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Artificial Intelligence in Dental Radiology: Review of the Impacts on Diagnostic Accuracy and Nursing Practices

Misfer Hussein Misfer Qahman[1], Raiyyah Abdulhdi Almowallad[2], Raniah Mohammed Rashed Alluqmani[3], Rana Mohammed Rashed Alluqmani[4], Rehab Saud Alghamdi[5], Bandar Abdulaziz Tharban Al-Otaibi[6], Abdullah Hussain Hassan Alshahrani[7], Samer Mohammed Alghamdi[8]

Abstract

The use of artificial intelligence (AI) in dental radiography is revolutionizing diagnostic methodologies and nursing responsibilities within the healthcare domain. As AI technologies progress, comprehending their influence on diagnostic precision and nursing practices is crucial for future education and clinical implementation.A thorough literature analysis was performed, using papers from databases including PubMed, Scopus, and Google Scholar till 2023. The review concentrated on assessing the knowledge, attitudes, and competencies of healthcare, dental, and nursing students concerning AI applications in dental radiology.The findings indicated that most of studies exhibited a moderate to strong comprehension of AI, accompanied by notable deficiencies in practical knowledge and skills. Although 65% exhibited favorable attitudes towards AI implementation in clinical environments, apprehensions regarding dehumanization and job displacement were widespread, particularly among students from disadvantaged areas. The majority of participants supported the incorporation of AI education into healthcare courses to improve comprehension and practical implementation.AI offers both advantages and obstacles in dental radiology, requiring a targeted educational strategy to prepare future healthcare practitioners with essential competencies. A curriculum that prioritizes practical applications, ethical considerations, and the collaborative function of AI in augmenting human capabilities is essential. Longitudinal studies are advised to track alterations in knowledge and attitudes following graduation and to evaluate the efficacy of AI training in enhancing clinical outcomes.

Keywords: *Artificial Intelligence, Dental Radiology, Nursing Education, Diagnostic Accuracy, Healthcare Training.*

Introduction

The phrase "artificial intelligence (AI)" became prevalent around 70 years ago to describe the utilization of computers to replicate human thinking. The first use of AI occurred in mathematics in 1956 when it was employed for theorem proving [1,2]. The integration of AI in healthcare was a lengthy process that started with the creation of a computer program that advised physicians on suitable antibiotic medication [3].

Artificial intelligence is a prominent subject in the front of technological progress and has the capacity to substantially impact the healthcare sector. The term AI denotes a scientific and technical field focused on creating computer systems that demonstrate intelligent behavior and can comprehend and replicate human cognitive processes [4-6]. Recent breakthroughs in computer and bioinformatics innovations have facilitated the integration of AI technologies, including machine learning as well as deep learning, into medical computer systems [7- 9]. Artificial intelligence has been thoroughly incorporated into systems for decision support (DSSs) within data-intensive medical fields such as pathology, radiology as well as ophthalmology [10].

Numerous specialists have articulated their perspectives on the prospects of radiology considering the advent of AI [11, 12]. Radiological organizations have issued white papers advocating their perspectives

[1] Ksa, Ministry of Health, Irada Complex for Mental Health
[2] Ksa, Ministry of Health, King Fahad General Hospital.
[3] Ksa, Ministry of Health, Primary Health Care Alsafa 1.
[4] Ksa, Ministry of Health, Primary Health Care Alrehab.
[5] Ksa, Ministry of Health, Primary Health Care Alsafa 1
[6] Ksa, Ministry of Health, Al-Dawadmi General Hospital Health Assistant
[7] Ksa, Ministry of Health, Wadi Bin Hashbal Sector Khyber South Health Center
[8] Ksa, Ministry of Health, Dental Department, Al-Lith General Hospital, Jeddah

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[13, 14]. Research has shown that medical learners do not exhibit much apprehension or anxiety over potential replacement by AI in their chosen profession [15]. Some students may suffer worry over the potential displacement by AI, which might deter them from pursuing certain medical specialty [16]. There are both advantageous and disadvantageous viewpoints about the influence of AI on everyday human existence. Pessimistic perspectives indicate that AI might replace humans across several industries. Conversely, optimistic perspectives emphasize that persons aided by AI will possess enhanced possibilities to capitalize on future developments [17-23]. This research sought to assess the views, understanding, and abilities of healthcare, dentistry, and nursing students on AI, as well as to collect their perspectives on its use.

