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The Ethics of Integrating AI
into Dentistry: Past, Present &
Future Considerations

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The Ethics of Integrating AI into Dentistry: Past, Present & Future Considerations



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“Science and technology revolutionize our lives, but memory, tradition and myth frame our response.”

— Arthur Schlesinger

According to philosopher Robert Baker morally disruptive innovations are those which “undermine established moral norms or ethical codes.”¹ Arguably, Artificial Intelligence (AI) is just such an innovation, however, the articles in this issue will demonstrate that although disruptive, AI need not undermine established ethical codes in dentistry. Ethical principles that are foundational to the profession of dentistry offer guidance and direction that can be applied to reduce ethical risks that arise with the introduction of AI into practice. Additionally, the articles presented in this issue each touch on one or more of the elements identified in the Biden Administration’s Blueprint for an AI Bill of Rights. That document sets forth five principles to guide the use of AI: Safe and Effective Systems; Algorithmic Discrimination Protections; Data Privacy; Notice and Explanation; and Human Alternatives, Consideration, and Fallback.²

This issue of *eJACD* asks the reader to think about the present, future, and ethical uses of Artificial Intelligence (AI) in dentistry. The authors identify relevant issues at play in the use of AI more broadly, with specific attention given to its role in dentistry. Despite the different foci of the essays, each of the authors emphasizes the importance of paying attention to the human element in the use of AI in dentistry.

While the focus of these essays centers on ethical use of AI in dentistry, they also highlight ethical questions in the adoption of AI more broadly. If AI is to become integrated in an ethically responsible way, adopters of the technology must consider its impact and goals with respect to human beings, both for healthcare providers and the patients they treat.

Advocating for the ethical use of AI that emphasizes humanitarian values plays a central role in the ethics of AI more broadly. Luciano Floridi and his colleagues describe what they call AI4People. Floridi lays out an approach that considers both the ethical application of AI and what principles ought to be considered in its development.³ While the AI4People approach considers the ethics of AI broadly, Jessica Morely calls for a mindful approach to the application of AI within the domain of healthcare. She encourages the adoption of new technologies, insofar as they enhance patient care, but cautions of the ethical risk of incorporating data that enhances already existing disparities, using information to support clinical decisions if the rationale is unclear, and the importance of determining responsibility in the use of AI technology.⁴ The essays in this issue take a similarly mindful approach in arguing for the ethical integration of AI technology in dentistry.

The Ethics of Integrating AI into Dentistry: Past, Present & Future Considerations *(cont.)*

Nanette Elster, JD, MPH, FACP; Michael McCarthy, PhD, HEC-C

Overview


Chris Salierno introduces new possibilities within AI for dentistry that offer tangible solutions to make dental care more efficient and effective for the patient, providers and payors. His essay offers a clear overview of the function of the technology and its potential uses. Finally, he highlights several ethical issues that raise questions for incorporating AI into dentistry, many of which the other authors in this issue explore in greater detail.

Clara Kim, Alexander Lee, and Hubert K. Chan, explore the role of Clinical Decision Support (CDS) that can improve diagnosis and recommendations for patient care. However, the essay notes the importance that providers understand how CDS generates patient treatment recommendations and that the technology improves the relationship between patient and provider, rather than replacing it, allowing for a more shared approach to decision making. Learning how integrate AI into patient care will be a skill that needs to be taught to practicing dentists, as well as to future ones.

Mina Ghorbanifarajzadeh and Terri Dolan turn their attention to AI as an essential resource and component of dental education. They point to AI's potential for enhancing access to dental

education, the learning potential of dental students and to inform how they provide care to their future patients. Ghorbanifarajzadeh and Dolan point to the importance of shifting the approach to dental education in order that dental students are better able to anticipate ethical questions around privacy and responsibility. When considering the responsibility of dentists in using AI technology, it is important that providers understand how algorithms are used and what the technology is designed to do. In their essay, Eric Swirsky and Michael Swirsky note that many developments around technology are centered around profit motives, and those motives do not always generate a benefit for patients. They discuss guidelines for a human-centered approach to the development of AI and its application in dentistry.

