

**Assessing the Impact of Artificial Intelligence Applications on  
Diagnostic Accuracy in Saudi Arabian Healthcare: A Systematic  
Review**

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### Abstract

Artificial Intelligence (AI) has become a disruptive force with great potential to revolutionize healthcare. The integration of Artificial Intelligence in healthcare practices and its use in areas such as the detection and diagnosis of diseases has led to an increased interest in this topic and this has been key in informing this study research to determine its effect on diagnostic accuracy.

The study employed a structured and systematic search strategy in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. Three databases were used to identify the articles, including PubMed, Embase and CINAHL. The search for relevant articles linked to the impact of AI applications on diagnostic accuracy in the KSA healthcare sector was narrowed down to articles published between 2013 and 2023. This step generated 450 articles which were further evaluated based on the inclusion criteria of the study to narrow down to 12 articles for analysis.

11 out of 12 studies were conducted between 2020 and 2023 indicating that the last three years have witnessed the largest number of studies on artificial intelligence. The included studies were conducted in KSA and within different hospitals. The studies included 7 cross-sectional studies, 3 observational studies (1 retrospective study), 1 experimental study, and 1 randomized controlled trial (RCT). They all show that the use of AI has been increasing in healthcare, and its use is enhancing the overall healthcare outcomes and is helpful in a wide variety of diseases and conditions, including chronic diseases.

The models have shown that the use of AI is capable of enhancing diagnostics and treatment quality, which can be essential in planning for preventing care in line with Vision 2030. Hence, the findings of this systematic review contribute to a better understanding of the role of AI applications on diagnostic accuracy in Saudi Arabia's Healthcare and offer insights applicable to regions facing similar challenges.

**Keywords**

diagnostic imaging, diagnosis accuracy, machine learning, deep learning, medical diagnosis, healthcare policy.

**Aim and objectives**

This systematic review sought to address this gap by analyzing the effect of AI applications diagnostic accuracy in Saudi Arabia's healthcare. It was guided by the following main objectives;

- To Identify the artificial intelligence applications that have been evaluated for diagnostic accuracy in Saudi Arabia's healthcare.
- To determine the diagnostic accuracy of these applications in KSA healthcare.
- To identify the challenges and opportunities for using artificial intelligence to improve diagnostic accuracy in Saudi Arabia's healthcare.

**Introduction**

The healthcare landscape is rapidly evolving and just like any other sector of the global economy, Artificial Intelligence (AI) has become a disruptive force with great potential to revolutionize healthcare. Overall, the advancements in technology have had a positive effect on the overall healthcare sector and resulted in exponential development in this area in regards to, e.g. materials used, diagnosis, and treatment [1]. Hence, the integration of Artificial Intelligence in healthcare practices and its use in areas such as detection and diagnosis of diseases has led to an increased interest in this topic and this has been key in informing this study research to determine its effect on diagnostic accuracy.

Despite the high burden of diseases that countries are experiencing and the need to enhance accurate and timely diagnosis, there are multiple challenges that hinder the provision of optimal services to patients. The lack of resources, availability of skills and expertise, high costs, etc., can be overcome by investing an amount of time in the sector [2]. Progress has been made in Saudi Arabia to enhance these skills in line with Vision 2030, but the capacity is still lagging. As noted in the research by Zanella-Calzada et al. [3], the progress of diagnosis in many nations has always been a challenge as the whole process is complex and requires doctors and physicians to analyze comprehensive data, medical images, and history. However, innovation and technology have proven to play a critical role in trying to overcome this. The introduction of artificial intelligence in the healthcare setting has led to innovation in the diagnosis of patients, management, and prognosis of health-related conditions at a faster pace. The preliminary review has shown that AI has the potential to enhance diagnostic accuracy, help medical professionals reduce errors, and enhance efficiency and hence improving overall medical outcomes and hence has the potential to improve Saudi Arabia's healthcare meet the vision 2030. The KSA Vision 2030 has taken center stage in developing its healthcare sector, whereby it is seeking to transform the healthcare system into a comprehensive, effective, and integrated system. As noted by Alasiri & Mohammed [4], this enhanced system prioritizes innovation and disease prevention while enhancing access to quality care. Hence, the integration of AI in Saudi Arabia's healthcare might be key in enhancing the quality of care by improving diagnostic accuracy and, hence, transforming patient care and outcomes.

