Automated diagnosis and treatment planning in dentistry

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Abstract---This study aims to investigate the perceptions and experiences regarding automated diagnosis and treatment planning in dentistry. The field of automated diagnosis and treatment planning is rapidly evolving, leveraging advanced technologies such as artificial intelligence (AI) and machine learning to enhance patient care and outcomes. However, there is a need to understand the perspectives of dental professionals regarding the adoption and implementation of these automated systems. A questionnaire survey was conducted among 100 dentists from various dental practices to gather data on their familiarity, usage, and perceptions of automated diagnosis and

treatment planning. The survey also explored the perceived benefits, challenges, and future implications of automated systems in dental care. Preliminary findings indicate that the majority of dentists in the sample (80%) have some level of familiarity with automated diagnosis and treatment planning. However, only 45% reported actively using such systems in their practice. Among the dentists using automated systems, the most commonly cited benefits include time-saving (60%), enhanced accuracy (55%), and improved treatment planning (50%). Challenges associated with the adoption of automated systems were also identified. Data privacy and security concerns were raised by 65% of the participants, highlighting the importance of safeguarding patient information in the implementation of automated diagnosis and treatment planning. Additionally, 40% of dentists expressed concerns about the initial financial investment required to adopt these systems. The results of this study provide insights into the perceptions and experiences of dentists regarding automated diagnosis and treatment planning in dentistry. These findings can inform further research and assist in the development of guidelines and recommendations for the successful integration and implementation of automated systems in dental practice. Future studies could explore the experiences and perspectives of patients in utilizing automated systems and their impact on patient satisfaction and treatment outcomes.

Keywords---Automated Diagnosis, Treatment, Planning, Dentistry.

Introduction

Automated diagnosis and treatment planning in dentistry has gained significant attention in recent years due to the rapid advancements in artificial intelligence (AI) and machine learning (ML) technologies. These automated systems offer the potential to revolutionize the field by improving diagnostic accuracy, optimizing treatment planning, and enhancing overall patient care. By leveraging AI algorithms and analyzing large datasets, dental professionals can benefit from more precise and efficient decision-making processes. This paper provides an in-depth exploration of the concept of automated diagnosis and treatment planning in dentistry, highlighting its potential benefits and discussing the challenges associated with its implementation.

In dental practice, accurate diagnosis and effective treatment planning are crucial for achieving successful outcomes. Traditionally, dental professionals relied on their clinical experience, knowledge, and subjective interpretation of patient data to make diagnostic and treatment decisions. However, this manual approach is prone to human error, subjectivity, and variability among practitioners. The emergence of automated systems in dentistry offers a promising solution to these challenges by leveraging AI and ML technologies to enhance the diagnostic process and treatment planning. These automated systems can process vast amounts of patient data, including clinical records, radiographic images, and genetic information, and apply advanced algorithms to analyze and interpret this information objectively and efficiently (Alhazmi et al., 2019).

The potential benefits of automated diagnosis and treatment planning in dentistry are manifold. Firstly, these systems can significantly improve diagnostic accuracy. By analyzing complex datasets and identifying subtle abnormalities, automated systems can assist dental professionals in detecting oral health conditions at an early stage, leading to timely interventions and improved patient outcomes. Secondly, automated treatment planning can optimize the decision-making process by considering patient-specific factors, such as medical history, anatomical variations, and treatment preferences. This personalized approach ensures that treatment recommendations align with the individual needs of each patient, resulting in more effective and efficient treatment outcomes. Additionally, automated systems can leverage predictive analytics to provide insights into treatment success rates, potential complications, and alternative treatment options, enabling dentists to make evidence-based decisions and enhance patient communication and education (Estai et al., 2018; Patel et al., 2021).

However, the implementation of automated diagnosis and treatment planning in dentistry also presents challenges that need to be addressed. One of the major concerns is ensuring patient privacy and data security. As automated systems rely on the analysis of sensitive patient information, including medical records and images, it is crucial to establish robust data protection measures, comply with privacy regulations, and ensure secure storage and transmission of data. Moreover, gaining acceptance and trust from dental professionals is essential for the successful integration of these technologies into daily practice. Adequate training and education programs should be provided to dental professionals to enhance their understanding of AI and ML concepts, address ethical considerations, and promote professional engagement (Willems et al., 2018).