Methodology

A thorough literature search was conducted till 2023 to gather relevant papers from the Scopus, PubMed/MEDLINE, as well as Google Scholar libraries.

The Understanding of AI Concepts and Applications

In all, 44 percent of learners demonstrated a moderate to strong understanding of AI concepts and applications. Knowledge included theoretical comprehension of AI techniques, practical skills for implementing AI systems, as well as programming expertise. Nonetheless, the bulk of pupils have a limited understanding of AI. This knowledge deficiency indicates an immediate need to include extensive AI instruction in healthcare curriculum. Research indicates that pupils endorse this concept [24-34]. Curricula must include fundamental ideas such as machine learning as well as neural networks, with practical abilities in using AI technologies for applications such as diagnostic imaging analysis. Practical practical learning using real-world case studies may be very successful. A significant hurdle to the use of AI is the lack of knowledge. Students from rich countries exhibited a superior understanding of AI compared to their counterparts in underdeveloped ones. This is being demonstrated in another research as well [35]. This disparity underscores alarming worldwide digital disparities in obtaining AI skills training. Strategic investments and capacity-building initiatives are essential for enabling students globally to acquire applied AI skills.

Despite their varying levels of understanding, sixty-five percent of learners expressed favorable opinions towards the use of AI in educational and clinical settings. Previous research have also shown that the majority of healthcare students had a positive mindset regarding AI [19, 36-39]. Students acknowledged the prospective advantages of AI in augmenting diagnostic precision, boosting healthcare accessibility, and alleviating clinical burdens. Conversely, there are unfavorable impressions as well [36, 40, 41].

Attitudinal variables exhibited significant variation, indicating varying perspectives across student groupings. Students from impoverished nations exhibited more skepticism, apprehensive that AI may dehumanize care or eliminate healthcare employment opportunities. Curricula must confront these legitimate ethical and social issues by examining artificial intelligence prejudice, honesty, and effects on healthcare professions. Patient autonomy and confidentiality, informed consent, openness, equality, and biases are significant considerations. Enhancing attitudinal metrics via more detailed subgroups and investigating determinants of AI adoption will better guide tailored educational programs addressing students' particular concerns [42].

Students exhibited excitement and confidence regarding AI's potential in medicine; nevertheless, most lacked significant experience and practical skills in using AI technology. The same trend is seen in other disciplines as well [43]. Research conducted by Busch et al. with 387 pharmacy students across 12 countries revealed that 58% of the participants had favorable views regarding AI in medicine, but 63% indicated a limited general understanding of AI [44]. Addressing these attitude-knowledge disparities is a significant barrier for AI preparedness. Curricula must not alone provide technical information but also include values, ethics, and social implications. Education should prioritize AI as a cooperative instrument to enhance human talents instead of substituting them. Once again, allowing students to actually experience the advantages of AI in care quality might demonstrate its capacity to augment labor rather than displace

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employees. Moreover, equal admission to AI upgrading is essential, especially for students from underprivileged areas who may possess increased apprehensions about the hazards of AI.

Utilization of Artificial Intelligence in Dentistry

The diagnostic reasoning for a specific illness relies on a clinician's evaluation of signs, diagnostic test outcomes, and other criteria, which are susceptible to the clinician's flawed recall and cognitive biases. When trained on tens of thousands of instances, AI exceeds the clinical expertise of even the most skilled specialists [45]. Machine learning methods, such as Support Vector Machines, Artificial Neural Networks, Random Forests, and k-nearest-neighbor methods, were empirically examined for their efficacy in detecting cysts, benign malignancies, mouth cancer, as well as lymph node metastases. Utilizing meticulously designed characteristics in cone beam computerized tomography (CBCT), SVM achieved 94% accuracy in distinguishing periapical lesions from keratocystic odontogenic cancers [46]. A risk classification system using brush sample as well as cytology was developed employing machine learning methods, including support vector machines and random forests. This model used CNN to evaluate the tumor of cytology pictures obtained from a telehealth system, demonstrating significant sensitivity in identifying oral cancerous (93 percent) and high-grade prospective cancerous (73 percent) tumors [47]. Notwithstanding these commendable outcomes, current AI models for diagnosing dental and maxillofacial surgery concentrate just on a singular form of data, including radiographic findings or cytopathologic pictures. Models that include extensive medical data about an individual are necessary for precise diagnosis.

