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The effect of artificial intelligence capability on patient satisfaction

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C H R O N I C L E

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A B S T R A C T

The study aims at exploring the effect of artificial intelligence as measured by machine learning capability and expert systems capability on patient satisfaction. As informant participants, medical staff workers in healthcare institutions in KSA comprise the population of the study. Hence, a sample consisting of 300 participants was used to gather research data via a questionnaire developed based on previous works. By means of Smart PLS 3.0 software, the results indicate that both machine learning and expert systems have significant effects on patient satisfaction. The study concluded that artificial intelligence capability is a cornerstone of patient satisfaction. such a statement encompasses theoretical and empirical implications as stated at the end of this study.

1. Introduction

Nowadays, artificial intelligence (AI) applications are used all over the world in many industries such as business organizations, healthcare sector, manufacturing, engineering, science. Impacts of AI on other variables as documented in the literature include satisfaction of bank customers (Al-Araj et al., 2022), customer relationship management (Li et al., 2023), employee satisfaction and loyalty (Prentice et al., 2020), customer-related decision making processes (Davenport & Ronanki, 2018), and healthcare industry (Bohr & Memarzadeh, 2020; Rosemann & Zhang, 2022). The current study is concerned with AI capability in the healthcare industry. Of course, AI capability results in numerous advantages in the healthcare industry concerning patient outcomes like customer satisfaction and loyalty (Lee & Yoon, 2021) and healthcare quality, performance and costs (Lee & Yoon, 2021; Gupta & Kumari, 2017).

As a capability of an organization refers to its ability to utilize its resources to attain human-like actions. AI capability was operationalized in terms of tangible and intangible resources (Mikalef & Gupta, 2021) and can be measured using some dimensions including machine learning and expert systems capabilities. The first dimension enables healthcare institutions to analyze medical records to reach medical decisions, and the second one assist such institutions to find medical solutions through detecting patterns in medical data (Wahl et al., 2018; Beam & Kohane, 2018; Venkatasubramanian, 2019; Yanase & Triantaphyllou, 2019; Jarvis et al., 2020; Pallathadka et al., 2023).

In fact, there is little research on the effect of AI capability on patient satisfaction in KSA. Therefore, this study was conducted to contribute to the literature and fill such gap research through investigating the effect of AI capability, i.e., machine learning capability and expert systems capability. In doing that, the study offers theoretical and empirical implications for both researchers and practitioners. It is structured as follows. The next section contains a review of the extant literature on AI capability and patient satisfaction and research hypotheses, followed by section 3 on research methodology in terms of research sample, measures, and theoretical model. Section 4 is on data analysis and results and contains tests of reliability and validity, model fit assessment, and hypotheses, after that section 5 on results discussion and conclusion. Finally, section 6 shows research implications and limitations.

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2. Literature review and hypotheses

2.1 AI definition and technologies

AI is a technology that works as an enabler for machines to imitate human cognitive functions through performing intellectual tasks (Yau et al., 2021). The core of AI is that it enables machines to carry out specific automated tasks and goals such as augmenting decision making process (Rosemann & Zhang, 2022; Li et al., 2023). Mikalef and Gupta (2021) defined AI as a system ability to learn from data to attain organizational and societal goals. Technologies of AI include natural language processing, machine learning, facial recognition, smart robotics, expert systems, and artificial neural networks (Ker et al., 2017; Wahl et al., 2018; Bawack et al., 2019; Yanase & Triantaphyllou, 2019; Jarvis et al., 2020; Lee & Yoon, 2021). Machine learning (ML) refers to data mining solutions that assist in forecasting some outcomes. It is divided into supervised and unsupervised learning techniques. The first type is related to data classification techniques such as artificial neural networks. On the other hand, the unsupervised type is used for data clustering to find hidden patterns (Pallathadka et al., 2023). In healthcare research, ML had been described as a program employed to perform tasks or taking decisions automatically from medical data, which means that ML represents a guide for medical decisions, principally, for investigating patient history, familial diseases, and medications (Beam & Kohane, 2018). The aim of natural language processing (NLP) is human language interpretation (Jarvis et al., 2020) and used in mining useful information from narrative texts such as physical examinations to assist clinical decision-making processes (Jiang et al., 2017). Facial recognition aims at recognizing human faces to map facial features through analyzing unstructured visual data (Jarvis et al., 2020). Smart robotics are designed to assist physicians during surgery (Yu et al., 2018) and expert systems are used to emulate human expertise to conduct clinical processes such as clinical diagnosis (Bawack et al., 2019).