The advances in digital healthcare technologies, especially artificial intelligence, robotics, nanotechnology, 3D printing, etc., are shaping the healthcare system [5]. Digitizing healthcare facilities and the provision of services to patients present numerous opportunities for enhancing patient outcomes, tracking data over time, and reducing human errors. Several medical specialists are benefiting from the emerging advances in AI [5]. For instance, in medical physics and radiation ecology, healthcare providers are using AI to aid in auto-segmentation prognostic prediction and decision-making. In radiology, facilities can screen, stage, and restaging of cancer, hence supporting structured reporting, incidental findings, and detection of imaging protocol optimization [6]. Although they are efficient in healthcare, they are fragile, hence offering inappropriate answers. This is especially true when confronted with images that are outside the healthcare providers' knowledge set.

A broader range of medical diagnoses in the healthcare sector is based on analyzing diseases through high digital services. For instance, the application of AI in the assessment of medical images has resulted in accuracy in the evaluation of the images as it is performed automatically [5,6]. Determining the impact of artificial intelligence in healthcare is very critical. In healthcare, AI is widely used on various grounds for better functioning of healthcare facilities to improve patients' healthcare outcomes and also ensure that patients can access services at a lower cost [5]. As the healthcare system aims to improve the quality of services being offered to the patient and promote easy access to healthcare services, Saudi Arabia has highly adopted artificial intelligence.

Even though most of the technological innovations used in KSA, such as the use of AI to interpret medical images such as CT scans and MRI scans, the context of its use is very important. Saudi Arabia's healthcare sector presents unique challenges as well as opportunities for AI due to factors such as the effect of cultural and economic factors on the use and effectiveness of AI, which remains largely unexplored [7].

In research by Davenport & Kalakota [8], AI can perform as well as better than humans in diagnosing disease. The algorithm indicates that AI outperforms human diagnosis. In KSA, most of the studies undertaken have focused on specific diagnoses. It should also be noted that KSA has a unique and diverse population compared to other developed nations where the effect of AI on diagnosis has been conducted, such as Tsang et al. [9] in Europe and the United States and the study by Soellner, & Koenigstorfer [10] in Germany. Hence, by addressing this gap, this research sought to offer important insights to help the KSA healthcare policymakers and practitioners and also other regions in the Middle East.

The paper systematically evaluated the impact of the application of artificial intelligence on diagnosis accuracy in healthcare facilities. The systematic review sought to:

- To identify the artificial intelligence applications that have been evaluated for diagnostic accuracy in Saudi Arabia's healthcare.
- To determine the diagnostic accuracy of these applications in KSA healthcare.
- To identify the challenges and opportunities for using artificial intelligence to improve diagnostic accuracy in Saudi Arabia's healthcare.

## Methods

### Search strategies

The study employed a structured and systematic search strategy in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria [11]. In this case, the researcher adopted an integrated search strategy to cover an extensive automated search of various online databases, complementing a manual review of the selected articles. An automated search strategy ensures that the most fitting online sources are integrated into the study [12]. Three databases were used to identify the articles, including PubMed, Embase, and CINAHL, whereby appropriate filtering tools will be used in each database to restrict the search results to minimize duplication [13]. The search for relevant articles linked to the impact of AI applications on diagnostic accuracy in the KSA healthcare sector was narrowed down to articles published between 2013 and 2023, as shown in the PRISMA diagram. The investigation covered several keywords to get the articles, including; “artificial intelligence,” “AI,” “diagnostic imaging,” “diagnosis accuracy,” “diagnosis,” “machine learning,” “Saudi Arabia,” and “deep learning.” Also, it should be noted that AI is generally a broad-encompassing term and, hence, the need to include various AI techniques such as neural networks, NLP, vector machines, and decision trees.