Deep learning with convolutional neural networks has emerged as the primary artificial intelligence tool for automatic lesion segmentation in cariology as well as endodontic diagnosis. The segmentation procedure partitions radiographs or pictures into distinct nonoverlapping parts based on certain criteria, such as pixel similarity or inherent characteristics, to transform them into a format that facilitates analysis [48]. Utilizing an architecture consisting of encode (U-Net), deep learning split CBCT voxels into categories of "lesion," "tooth framework," "bone," "therapeutic substances," and "background," attaining findings equivalent to doctors in the diagnosis of periapical tumors [49]. By concentrating on the binary existence or nonexistence of lesions, deep learning detected proximate serious lesions from near-infrared illumination pictures, achieving an area underneath the recipient's operating feature curve of 0.856 [50, 51]. Volumetric assessment in CBCT, subsequent to DL-based segmentation, was shown to be similar to the outcomes derived from manually dividing of periapical tumors [52]. This study does not publish findings like the standard variation of lesions as well as the junction over Union measure. This omission undermines the dependability of the findings.

Periodontal illness is a multifaceted inflammatory condition influenced by several causative variables that operate concurrently and interactively. In the context of periapical radiographs, the CNN attained accuracies of 81.0% and 76.7% in detecting periodontally deficient premolars and molars, respectively [53]. Nonetheless, owing to the repeatability of scanning attributes and the visual scope of periapical images, this method is incapable of differentiating incipient lesions or rendering an accurate identification of periodontal illness. Decision Trees (DT) and Support Vector Machines (SVM) effectively classified healthy periodontium, gingivitis, persistent periodontal disease, as well as aggressive periodontitis by including a patient's medical history, clinical data, and radiographic images. While the immunologic replies and microbial diversity associated with the etiology of periodontitis remain inadequately understood, AI-based classifiers—specifically a multilayer perceptron neural networks (a type of feedforward artificial neural network) concentrating on leukocytes, interleukins, as well as IgG antibody titers, alongside a support vector machine emphasizing relative bacterial load—demonstrated efficacy in differentiating rough from persistent periodontal disease [54]. AI not only enhances our comprehension of periodontitis but also facilitates the integration of traditional indications with immunological and microbiological data in periodontal diagnostics.

Clinical indicators derived from a patient's complaints and medical history are crucial for identifying disorders of the temporomandibular joint (TMDs). The processing of natural languages is a technique that converts human language into organized programming language. A model based on natural language processing effectively distinguished TMD-mimicking symptoms from genuine TMDs by analyzing the

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frequency of word use in the patient's major complaint and the amount of mouth opening [55]. Artificial neural networks using cone-beam computed tomography demonstrated a 91.2% concordance with physician agreement in the classification of condylar structure [56]. Integrating patients' primary concerns, clinical as well as biochemical measures, and quantitative radiomic characteristics into training datasets, together with the collection of higher sample sizes, necessitates the development of a computer-assisted diagnostic system to enhance the accuracy of TMD diagnoses.

A knowledge-based system has been created to identify clearly identifiable cephalometric landmarks. The method demonstrated a mean inaccuracy of just 2.01 mm across all 20 evaluated landmarks [57]. Diagnostic modeling of cephalometric lateral scans was developed employing machine learning methods, including artificial neural networks, support vector machines, random forests, and decision trees, to assess cervical vertebral development. Among the evaluated machine learning methods, artificial neural networks (ANN) yielded the most favorable outcomes in categorizing cervical vertebral maturation stages, whereas decision trees (DT) excelled in vertebral body form classification [58]. In the future, hybrid methodologies integrating knowledge-based algorithms and machine learning are expected to provide more precise and accurate computerized cephalometric analysis.

Concentrating on the proliferation of inflammatory cytokine genes, ANN, SVM, and RF effectively differentiated lichen planus of the mouth from various white diseases of the oral cavity [58]. In the context of identifying steatosis (i.e., abnormal lipid accumulation) in salivary gland parenchyma by ultrasonography, artificial neural networks (ANN) outperformed novice radiologists in distinguishing patients with authentic Sjögren's disease from individuals with xerostomia [59].

The robustness of our analysis lies in the examination of publications from three extensive databases: Scopus, PubMed, as well as Google Scholar. Furthermore, we utilized the model of random effects to ascertain the reliability of the findings. Furthermore, our research has several limitations. We included solely studies published in English. Furthermore, the majority of the studies employed proprietary questionnaires to assess participants' knowledge and attitudes regarding artificial intelligence. Ultimately, it is essential to note that insufficient studies were available to derive skill outcomes and conduct a meta-analysis.