2.2 AI advantages

Using AI technologies is associated with numerous advantages. Examples of these advantages embrace exploring customer preferences and enhancing organization productivity (Kumar et al., 2022), improving products functions and performance, helping staff taking enhanced decisions, optimizing business operations, exploring new markets, improving workers' creativity by automating tasks, and optimizing marketing and sales processes (Davenport &Ronanki, 2018). Particularly, AI is used in healthcare industry to help medical staff in tasks such as patient diagnosis and treatment, image analysis, automation of medical services (Bohr &Memarzadeh, 2020), drug creation, online consultations, projecting medical events, mining medical records, and designing treatment plans (Gupta & Kumari, 2017) as well as healthcare research, public health interventions, and management of healthcare systems (Rosemann & Zhang, 2022).Overall, AI technologies assist care providers to offer a new value for patients and therefore boost the whole efficiency of patient outcomes like customer satisfaction and loyalty, and equip hospitals with crucial returns similar to heightened disease treatment, boosted patient engagement, lowered medical errors and costs, and better-quality productivity (Lee & Yoon, 2021). To take advantage of AI, organizations should possess AI capability.

2.3 AI capability

AI capability has been defined as an organization's ability to organize organizational resources and utilize computer systems to carry out human-like practices such as learning, reasoning, and self-correction of business tasks (Mikalef et al., 2019). For Zhang et al. (2020), AI capability represents an innovation team's ability to use AI technologies to emulate human cognitive tasks and accomplish functions in an intelligent fashion. AI capability was conceptualized by Mikalef and Gupta (2021) in terms of data and technology tangible resources, technical and business human skills, and intangible resources such as internal coordination, change capacity, and risk tendency. Zhang et al. (2020) indicated that the measures of AI capability include the capability to mimic human intellectual behavior, anticipate customer behavior, support AI for learning and reasoning, as well as develop procedures to imitate human intelligence and perceptive functions. Bawack et al. (2019) developed a framework of AI capability consisted of four pillars, which are sense (computer vision, speed recognition, and biometrics), comprehend (natural language processing, text analyses, pattern recognition, and knowledge engineering), learn (neural networks, machine learning and genetic programming), and act (expert systems, fuzzy logic systems, decision support systems, and robotics).

For the current study, AI capability refers to hospital staff abilities to learn and act via using AI technologies such as machine learning and expert systems. A hospital capability in machine learning represents its ability to access large unstructured data, store and analyze digital medical records, extract relevant information from such records and well as narrative texts, benefit from electronic records to make medical decisions, and analyze visual unstructured data such as images to conduct image analysis (Jiang et al., 2017; Beam & Kohane, 2018; Jarvis et al., 2020; Pallathadka et al., 2023). On the other hand, AI expert systems as a knowledge-based computer systems are useful in searching for solutions through recognizing patterns due to its deployment of relevant heuristics (Venkatasubramanian, 2019) and assist physician in patient diagnosis (Yanase & Triantaphyllou, 2019), and choosing treatment plans (Wahl et al., 2018).

2.4 Patient satisfaction

Generally, customer satisfaction has been defined as an individual assessment of products or services performance. It is clarified by customer perceived quality and customer perceived value and, on the other hand, establishes customer complaints and customer loyalty (Wang, 2022).Patient satisfaction in AI context can be attained through enhancing the quality of healthcare services, reducing costs of healthcare services, and lowering healthcare errors(Lee and Yoon, 2021),enhancing

patient safety (Durand et al., 2015; Campanella et al., 2016; Dewa et al., 2017), reducing medical costs (Tsai et al., 2015; Kruse et al., 2017; Meesala & Paul, 2018; West et al., 2018), ensuring medical service quality (Moss et al., 2016; Salmond & Echevarria, 2017),and reducing waiting-time (Xu & Li, 2016; Liddy et al., 2016; Woo et al., 2017). For the current study, patient satisfaction is an endogenous variable measured based on medical staff perspectives because they possess the required information on the effect of AI capability based on their experience in such a context.

