahim Al- Daoud, Asokan Vasudevan.
*Drafting - original draft:* Suleiman Ibrahim Shelash Mohammad, Peng Luo.
*Writing - proofreading and editing:* Suleiman Ibrahim Shelash Mohammad, Asokan Vasudevan.