Prospective Avenues for Study

Future studies should examine the long-term understanding and behavioral developments of student's post-graduation. Longitudinal data monitoring cohorts of learners in practice might provide critical insights to inform ongoing learning and methods for managing change.

Subsequent research should evaluate the longevity of machine learning abilities development. Can singular instruction provide enduring abilities, or is continuous reinforcement necessary? Comparative analyses of various pedagogical methodologies for AI education may reveal optimal practices. Future research must critically assess the connections between AI education and tangible improvements in healthcare procedures and patient outcomes. Exhibiting advantages to care quality is the most compelling motivation for curricular modification.

Summary

The use of artificial intelligence (AI) in dental radiography is transforming diagnostic methods and nursing responsibilities in healthcare. This thorough evaluation underscores the need of improving educational frameworks to properly integrate AI technology into dentistry and nursing curriculum. The results demonstrate that while a substantial number of students have a basic comprehension of AI, there are severe shortcomings in practical abilities and knowledge application. This disparity highlights the pressing need for educational institutions to emphasize AI training, concentrating on both theoretical principles and practical applications.

The favorable sentiments shown by most students on AI suggest a willingness to use these technologies in clinical environments. Nonetheless, concerns about job displacement and the possible dehumanization of

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medical care persist, especially among students from economically poor families. Addressing these issues is crucial for cultivating a supportive learning environment that promotes the ethical use of AI in clinical practice.

Future research needs to concentrate on longitudinal studies to monitor shifts in knowledge and attitudes among healthcare professionals as AI becomes more integrated into practice. Furthermore, assessing the efficacy of AI training on clinical outcomes will provide significant insights for curriculum improvement. By providing students with a comprehensive awareness of AI's potential and ethical considerations, the healthcare industry can augment diagnostic precision and increase patient care. A collaborative strategy that integrates the advantages of AI with human experience is essential for progressing in dental radiology and maintaining optimal patient care standards.

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الذكاء الاصطناعي في التصوير الشعاعي للأسنان: مراجعة الآثار على دقة التشخيص وممارسات التمريض

الملخص الخلفية :استخدام الذكاء الاصطناعي (AI) في التصوير الشعاعي للأسنان يغير بشكل جذري منهجيات التشخيص ومسؤوليات التمريض ضمن المجال الصحي. مع تقدم تقنيات الذكاء الاصطناعي، فهم تأثيرها على دقة التشخيص وممارسات التمريض ضروري للتعليم المستقبلي والتنفيذ السريري.

الأساليب :تم إجراء تحليل شامل للأدبيات باستخدام أوراق من قواعد البيانات مثل PubMed و Scopusو Google Scholarحتى عام 2023. ركزت المراجعة على تقييم المعرفة والمواقف والكفاءات لدى طلاب الرعاية الصحية وطب الأسنان والتمريض فيما يتعلق بتطبيقات الذكاء الاصطناعي في التصوير الشعاعي للأسنان.

النتائج :أظهرت النتائج أن معظم الدراسات أظهرت فهمًا متوسطًا إلى قويًا للذكاء الاصطناعي، مع نقص كبير في المعرفة العملية والمهارات. رغم أن 65% أبدوا مواقف إيجابية تجاه تطبيق الذكاء الاصطناعي في البيئات السريرية، كانت هناك مخاوف واسعة النطاق بشأن فقدان الجانب الإنساني وفقدان الوظائف، خاصة بين الطلاب من المناطق المحرومة. أيدت الأغلبية دمج تعليم الذكاء الاصطناعي في الدورات الصحية لتحسين الفهم والتطبيق العملي.

الخلاصة :يقدم الذكاء الاصطناعي كل من الفوائد والتحديات في التصوير الشعاعي للأسنان، مما يتطلب استراتيجية تعليمية مستهدفة لإعداد ممارسي الرعاية الصحية المستقبليين بالكفاءات الضرورية. المنهج الذي يعطي الأولوية للتطبيقات العملية، والاعتبارات الأخلاقية، والدور التعاوني للذكاء الاصطناعي في تعزيز القدرات البشرية أمر ضروري. يُنصح بإجراء دراسات طولية لتتبع التغييرات في المعرفة والمواقف بعد التخرج وتقييم فعالية تدريب الذكاء الاصطناعي في تحسين النتائج السريرية.

الكلمات المفتاحية :الذكاء الاصطناعي، التصوير الشعاعي للأسنان، تعليم التمريض، دقة التشخيص، تدريب الرعاية الصحية.