Dental Diagnosis and Treatment Planning

Dental diagnosis involves the identification and assessment of oral health conditions, while treatment planning refers to the formulation of an appropriate treatment strategy based on the diagnosed condition. Traditionally, these processes heavily relied on the expertise and experience of dental professionals, involving manual examination, patient history analysis, and radiographic interpretations. However, this manual approach may be time-consuming, subjective, and susceptible to human error (Alhazmi et al., 2019; Willems et al., 2018).

Emergence of Automated Systems

The integration of AI and ML technologies in dentistry has opened up new possibilities for automated diagnosis and treatment planning. These systems are designed to analyze large volumes of patient data, including clinical records, radiographic images, and genetic information. By leveraging advanced algorithms, automated systems can identify patterns, detect anomalies, and provide accurate and efficient assessments. This allows dental professionals to make more informed decisions, leading to improved patient outcomes (Gani et al., 2020).

Significance of the Study

The study on automated diagnosis and treatment planning in dentistry holds significant importance in revolutionizing the field of oral healthcare. By leveraging advanced technologies such as artificial intelligence (AI) and machine learning (ML), this study addresses the need for more accurate, efficient, and objective diagnostic and treatment processes. The significance of this study can be highlighted in several aspects that contribute to improving patient care and outcomes.

First and foremost, the development and implementation of automated systems in dentistry have the potential to significantly enhance diagnostic accuracy. Human clinicians, while highly skilled and knowledgeable, may overlook subtle abnormalities or patterns in patient data due to various factors such as subjectivity and variability among practitioners. Automated systems, on the other hand, can analyze large volumes of patient data and apply sophisticated algorithms to detect even the most minute oral health conditions. This early detection leads to timely interventions, preventing the progression of diseases and ultimately improving patient outcomes.

Furthermore, automated diagnosis and treatment planning systems assist dental professionals in formulating optimal treatment strategies. By considering patient-specific factors such as medical history, anatomical variations, and treatment preferences, these systems generate personalized treatment recommendations. This ensures that the chosen course of action aligns with the individual needs of each patient, leading to more effective and efficient treatment outcomes. The ability to tailor treatments to specific patients enhances patient satisfaction and contributes to better overall oral healthcare.

In addition to improving accuracy and treatment planning, automated systems offer significant time and resource efficiency benefits. Dental professionals often face time constraints in their daily practice, and manual processes can be time-consuming. Automated systems streamline and automate tasks such as data analysis and interpretation, enabling dental practitioners to focus more on patient care and clinical decision-making. By eliminating the need for manual data processing, dental professionals can allocate their time and resources more efficiently, leading to improved productivity and patient throughput.

Moreover, automated diagnosis and treatment planning systems facilitate evidence-based decision-making. These systems can leverage predictive analytics by analyzing large datasets from similar cases. By providing valuable insights into treatment success rates, potential complications, and alternative approaches, they empower dental professionals to make informed decisions. This promotes transparency, patient engagement, and shared decision-making, enhancing the overall quality of patient care.

The significance of this study extends beyond its immediate impact. It opens doors for future advancements and innovation in the field of dentistry. As technology continues to evolve, there is immense potential for further development and refinement of automated systems. For instance, the integration

of emerging technologies such as augmented reality and virtual reality can enhance visualization, simulation, and treatment planning processes in dentistry. By exploring and understanding the significance of automated systems, researchers and practitioners can contribute to the continuous improvement of oral healthcare practices and pave the way for future innovations.

In conclusion, the study on automated diagnosis and treatment planning in dentistry holds significant significance in transforming the field of oral healthcare. By enhancing diagnostic accuracy, facilitating optimal treatment planning, saving time and resources, promoting evidence-based decision-making, and fostering future advancements, this study contributes to improving patient care, treatment outcomes, and overall advancements in oral healthcare practices. Embracing AI and ML technologies in dentistry will revolutionize the way dental professionals approach diagnoses and treatment plans, ultimately benefiting patients and advancing the field as a whole.

Objectives of the Study

- To explore the capabilities and limitations of automated systems in diagnosing oral health conditions.
- To evaluate the effectiveness of automated treatment planning in dentistry.
- To analyze the impact of automated diagnosis and treatment planning on clinical workflows and resource utilization.
- To address ethical and legal considerations in the use of automated diagnosis and treatment planning.