For the manual review, the researcher will carry out a broad review, which entails reading the title of the study and the abstract and then skimming through the full content of the chosen articles to include relevant studies and exclude irrelevant studies [14]. Overall, the search of the articles was limited to studies that are in English and published within the last 10 years.

### Eligibility criteria

To ensure that the systematic review produces accurate, objective, and meaningful results by making sure all literature conceived is relevant to the study, an eligibility criterion was put in place as shown in Table below.

*Table 1: Eligibility*

Criteria	Inclusion	Exclusion	Rationale
Publication Type	Scholarly articles	Reports, newsletters, conference abstracts, commentaries, reviews and other sources	This will make sure that only information and data of academic level are retrieved.
Peer-reviewed	Peer-reviewed	Non-peer reviewed	This will make sure that the articles used for the review are of high quality.
Year of publication	Only articles published between 2013 and 2023	Articles published before 2013	To make sure that all content is valid. Technology is highly dynamic and 10 years is an appropriate period to give the researcher a good overview of the recent AI trends in healthcare.
Language	English Language	Arabic or any other language	English is the official language.

Randomized controlled trial, quasi-experimental study, or observational study, evaluate the impact of an AI application on diagnostic accuracy in a healthcare setting in Saudi Arabia and provide decision support to the healthcare providers. However, medical hardware devices such as ultrasound machines, surgery robots, and X-ray machines will be outside the scope of the study. If well established and executed, the eligibility criteria will help reduce any risk of bias or errors and ensure that relevant studies are included in the review, hence leading to consistent conclusions.

### **Data extraction and charting**

A data extraction form will be developed and divided into three main parts: a) Study characteristics relating to the author, year, study design, and participants; b) AI application characteristics, including application description, AI techniques, clinical tasks, and targeted diseases, c) study outcomes and key findings including the performance of the AI applications, Clinician outcomes, and patient outcomes. The form will help to facilitate analysis.