2.5 AI capability and patient satisfaction

Research on AI in the healthcare industry reported numerous effects of AI. It was acknowledged that AI technologies help processing data to discover knowledge and create novel methods to improve healthcare quality (Hazarika, 2020), enhance patient satisfaction and decrees medical costs (Sogani, 2020), find medical solutions based on heuristics of human expertise (Venkatasubramanian, 2019; Yanase &Triantaphyllou, 2019), help analyzing vast volume of medical data (Gupta & Kumari, 2017), improve worker productivity (Kumar et al., 2022), assist in patient diagnosis and treatment (Bohr & Memarzadeh, 2020), support healthcare research (Rosemann & Zhang, 2022), recover online consultations (Gupta & Kumari, 2017), make diagnosis decisions (Yanase &Triantaphyllou, 2019), conclude medical scenarios like detecting drug interactions and improve diagnosis accuracy (Obermeyer & Emanuel, 2016). As the focus of the current study is on one exogenous latent variable, i.e., AI capability, which comprises two observed variables: capability of AI machine learning and capability of AI expert systems, and in line with the potentials of such capabilities on healthcare outcomes, it was expected that these two constructs show significant and positive effects on patient satisfaction, hence, it is concerned with testing the following two hypotheses:

H_1: *Machine learning capability is significantly and positively related to patient satisfaction.*
H_2: *Expert system capability is significantly and positively related to patient satisfaction*.

3. Methodology

3.1 Research sample and data collection

The sample of the current study consists of 300 medical staff participants who have relevant information about AI applications in the healthcare industry in KSA. Subjectively, participants were asked to give their perceptions about AI capabilities in terms of machine learning and expert system capabilities as well as their effects on patient satisfaction through a questionnaire encompassing 14 items. The final sample contained 257 participants after excluding 43 responses as outliers and invalid responses.

3.2 Research measures

AI capability in the current study consists of two observed variables: machine learning capability and expert systems capability. These two independent variables were measured using ten items developed based on prior studies as shown in Table 1 patient satisfaction as a dependent variable was measured using 4 items in line with previous studies as mentioned in section 2.4 and demonstrated in Table 1. It should be noted that patient satisfaction was measured based on medical staff perceptions as its items are about the potential of AI capability.

Table 1
Research questionnaire

Variables	Items	Sources
Machine learning	Capability of …	Jiang et al., 2017; Beam &Kohane, 2018; Jarvis et al., 2020; Mikalef and Gupta, 2021; Pallathadka et al., 2023.
	- Access to large unstructured data.	
	- Data storage and analyses.	
	- Extracting useful information from narrative texts such as physical examination.	
	- Using clinical data in making automated clinical decisions.	
	- Analyzing unstructured visual clinical data.	
Expert systems	Capability of …	Obermeyer & Emanuel, 2016; Wahlet al., 2018; Bawack et al., 2019; Venkatasubramanian, 2019.
	- Emulating human expertise.	
	- Searching for medical solutions through pattern recognition.	
	- Drawing medical scenarios such as drug interactions.	
	- Supporting physicians in patient diagnosis.	
	- Providing treatment advice.	
Patient satisfaction	Satisfaction with …	Moss et al., 2016; Dewa et al., 2017; Woo et al., 2017; Meesala& Paul, 2018; Lee & Yoon, 2021;
	- AI results in lowered medical errors.	
	- AI leads to reduced medical costs.	
	- AI gives rise to higher quality medical services.	
	- AI causes decreased waiting-time for medical service access.	

3.3 Research model

The theoretical model of the study as drawn in Fig. 1 shows that the study is concerned with testing two hypotheses on the effect of machine learning capability and expert system capability as two dimensions of AI capability on patient satisfaction.