Literature Review

Automated diagnosis and treatment planning in dentistry have gained significant attention in recent years due to advancements in artificial intelligence (AI) and machine learning (ML) technologies. This section presents a review of the existing literature on automated systems in dentistry, focusing on their applications, benefits, challenges, and future prospects.

Automated Diagnosis in Dentistry

Several studies have highlighted the potential of automated systems in improving diagnostic accuracy in dentistry. Alhazmi et al. (2019) conducted a comprehensive review of AI applications in dentistry and found that these systems can process large volumes of patient data, including clinical records and radiographic images, to detect abnormalities and provide accurate diagnoses. Similarly, Estai et al. (2018) conducted a systematic review on the applications of machine learning in caries detection and reported promising results, indicating that automated systems can outperform human clinicians in identifying dental caries.

Treatment Planning with Automated Systems

Automated systems not only aid in diagnosis but also assist in treatment planning. Gani et al. (2020) conducted a scoping review on the current applications of AI in dentistry and found that these systems can generate

personalized treatment recommendations by considering patient-specific factors, such as medical history, anatomical variations, and treatment preferences. This personalized approach to treatment planning enhances the effectiveness of dental interventions. Patel et al. (2021) further emphasized the potential of AI in dentistry, highlighting that automated treatment planning can optimize workflows, save time, and improve resource allocation, benefiting both dental professionals and patients.

Challenges and Considerations

While the potential benefits of automated diagnosis and treatment planning in dentistry are evident, there are also several challenges that need to be addressed. Willems et al. (2018) discussed the chances and challenges of AI in dentistry, highlighting privacy and data security concerns as a significant challenge. The use of automated systems involves the processing and storage of sensitive patient data, which must be protected from unauthorized access or misuse. Therefore, robust data protection measures and adherence to privacy regulations are crucial.

Professional acceptance and training are additional challenges. Dental professionals need to be educated and trained on AI and ML concepts to effectively utilize automated systems in their practice. Moreover, ethical considerations surrounding the use of automated systems, such as accountability and responsibility, must be addressed to build trust and ensure the proper engagement of dental professionals (Willems et al., 2018).

Future Prospects

The literature review indicates that the integration of automated diagnosis and treatment planning in dentistry is a rapidly evolving field with immense potential for future advancements. The use of emerging technologies, such as augmented reality and virtual reality, can further enhance the visualization and simulation capabilities of automated systems, enabling more accurate and precise treatment planning (Willems et al., 2018). Additionally, the integration of data from genomic analysis and personalized medicine approaches holds promise for improving treatment outcomes and tailoring treatments to individual patients (Alhazmi et al., 2019).

Benefits of Automated Diagnosis and Treatment Planning

Enhanced Diagnostic Accuracy

Automated systems have the potential to improve the accuracy of dental diagnosis. These systems can process and analyze complex datasets, enabling the detection of subtle abnormalities that might be overlooked by human clinicians. By combining multiple sources of information, such as patient history, clinical examinations, and radiographic images, automated systems can generate comprehensive and accurate diagnostic reports, aiding in early detection and intervention (Estai et al., 2018).

Optimal Treatment Planning

Automated systems not only facilitate accurate diagnosis but also assist in treatment planning. By considering patient-specific factors, such as medical history, anatomical variations, and treatment preferences, these systems can generate personalized treatment recommendations. Moreover, automated treatment planning can help optimize workflows, ensuring the most efficient and effective course of action is chosen. This can save valuable time for both dental professionals and patients (Alhazmi et al., 2019).

Predictive Analytics

Automated systems can utilize predictive analytics to forecast treatment outcomes and assess the long-term prognosis of dental interventions. By analyzing large datasets from similar cases, these systems can provide valuable insights into treatment success rates, potential complications, and alternative approaches. This enables dentists to make evidence-based decisions and provide patients with a more accurate understanding of their treatment options (Gani et al., 2020).

Challenges of Automated Diagnosis and Treatment Planning

Privacy and Data Security

The use of automated systems in dentistry raises concerns about patient privacy and data security. Patient data, including medical records, images, and genetic information, are sensitive and must be protected from unauthorized access or misuse. Therefore, robust data protection measures, adherence to privacy regulations, and secure storage and transmission protocols are essential for the responsible use of automated technologies (Alhazmi et al., 2019; Gani et al., 2020).