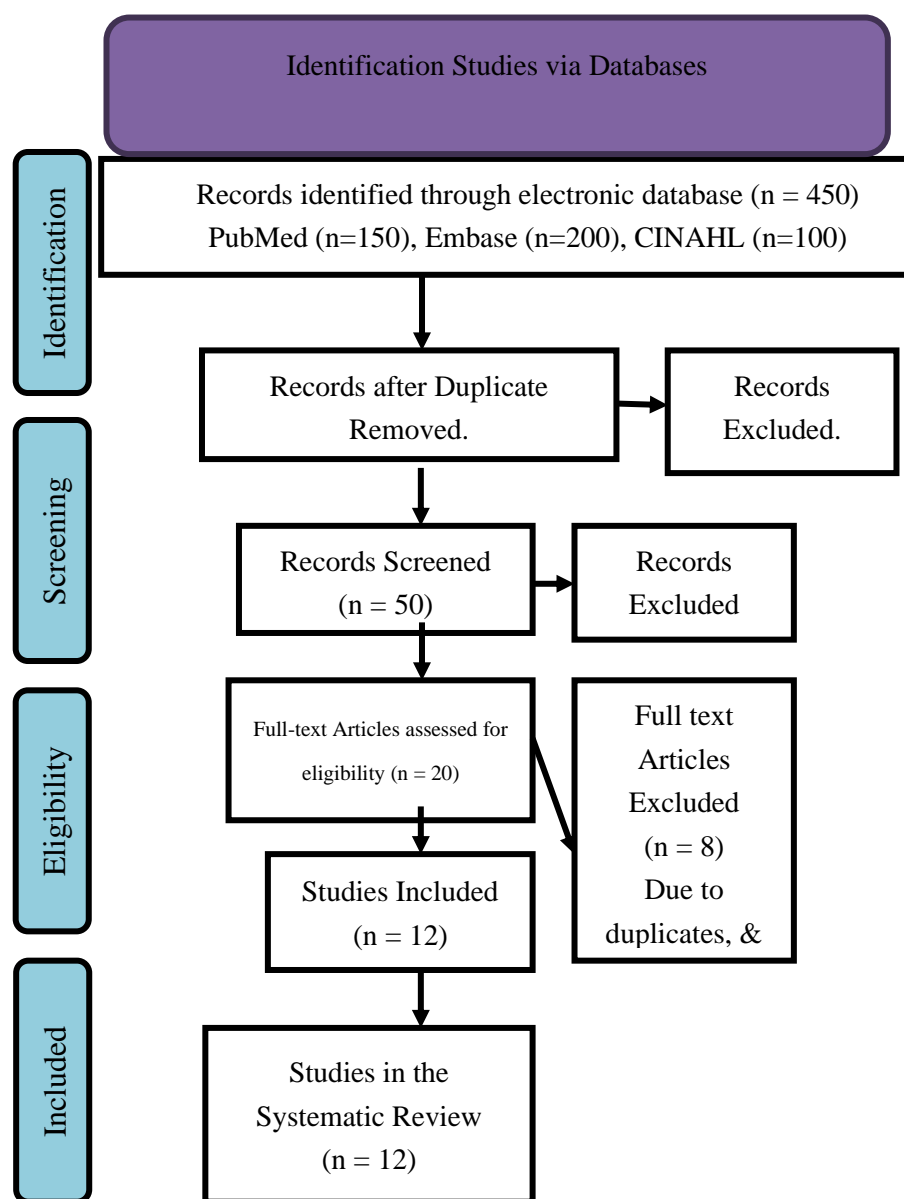
### **Data analysis**

The data from the retrieved articles will be analyzed using the narrative approach. This approach is a qualitative method of data analysis that entails the researcher identifying and interpreting all the Key Findings of the included research studies. To meet the objective of the study, the following research questions will be considered;

- What artificial intelligence applications have been evaluated for diagnostic accuracy in Saudi Arabia's healthcare?
- What is the diagnostic accuracy of these applications in KSA healthcare?
- What are the challenges and opportunities for using artificial intelligence to improve diagnostic accuracy in Saudi Arabia's healthcare?

## Results

Figure 1: PRISMA flow diagram based on PRISMA Guidelines



The initial search obtained a total of 450 articles from various PubMed, Embase and CINAHL databases. These articles were further evaluated based on the inclusion criteria of the study, whereby 400 duplicate records were excluded from the study. After that, 30 articles were excluded after assessing the articles based on the titles and the abstract contents. Hence, 20 articles remained and the researcher conducted a full-text assessment for eligibility, of which 8 articles were excluded and 12 articles included for the review, as shown in Figure 1 above:

### Study Characteristics

Table 2 below presents the characteristics of the reviewed studies, including the authors and year of publication, study design and the participants, and involved hospitals or countries. The analysis shows that most of the studies, 11 out of 12, were conducted between 2020 and

2023. This shows that the last three years have witnessed the largest number of studies on artificial intelligence, which is probably because it is during this period that AI has gained much interest in the health sector. The included studies were conducted in KSA and within different hospitals.

In regards to the study design, the 12 studies included 7 cross-sectional studies, 3 were observational studies (1 retrospective study), 1 experimental study and 1 randomised controlled trial (RCT). All the studies mentioned the participants or the sample characteristics ranging from healthcare professionals, involved hospitals or clinics and patients.

Table 2: Characteristics of the included studies

Author and year	Study design	Sample	Hospital /Country	Findings and outcomes
Barakat, A. A. R. (2022).	A cross-sectional study	309 ophthalmologists, and physicians involved in diabetic eye care	Saudi Arabia	79% of the respondents expect clinical efficiency to increase with the use of AI. 63% believe it will decrease the workforce of physician
Aldhafeeri, F. M. (2022).	online cross-sectional online survey	562 Saudi radiographers	Saudi Arabia	88.5% stated that AI would improve the accuracy of diagnosis. Challenges- high cost of equipment, inadequate knowledge, 'fear of losing employment, and concerns related to potential medical errors and cyber threats.
Alghamdi, S. A., &Alashban, Y. (2023).	a cross-sectional study	129 radiologists	Saudi Arabia	majority of the participants had a positive outlook 17.0% of participants indicated concern that AI will replace their jobs