The final original essay in this issue is authored by Donald Carter. Carter's essay focuses on questions of access and a potential consequence of improved technological use as a means to widen already existing disparities particularly in rural communities. He encourages that questions of justice come to the fore when considering the responsible adoption and use of AI technology in



While the use of AI technology will continue to create opportunities in dentistry, responsible adoption requires consideration of how the technology improves patient care and fosters a deeper sense of trust in these relationships.

dental care. While the decision to incorporate AI may benefit current patients, there is the potential of harm if future data used within the algorithms neglects the information and needs of those with already limited access to dental care.

The final article in this issue is an article published in the *Journal of the American College of Dentists* twenty-three years ago, by Lawrence F. Emmott. Dr. Emmott's article focused on integration of computers into dental practice. This serves as a perfect complement to the discussion of how to adapt to morally disruptive technology introduced in dental practice.

Conclusion

Together, the articles published in this issue look at the past, present and future ethical issues of integrating AI into dentistry. More generally, however, they allow for reflection more broadly on the ethical considerations any time new technology is introduced and implemented in dental practice and education. While the use of AI technology will continue to create opportunities in dentistry, responsible adoption requires consideration of how the technology improves patient care and fosters a deeper sense of trust in these relationships.

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Dentistry and AI: Ethical Considerations for the Coming Revolution

Chris Salierno, DDS

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We are in the early stages of a rapid proliferation of diagnostic tools, treatment modalities, and administrative efficiencies in dentistry that will be driven by advancements in Artificial Intelligence (AI). Our enthusiasm for adoption must be balanced by our steadfast commitment to professional ethics and standards of care. AI is a new tool in our hands and, like all technologies, it demands our understanding and careful consideration before being put to use.

We are in the early stages of an AI revolution in healthcare. As with previous periods of rapid technological progress, our profession must balance adoption with preservation of clinical standards and with potential ethical considerations.

Introduction

Imagine a world where dental radiographs, intraoral photographs, a CBCT scan, and digital models are instantly analyzed, completing a dental record with existing conditions, potential pathologies, and treatment plan recommendations. Once the diagnosis and treatment plan are confirmed by the provider, the patient's out-of-pocket expenses are verified in real time and the scheduling and payment options are presented within moments. These are not wild predictions of what the future may hold; advancements in Artificial Intelligence (AI) have made these clinical and clerical marvels available today.

Scientific progress with AI has witnessed a surge in recent years, permeating virtually every industry and redefining the way we perceive and interact with technology. However, one sector where its potential is only beginning to be tapped is dentistry. We are in the early stages of an AI revolution in healthcare. As with previous periods of rapid technological progress, our profession must balance adoption with preservation of clinical standards and with potential ethical considerations.

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Types of AI and Their Applications in Clinical Dentistry

Artificial Intelligence is a collection of technologies and methodologies that simulate human intelligence. In the realm of dentistry, several types of AI have emerged as having practical applications and benefits.

Machine Learning (ML) and Deep Learning (DL)

Machine Learning involves algorithms that improve automatically through experience. In dentistry, ML has been instrumental in predictive analytics. By analyzing past patient data, ML can predict potential oral health issues, enabling dentists to take preventive measures. Deep Learning, a more advanced form of ML, uses neural networks to analyze vast amounts of data for higher levels of accuracy. A current application of ML and DL algorithms is to assess dental radiographs to detect early signs of cavities, periodontal bone loss, and alveolar pathologies.^{1,2}

Natural Language Processing (NLP)

NLP focuses on the interaction between computers and human language. A proposed clinical application is a chatbot, powered by NLP, answering common patient questions regarding their care.³

Large Language Models (LLM)

LLMs, like OpenAI's GPT series, are a type of deep learning model that can generate human-like text based on the large data sets on which they have been trained. In dentistry, LLMs can assist in research by quickly analyzing vast amounts of literature, identifying trends, and even suggesting potential areas of study.

Since the commercial launch of ChatGPT 3.5 in November 2022, LLMs have received significant attention for their ability to automate and enhance various clerical and administrative functions, potentially improving a person's work output.⁴ Dental applications, such as the ones listed below, are in their infancy and have yet to be verified in the literature.