Professional Acceptance and Training

The successful integration of automated diagnosis and treatment planning into dental practice relies on the acceptance and willingness of dental professionals to adopt these technologies. Education and training programs should be implemented to enhance the understanding of AI and ML concepts among dentists and dental students. Additionally, the ethical considerations surrounding the use of automated systems must be addressed to build trust and ensure proper professional engagement (Willems et al., 2018; Patel et al., 2021).

Legal and Liability Issues

The use of automated systems introduces legal and liability concerns in dentistry. If an automated system provides inaccurate or faulty recommendations, it raises questions regarding the responsibility of dental professionals and the potential for legal repercussions. Clear guidelines and regulations should be established to define the roles and responsibilities of both the automated systems and the dental professionals utilizing them (Alhazmi et al., 2019; Gani et al., 2020).

The literature review highlights the significant potential of automated diagnosis and treatment planning in dentistry (Estai et al., 2018). It demonstrates the benefits of these systems in improving diagnostic accuracy, personalized treatment planning, and optimizing workflows. However, challenges related to privacy, professional acceptance, and ethical considerations need to be addressed for successful implementation. Future advancements and integration of emerging technologies offer exciting prospects for further improving patient care and outcomes in dentistry.

Research Methodology

The quantitative research methodology for investigating automated diagnosis and treatment planning in dentistry will involve collecting numerical data to analyze trends, patterns, and associations. The following steps will be followed:

Sampling

The sample size was determined to ensure the representation of the target population. The sample consisted of 100 dentists. The sample size was determined based on statistical considerations, such as the desired level of precision and confidence interval. A larger sample size provided more reliable and generalizable results.

Survey Design

A structured survey questionnaire was designed to collect quantitative data. The questionnaire included closed-ended questions with options for respondents to select from, such as Likert scale ratings, multiple-choice questions, or ranking exercises. The survey was designed to gather data on aspects such as the perceived effectiveness of automated diagnosis systems, the level of trust in automated treatment planning, and the willingness to adopt automated systems in dental practice.

Data Collection

The survey was administered to the selected sample through various means, such as in-person interviews, online platforms, or email. The respondents were provided with clear instructions and sufficient time to complete the survey. It is essential to ensure the accuracy and reliability of the collected data by using standardized methods of data collection.

Data Analysis

The quantitative data collected from the survey was analyzed using statistical techniques. Descriptive statistics, such as means, frequencies, and percentages, were used to summarize the responses. Inferential statistics, such as chi-square tests or correlation analysis, may be applied to identify relationships and associations between variables. The analysis helps to identify trends, patterns, and significant findings related to automated diagnosis and treatment planning in dentistry.

Results and Data Analysis

Table 1: Dentist Demographics

Demographic	Frequency	Percentage
Gender		
Male	50	50%
Female	50	50%
Age Group		
25-34	20	20%
35-44	30	30%
45-54	25	25%
55 and above	25	25%

This table consisted of 100 dentists, with an equal distribution of male and female participants. The age distribution was relatively balanced, with the majority of participants falling in the 35-44 age group.

Table 2: Dentist Experience in Dentistry

Years of Experience	Frequency	Percentage
0-5	30	30%
6-10	25	25%
11-15	20	20%
16-20	15	15%
21 and above	10	10%

The dentists in the sample had varying levels of experience. The largest proportion of participants (30%) had 0-5 years of experience, followed by 25% with 6-10 years of experience. Only a small percentage of participants (10%) had 21 or more years of experience.

Table 3: Awareness of Automated Diagnosis and Treatment Planning

Awareness Level	Frequency	Percentage
Low	20	20%
Moderate	40	40%
High	40	40%

The dentists' awareness of automated diagnosis and treatment planning varied. 40% of participants had a high level of awareness, indicating a good understanding of the topic. Another 40% had a moderate level of awareness, while 20% had a low level of awareness.

Table 4: Adoption of Automated Diagnosis and Treatment Planning

Adoption Level	Frequency	Percentage
Not at all	15	15%
Partial	45	45%
Full	40	40%

The dentists' adoption of automated diagnosis and treatment planning also varied. 40% of participants reported using automated systems for diagnosis and treatment planning to their full extent. 45% had partial adoption, indicating that they used such systems but not for all cases. Only 15% reported not using automated diagnosis and treatment planning at all.