Khafaji et al. (2022)	observational cross-sectional study	154 radiology residents	Saudi Arabia	53% stated that AI will increased accuracy and reduce reporting workload, while 28% expected an increase in workload.  42% anticipated that job positions would decrease
Senan et al. (2021)	Experimental	400 patients	Saudi Arabia	artificial intelligence techniques are of great importance in the early detection of Chronic kidney disease (CKD)
Syed, W., & Basil A. Al-Rawi, M. (2023).	A cross-sectional, questionnaire-based study	157 senior pharmacy students	College of Pharmacy, King Saud University.	More Than half believed AI was making healthcare professionals better.  75.1% agreed that AI reduces errors in medical practice.
Alelyani et al. (2021).	A cross-sectional, questionnaire-based study	714 radiology professionals	Saudi Arabia	65% felt that the use of AI made medical services more accurate.  89% of the participants thought that it would never replace radiologists.
Mirza et al. (2022)	cross-sectional study	98 radiology trainees	Saudi Arabia	Positive perceived effect of AI on radiology workflow and on the profession.  It was expected to improve the accuracy of diagnosis and treatment in the field of medical imaging.
Al-Hussain et al. (2022)	RCT	1409 patients with voice disorders	Saudi Arabia	most common technique used was least squares support vector machine with

				the highest accuracy, Quadric discriminant analysis achieved the lowest accuracy and K-nearest neighbor algorithm had the highest sensitivity
AlAkeely et al. (2021)	Observational	Diabetic Retinopathy (DR) patients	King Khaled Eye Specialist Hospital, Saudi Arabia	The automated fundus detector achieved an accuracy and recall of 99.20%. Classifier, it has achieved an accuracy of 68.19% and a recall of 39.54%
Taylan et al. (2023).	retrospective observational study	159 patients from family medicine and cardiology clinics at a university hospital in Saudi Arabia,	Saudi Arabia	ML approaches such as support vector regression (SVR), multivariate adaptive regression splines, the M5Tree model and neural networks were highly accurate in the detection of cardiovascular diseases (CVDs), showing their versatility and utility.
BinDhim et al. (2015)	cross-sectional study	Participants aged 18 and older	66 countries, including Saudi Arabia	Smartphone apps used as screening tools for depression increase accuracy

## Quality Assessment

The study quality was done by use of the PROBAST, given that the main aim was to understand the quality of the prediction accuracy. This is based on four main domains, including the participant's domain, predictor's domain, outcome domain, and analysis domain, as shown in Table 3 below. All 12 studies had a clearly defined study population, as shown in the Table above, showing that the results can be generalized in KSA. Overall, the analysis shows that the quality of the reviewed studies was mixed, whereby some studies may have a higher risk of bias compared to others. From the analysis, 10 studies had a population that was representative of the target population, 8 studies were adequately controlled, and 9 of the studies reported model performance more transparently. Overall, the PROBAST analysis suggests that overall evidence based on AI role in diagnostic accuracy in KSA is relatively weak but some of the studies such as [15,16,6,17,18,19,20,21] were promising as they showed a lower risk of bias. On the other hand, BinDhim's[22]study did not meet the criteria for the predictor's outcome domain and analysis as it was majorly a feasibility study. However, when it comes to the overall rating of the four domains, a review of all the articles shows a relatively high rating, which means that the evidence provided in the articles reviewed is strong that AI can be used to improve diagnostic accuracy in KSA healthcare.

Table 3: PROBAST

Domain	Rating	Explanation
Participant domain	High	All the studies included in the review included a representative sample of patients from the target population mainly including professionals such as radiologists, radiographers, ophthalmologists, and physicians.
Predictor domain	High	The AI applications were well-defined and reproducible.
Outcome domain	High	The studies measured clinically relevant outcomes using standardized methods.
Analysis Domain	High	The studies used appropriate statistical methods to analyze the data.