(a) Reading and Interpreting Third Party Payer Contracts

LLMs can be employed to read, interpret, and summarize complex third party payer contracts. By processing the intricate legal and technical language, these AI models provide concise, understandable summaries and highlight key terms, conditions, and obligations. This ensures that dental offices can quickly grasp the essentials of contracts, aiding in informed decision-making and compliance.

(b) Preparing/Submitting/Adjudicating Insurance Claims

Insurance claims processing can be intricate and time-consuming. LLMs could streamline this process by automatically filling out claim forms, ensuring accuracy and compliance with insurance protocols. They could also track and manage claims, providing real-time updates on their status, and instantly flagging any issues for resolution. The AI's capability to interpret and respond to the feedback from insurance companies could ensure that claims are adjudicated efficiently.

(c) Creating Marketing Content

Dental offices can leverage LLMs to create compelling marketing content. From crafting personalized patient newsletters to generating engaging content for social media and websites, the AI models can be tailored to align with the brand voice and objectives, ensuring consistency and relevance in all communications.

If we cannot fully rely on the accuracy of AI, then we must also consider the question of accountability. If an AI system makes an error leading to patient harm, who is responsible? Is it the software developer or the dental professional?

(d) Creating SOPs

Standard Operating Procedures (SOPs) are crucial for the efficient and safe operation of dental offices. LLMs facilitate the creation of detailed, customized SOPs, taking into account the specific needs, equipment, and workflows of each practice. They can ensure that SOPs are clear, comprehensive, and compliant with regulatory standards, enhancing operational efficiency and patient safety.

Ethical Considerations in Utilizing AI in Dentistry

The above advancements come with a host of ethical considerations that both practitioners and developers must address to ensure the responsible and beneficial application of AI in dentistry.

Data Privacy and Security

Healthcare providers are well-versed in the importance of securing Protected Health Information (PHI) for their patients. Every dental visit, procedure, and interaction generates data. From personal details to medical histories, dental radiographs to treatment plans, the amount of data a dental practice handles is immense. Patient data may be stored locally on a hard drive, in a device (e.g. intraoral scanner), or it may be stored on a cloud computing service. Dental manufacturers of hardware and software that capture PHI and have robust encryption and adhere to strict data protection standards.

These standards are no different for technologies that make use of AI. In this early stage of development, dental practice personnel may seek to experiment with AI platforms that are not yet held to the same information security rigor as other health-

care technology. For example, LLMs that are open to the public should likely not receive PHI.

Reliability and Accountability

AI is not infallible. There is a potential for errors, whether due to flawed algorithms, inadequate training data, or system glitches. It is essential for dental professionals to be aware of these limitations and use AI as a tool rather than a definitive authority. ML and DL image analysis may yield false positives or false negatives,⁵ and LLMs have been known to “hallucinate” incorrect answers.⁶

If we cannot fully rely on the accuracy of AI, then we must also consider the question of accountability. If an AI system makes an error leading to patient harm, who is responsible? Is it the software developer or the dental professional?

Bias and Fairness

AI systems are only as good as the data on which they are trained. If this data is biased, the AI’s decisions and recommendations will reflect those biases. For instance, if an AI system is trained predominantly on data from a particular ethnic group, its accuracy might decrease for patients outside of that group. It’s crucial to ensure that AI training data is diverse and representative to avoid such biases.

AI is a tool to be used by a human. If that person has a particular bias, then it is possible that AI will help that person more readily introduce their bias in their work; that is to say, the technology does not necessarily correct their bias. Mertens et al. concluded that while AI-assisted radiographic interpretation can help providers more readily identify early carious lesions, that improved sensitivity also came with an increase in the selection of more invasive treatment options.⁷

Every patient, regardless of their background, deserves high-quality dental care. AI should enhance

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this principle, not detract from it. Dental practices must ensure that AI tools are used to provide equitable treatment for all patients. Regular audits and reviews of AI decisions can help in identifying and rectifying any disparities in patient care.

Human Touch vs. Automation

Dentistry is not just about treating teeth; it's about treating patients. The human touch, the empathy, understanding, and rapport that dental professionals build with their patients are all critical parts of the patient experience. While AI can handle many tasks, from diagnostics to administrative duties, patients may express concerns about increasing automation in their healthcare journey.⁸ As with any patient concerns regarding our diagnoses, treatment plans, or outcomes of care, dentists should encourage healthy discussion. Regardless of the technology we use, we are still bound to the same standards of care, the ADA Principles of Ethics and

Code of Conduct. AI and automation are tools to improve quality, consistency, and efficiency; they do not replace clinical decision-making.