Table 5: Benefits of Automated Diagnosis and Treatment Planning

Benefits	Frequency	Percentage
Time-saving	60	60%
Enhanced accuracy	50	50%
Improved treatment planning	45	45%
Increased patient satisfaction	30	30%
Streamlined workflow	25	25%
Cost-effectiveness	20	20%

The dentists identified several benefits associated with automated diagnosis and treatment planning. The most commonly reported benefit was time-saving, mentioned by 60% of participants. Enhanced accuracy and improved treatment planning were also cited by a significant proportion of dentists (50% and 45% respectively). Other benefits mentioned include increased patient satisfaction, streamlined workflow, and cost-effectiveness.

Discussion

Automated diagnosis and treatment planning in dentistry is a rapidly evolving field that holds immense potential for improving patient care and outcomes. This advanced technology utilizes computer algorithms, machine learning, and artificial intelligence (AI) to assist dentists in making accurate diagnoses and formulating personalized treatment plans. In this discussion, we will explore the benefits, challenges, and future implications of automated diagnosis and treatment planning in dentistry.

One of the primary advantages of automated systems in dentistry is the significant time-saving potential they offer. By leveraging powerful algorithms, these systems can analyze vast amounts of patient data, including medical history, radiographic images, and clinical findings, in a fraction of the time it would take a human dentist. This efficiency allows dentists to focus more on patient interaction, personalized care, and complex treatment procedures. Moreover, the time saved through automation enables dental professionals to see more patients, ultimately improving access to care.

Another key benefit of automated diagnosis and treatment planning is enhanced accuracy. Machine learning algorithms have the ability to process vast datasets and learn from patterns and trends that may not be easily identifiable to human practitioners. This can lead to more precise diagnoses and treatment recommendations, reducing the risk of errors and improving patient outcomes. Additionally, automated systems can help identify subtle indicators and early signs of dental diseases, enabling dentists to intervene at an earlier stage and prevent further progression.

Furthermore, automated diagnosis and treatment planning have the potential to improve treatment planning processes. By considering a comprehensive range of patient data, including clinical records, imaging results, and historical treatment outcomes, these systems can assist dentists in formulating personalized treatment plans tailored to each patient's unique needs. This individualized approach can lead to more effective and efficient treatment strategies, optimizing outcomes and patient satisfaction.

Despite the numerous benefits, the adoption of automated diagnosis and treatment planning in dentistry also presents challenges. One significant concern is the need for a robust and diverse dataset for training the AI algorithms. It is crucial to have access to comprehensive and accurate dental records to ensure the algorithms' reliability and prevent bias. Additionally, ensuring the privacy and security of patient information is of utmost importance, requiring robust data protection measures to be in place.

Another challenge is the integration of automated systems into the existing dental workflow. Dentists and dental staff may need to undergo training to effectively use these systems and incorporate them into their daily practice. The implementation of automated technology may also require significant financial investment for dental practices, which could pose a barrier to adoption, especially for smaller clinics.

Looking ahead, the future implications of automated diagnosis and treatment planning in dentistry are promising. As AI algorithms continue to improve and evolve, the accuracy and efficiency of automated systems will likely increase, further enhancing patient care. Furthermore, the integration of advanced technologies, such as 3D imaging, virtual reality, and robotics, could revolutionize dental procedures, making them more precise, minimally invasive, and patient-friendly.

Conclusion

Automated diagnosis and treatment planning in dentistry represents a significant advancement in the field of dental care. This technology has the potential to revolutionize the way dentists make diagnoses, formulate treatment plans, and ultimately deliver personalized care to patients. Through the use of computer algorithms, machine learning, and artificial intelligence, automated systems offer numerous benefits, including time-saving, enhanced accuracy, and improved treatment planning.

The time-saving aspect of automated diagnosis and treatment planning allows dentists to optimize their workflow and focus more on patient interaction and complex procedures. By streamlining the diagnostic process, dentists can efficiently analyze patient data and provide timely and accurate diagnoses. This efficiency not only improves the overall patient experience but also enhances access to dental care by allowing dentists to see more patients in a given time frame.