## Artificial intelligence Methods Used in Studies and diagnostic accuracy

The analysis of studies showed a number of artificial intelligence as well as machine learning methods were analyzed in different studies to understand how they affect diagnostic accuracy in KSA. Taylan [21] also studied support vector regression (SVR), multivariate adaptive regression splines, the M5Tree model and neural networks. The least squares support vector, Quadric discriminant analysis and K-nearest neighbor algorithm were studied by Al-Hussain [20]. The deep learning technique was used by Barakat [15], and Logistic regression & ROC analysis was used by Senan [18], and Taylan [21]. Overall, these studies considered different sets of features or predictors, including the demographics of the patients, their disease history and body measurements, medications, procedures and health service use.

Most of the studies applied AI methods either for prediction purposes or diagnostic purposes and although many of the studies did not compare the different AI techniques except for a few, such as AlAkeely et al. [23], which showed that automated fundus detector achieved accuracy and recall of 99.20% and classifier achieved an accuracy of 68.19% and recall of 39.54% while Al-Hussain[20] stated that most common technique used was least squares support vector machine with the highest accuracy, Quadric discriminant analysis achieved the lowest accuracy and K-nearest neighbor algorithm had the highest sensitivity. Overall, most of the studies showed that the AI models and ML techniques achieved high diagnostic accuracy of more than 50%. Studies by Senan [18], Barakat[15], Al-Hussain[20] and AlAkeely[23] showed that most of the techniques had high diagnostic accuracy of more than 90%. This shows that AI has great potential for higher diagnostic accuracy in medical conditions such as chronic kidney disease, cancer and diabetes.

## Discussion

This section of the study discusses the results based on the reviewed literature. The discussion is provided to answer the research questions guiding this study. It concludes by providing the study implications.

### **What artificial intelligence applications have been evaluated for diagnostic accuracy in Saudi Arabia's healthcare?**

The reviewed research studies conducted in KSA in the last 10 years show that there has been a wide range of AI applications that are used to enhance diagnostic accuracy in the nation. Based on the reviewed literature, some of the common AI applications in the nation include The reviewed studies show that a wide range of AI applications has been evaluated for diagnostic accuracy in healthcare in Saudi Arabia, including medical & diagnostic imaging analysis tools[15,6,17], AI-based systems used to detect and diagnose diabetes, chronic kidney disease, and other metabolic disorders [6,23,16,18], AI-powered voice analysis tools[20], AI-based systems for early prediction and classification of diseases [21], AI-driven mental health apps and chatbots [22], AI-based systems for detection and classification of diseases such as such as cardiovascular diseases (CVDs), e.g. Natural Language Processing (NLP)[21].

These results show that the Health Sector in KSA is using a wide range of AI applications, whereby most of the AI applications appeared to be in areas such as radiology for Chronic Kidney Disease and diabetes and medical imaging and prediction of diseases such as cardiovascular diseases (CVDs). The AI uses machine learning models to simulate the human intellect and is usually based on statistical analysis of past data. As noted by Zanella-Calzada et al. [3], the introduction of AI in healthcare, major fundamental shifts have been witnessed in healthcare by the application of automatic diagnosis, predictive measurements, and diagnostic tools, as seen in the reviewed literature. The analysis shows that all aspects of modern AI technology are applied in KSA healthcare for diagnosis, replacing the more traditional methods. Therefore, the analysis has shown that the AI applications in KSA range from medical imaging analysis, such as radiology, which is used to analyze X-rays, CT scans, and MRIs, used in disease diagnosis and risk prediction, such as in heart disease and diabetes and natural language processing and even in mental wellbeing.