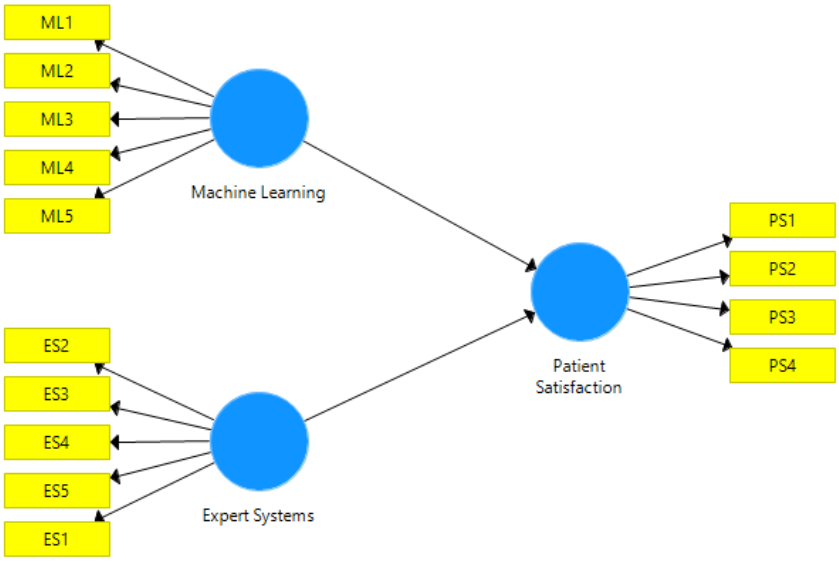

Fig. 1. Research theoretical model

4. Data analysis and results

4.1 Reliability and validity

Reliability was measured using Cronbach's alpha coefficient (α) and composite reliability (CR), and validity was evaluated via convergent validity; i.e., using factor loadings. The cutoff value of both alpha coefficients and CR values is 0.70, as well, factor loadings (FL) should be higher than 0.50.The results of reliability and validity in Table 2 indicate that all alpha and CR values are more than 0.70 and all factor loadings and AVE values are higher than 0.50; machine learning (α = 0.785, CR = 0.853, FL = 0.710-0.761, AVE = 0.538), expert systems (α = 0.818, CR = 0.873, FL = 0.0.690-0.793, AVE = 0.580), and patient satisfaction (α = 0.701, CR = 0.809, FL = 0.632-0.791, AVE = 0.538). Hence, reliability and validity are assured.

Table 2
Results of reliability and validity

Factors and items	FL	AVE	CR	α
Machine learning	**0.710-0.761**			
ML1	0.735	0.538	0.853	0.785
ML2	0.71			
ML3	0.731			
ML4	0.761			
ML5	0.729			
Expert systems	**0.690-0.793**			
ES1	0.69	0.58	0.873	0.818
ES2	0.767			
ES3	0.786			
ES4	0.793			
ES5	0.768			
Patient satisfaction	**0.623-0.791**			
PS1	0.791	0.516	0.809	0.701
PS2	0.708			
PS3	0.623			
PS4	0.741			

4.2 Model fit assessment

Three indicators are used to assess the current model fit, which are determination coefficient (R^2), Stone-Geiser's (Q^2), and the effect size (f^2). Values of R^2 are classified into three categories: low values ($R^2 < 0.19$), medium values ($0.20 < R^2 < 0.33$), and strong values ($R^2 > 0.33$). As a measure of the predictive power of the model, Q^2 value should be above zero. Values of f^2 are characterized as low values ($0.02 < f^2 < 0.15$), medium values ($0.16 < f^2 < 0.35$), and strong values ($f^2 > 0.35$). The results of mode fit assessment in Table 3 show that the current model fits the present data well as the explaining power of machine learning and expert systems is strong ($R^2 = 0.468$), Q^2 value is higher than zero ($Q^2 = 0.233$), the effect size of machine learning on patient satisfaction is medium ($f^2 = 0.162$), and the effect size of machine learning on patient satisfaction is medium ($f^2 = 0.204$).

4.3 Hypotheses testing

Using SmartPLS 3.0 software, the results of hypothesis testing as portrayed in Fig. 2 highlight a medium effect of machine learning on patient satisfaction (β = 0.384) and a medium effect of expert systems on patient satisfaction (β = 0.029).