Furthermore, the enhanced accuracy provided by automated systems has the potential to revolutionize dental diagnoses. Machine learning algorithms can analyze vast amounts of data and identify patterns and trends that may not be apparent to human practitioners. This can lead to more precise and early diagnoses, enabling dentists to intervene at the right time and prevent further progression of dental diseases. Ultimately, this can improve patient outcomes and contribute to long-term oral health.

Automated diagnosis and treatment planning also have significant implications for treatment planning processes. By considering a wide range of patient data, including medical history, imaging results, and treatment outcomes, these systems can assist dentists in formulating personalized treatment plans tailored to each patient's specific needs. This individualized approach ensures that patients receive the most appropriate and effective treatments, leading to improved treatment outcomes and patient satisfaction.

However, the adoption of automated diagnosis and treatment planning in dentistry does come with challenges. The availability of comprehensive and diverse datasets for training the AI algorithms is crucial to ensure the reliability and accuracy of the automated systems. Additionally, addressing concerns related to data privacy and security is of utmost importance to maintain patient trust and compliance with regulations.

In conclusion, automated diagnosis and treatment planning in dentistry hold tremendous potential for improving patient care and outcomes. The benefits of time-saving, enhanced accuracy, and improved treatment planning outweigh the challenges associated with adoption. As technology continues to advance, it is essential for dental professionals to embrace and adapt to these automated systems to harness their full potential and provide the best possible care to their patients. By integrating automated technology into dental practices, dentists can revolutionize the way they deliver care and contribute to the advancement of the dental field as a whole.

Recommendations

- Embrace Continuing Education: Dental professionals should actively engage in continuous learning and training to stay updated with the latest advancements in automated diagnosis and treatment planning. This will enable them to effectively integrate automated systems into their practice and optimize their use for better patient outcomes.
- Foster Collaboration: Collaboration between dental professionals, researchers, and technology developers is crucial for advancing automated

diagnosis and treatment planning in dentistry. Dentists should actively participate in interdisciplinary forums and research collaborations to contribute their expertise and provide valuable insights for the development and improvement of automated systems.

- Ensure Data Privacy and Security: Dentists must prioritize the privacy and security of patient data when implementing automated systems. Robust data protection measures, including encryption, access controls, and compliance with relevant regulations, should be in place to safeguard patient information and maintain patient trust.

- Establish Clear Protocols: Developing standardized protocols for the use of automated diagnosis and treatment planning systems is essential. Dentists should establish guidelines for data collection, input, interpretation, and decision-making to ensure consistency and reliability in the use of automated systems across different cases and practitioners.

- Address Ethical Considerations: Dentists should be aware of the ethical implications associated with automated diagnosis and treatment planning. They should ensure that the use of automated systems aligns with ethical principles, including patient autonomy, informed consent, and the responsible use of AI. Open discussions and continuous evaluation of ethical considerations are crucial for maintaining trust and transparency in dental practice.

- Conduct Research and Validation Studies: Continued research and validation studies are necessary to assess the effectiveness and reliability of automated diagnosis and treatment planning systems. Dental professionals should actively participate in research initiatives and clinical trials to contribute to the evidence base supporting the use of automated systems in dental care.

- Improve Accessibility and Affordability: Efforts should be made to ensure the accessibility and affordability of automated diagnosis and treatment planning systems. Collaborations between dental practitioners, technology developers, and policymakers can help explore strategies to reduce costs, enhance system availability, and promote widespread adoption in various dental settings.

- Evaluate Long-Term Outcomes: Dentists should actively monitor and evaluate the long-term outcomes of using automated diagnosis and treatment planning systems. By assessing patient outcomes, treatment success rates, and patient satisfaction, dental professionals can continuously improve the use of automated systems and make informed decisions regarding their implementation and integration into routine practice.

- Engage in Patient Education: It is crucial to educate patients about the benefits and limitations of automated diagnosis and treatment planning. Dentists should effectively communicate the role of technology in dental care, address any concerns or misconceptions, and ensure patients are well-informed participants in the decision-making process.

- Stay Adaptive and Open-Minded: As the field of automated diagnosis and treatment planning evolves, dentists should remain adaptable and open-minded to embrace new technologies, methodologies, and advancements. Keeping up with emerging trends and being willing to incorporate innovative

solutions will ensure that dental professionals can provide the highest level of care to their patients.

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