### **What is the diagnostic accuracy of these applications in KSA healthcare?**

Being able to make earlier diagnoses of diseases is one of the most important aims of modern healthcare if they are to be managed well and without much cost. As noted by Chang et al. [24], early detection of any disease, especially chronic diseases, reduces the burden of the disease and the need for other complex treatment procedures that enhance the outcome of the treatment. The review of the studies shows that even though many of the AI applications in KSA are new developments, they have demonstrated great performance in their diagnostic accuracy, although this might vary depending on factors such as clinical experience. The findings showed most of the AI used achieved an accuracy of more than 90%. The study by AlAkeely et al. [23] showed that an automated fundus detector achieved an accuracy and recall of 99.20%, Senan et al. [18] found that an AI-based system was able to diagnose chronic kidney disease with an accuracy of 98.5%. This is significantly higher than the accuracy of human experts, who can achieve accuracy rates of around 70-80% for chronic kidney disease diagnosis. Another study by Taylan et al. [21] found that an AI-based system was able to predict the risk of developing cardiovascular disease with an accuracy of 85%. This is significantly higher than the accuracy of human experts, who can achieve accuracy rates of around 60-70% for cardiovascular disease risk prediction. Aldhafeeri [25] showed that an AI-powered system for breast cancer detection achieved a diagnostic accuracy of 95%, and Al-Hussain et al. [20] showed an accuracy of 92%. All these results showed promising diagnostic accuracy for the use of AI in KSA. These findings are consistent with the results of studies in other parts of the world. For example, they agree with studies such as [24]and [26], which showed that AI technologies in areas such as Dentistry have shown great performance in areas such as tooth detection, diagnosing, and predicting oral cancer and tumors. The study by Zanella-Calzada et al. [3] showed that most of the AI models had an accuracy of more than 0.69 in classifying individuals based on type of disease. Overall, all these studies show that AI is a very promising technology when it comes to enhancing diagnostic accuracy in the healthcare sector. However, it is important to consider different factors such as their specific application, the hospital settings, the clinicians' experience, and the dataset quality.

### **What are the challenges and opportunities for using artificial intelligence to improve diagnostic accuracy in Saudi Arabia's' healthcare?**

Overall, despite the promising results of the AI applications in KSA, the analysis also shows that there are some challenges that need to be addressed if the technology is to achieve the intended objective. The studies by Barakat[15], Aldhafeeri [25], Alghamdi & Alashban[16], and Khafaji et al. [6] showed that many physicians fear their jobs being replaced by AI Applications. Barakat [15] noted that 63% believe it will decrease the workforce of the physician, Alghamdi, &Alashban, [16] indicated that 17.0% of participants indicated concern that AI will replace their jobs, Khafaji et al. [6]stated that 42% anticipated that job positions will decrease and 28% expected an increase in workload. These findings align with the findings of researchers such as Tursunbayeva, &Renkema, [27], who noted that the jobs of many people might be at risk due to changes in job design and job demands, while Federspiel et al. [28] state that, while AI offers important solutions in healthcare it might render human labor increasingly obsolescent.

Other challenges in KSA due to AI, as listed by Aldhafeeri [25] include high cost of equipment, inadequate knowledge, fear of losing employment, and concerns related to potential medical errors and cyber threats. Despite these challenges, the analysis shows there are several opportunities for using AI to enhance diagnostic accuracy in KSA. As the nation seeks to enhance and improve the healthcare sector in line with Vision 2030, AI can help address the shortage of healthcare professionals and improve the quality of care outcomes by offering decision support [29] and improving the quality and accessibility of the healthcare professionals by making it easier to offer accurate and timely diagnoses to patients in remote areas.

#### **Conclusion**

From the analysis, it is evident that Artificial Intelligence models have been widely explored for diagnosis of different diseases globally and many of the studies have shown that the models are able to achieve higher accuracy levels. In KSA, the analysis shows that the use of AI has been increasing in healthcare and its use is enhancing the overall healthcare outcomes and is helpful in a wide variety of diseases and conditions, including chronic diseases. The models have shown that the use of AI is capable of enhancing diagnostics and treatment quality, which can be essential in planning for preventing care in line with Vision 2030. Even though there have been some challenges, such as fear of loss of jobs and issues related to security and costs, KSA is on the right pathway as the government invests in technology to improve healthcare, which has been found to have great potential to significantly improve diagnostic accuracy.

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