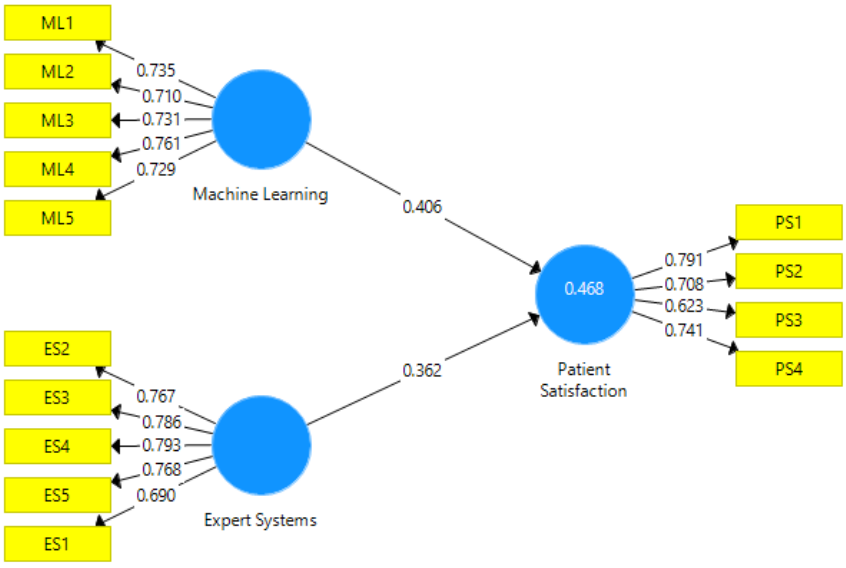

Fig. 2. Research structural model

The detailed results as shown in Table 3 indicate that patient satisfaction is significantly affected by machine learning (β = 0.406, t-value = 7.053, p-value = 0.000) and expert systems (β = 0.362, t-value = 6.44, p-value = 0.000). These results confirmed that the first hypothesis on the effect of machine learning on patient satisfaction and the second hypothesis on the effect of expert systems on patient satisfaction are supported. However, the results revealed that the effect of machine learning is higher than the effect of expert systems.

Table 3
Results of hypotheses testing

Independent variables	Path	Dependent variable	β	t-value	p-value	Result
Machine learning	→	Patient satisfaction	0.406	7.053	0	Supported
Expert systems	→	Patient satisfaction	0.362	6.44	0	Supported

* significant at significant level of 0.05.

5. Discussion and conclusion

The results pointed out that AI capability as measured by machine learning capability and expert systems capability exerts a significant effect on patient satisfaction in KSA. In fact, these results are in line with previous studies in which numerous advantages of AI capabilities, e.g., machine learning capability, were introduced including storing and analyzing digital medical records, making medical decisions, carrying out image analysis through analyzing unstructured data (Pallathadka et al., 2023; Beam & Kohane, 2018; Jarvis et al., 2020). Similarly, previous studies acknowledge the role of expert systems in searching for solutions via recognizing patterns in medical data, assisting physicians in doing effective diagnosis, and choosing treatment plans (Venkatasubramanian, 2019; Wahl et al., 2018; Yanase &Triantaphyllou, 2019).Consequently, AI technologies is positively related to improving patient satisfaction, lessening medical costs, enhancing workers' productivity, recovering medical online consultations and making medical decisions as well as detecting drugs interactions (Hazarika, 2020; Gupta & Kumari, 2017; Yanase &Triantaphyllou, 2019; Obermeyer & Emanuel, 2016; Kumar et al., 2022; Sogani, 2020). Hence, it was concluded that medical institutions can make their patients more satisfied through adopting AI capability in terms of machine learning and expert systems. Such a conclusion has several implications for both academics and practitioners.

6. Implications and limitations

Theoretically, the current study contributes to the literature on the impacts of artificial intelligence capability as it investigates the effect of AI capability, i.e., machine learning capability and expert systems capability, on patient satisfaction. Second, the study adds evidence on the positive effect of AI on patient satisfaction to participate in generalizing such an impact. Empirically, the study instructs decision makers in the Saudi healthcare industry that relying on AI capability represents another cornerstone in satisfying patients. However, the study is limited in terms of its theoretical framework as it considers two dimensions of AI capability. Furthermore, the study was carried out using a sample of medical staff participants because they

were informed about machine learning and expert systems applications in the healthcare industry. Therefore, further studies are required using more dimensions of AI capability and designing new instruments to reflect patients' opinions.

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