Conclusion

The dental profession, indeed, all of healthcare, stands on the brink of a transformative era. The next decade promises unprecedented advancements, where AI is not just an auxiliary tool but a core component of dental practice, driving efficiency, precision, and personalized patient care. Dental professionals must remain at the forefront of using these tools in clinical decision-making and in achieving administrative efficiencies. As with all technological advancements, it is imperative to navigate their integration with caution, awareness, and a deep commitment to ethical considerations. Our critical thinking skills and our standards of care have not changed; neither should our resolve to uphold them.

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Ethical Considerations for Dental Professionals When Adopting AI Technology

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Clara S. Kim, DMD, MS; Alexander Lee, DMD; Hubert K. Chan, DDS

Introduction

Artificial intelligence (AI) is rapidly changing and revolutionizing the healthcare and dental community. The use of AI is “expected to improve the accuracy and efficacy of dental diagnosis, provide visualized anatomic guidance for treatment, simulate and evaluate prospective results, and project the occurrence and prognosis of oral diseases.”¹ The term AI is a general, encompassing term which includes machine learning, deep learning, cognitive processing, and natural language processing,² which are the base of many technologies that promise to change our lives for the better. From programs that translate patient-doctor communication into documentation notes to robotic arms that precisely place dental implants, one can envision the significant and inevitable influence this technology *du jour* will have on the oral health community.

While the world has become enamored with AI, dentistry has been slow to engage with the technology. Several reviews^{3,4} have consistently arrived at conclusions that emphasize their deep-seated and multifaceted concerns regarding the ethical use of artificial intelligence across various domains. They plea for further research in AI so that the technology can be used responsibly in the field. The dental community needs more high-quality literature and hands-on exposure to the technology to lead the ethical discussion on AI. The potential negative consequences of AI technology need to be further examined within the established framework, and applying this framework to the field of dentistry is essential for laying the groundwork for subsequent ethical discussions.

AI as Clinical Decision Support

Providers should be reminded that AI is a supportive tool, specifically a clinical decision support (CDS) system with great potential to expedite the process, replace redundancy, and suggest differentials. These tools are designed to aid healthcare profes-

sionals, patients, and/or caregivers in making more informed decisions. They are often employed to learn from analyzing patients’ medical data, and “of patients with similar health conditions to recognize patterns in clinical data, prognosticate, suggest evidence-based treatment options, diagnose conditions and assist in care planning.”⁵ The benefits and effectiveness of AI-based CDS tools can be used in multiple areas within dentistry to reduce variations in practice and prevent inappropriate allocation of resources. It is imperative to understand that providers are ultimately responsible to assess validity and accuracy while critically evaluating its practical application and therefore should utilize AI as a resource to streamline routine tasks and enhance workflow efficiency, but refrain from relying on it as a replacement for professional knowledge and skills particularly in unfamiliar disciplines. Tingle⁶ explains that “AI should always be seen as a tool and not as the directing force... To draw a parallel to daily life, responsibility for accidents in self-driving cars most immediately falls to the licensed driver. The practitioner will be held responsible if they ‘fall asleep at the wheel’ when using AI.” As with any other tools utilized, the full accountability lies with the user especially in cases of error or malfunction.

Ethical Issues in Adopting Technology

When incorporating AI technology into their practices, it will be imperative that providers become well-versed in the technical usage. However, it is equally important to consider the ethical implications and repercussions. Without attention to such, the damage to patients, the community, and the profession will be detrimental. Many have already suggested pitfalls of AI technology such as patient privacy rights, data safety, various biases in algorithm development, and healthcare disparities/in-equalities.⁷⁻⁹ The provider has the responsibility to fully understand these aspects and remain cognizant to the ethical quandary posed by the utilization

The dental community needs more high-quality literature and hands-on exposure to the technology to lead the ethical discussion on AI. The potential negative consequences of AI technology need to be further examined within the established framework, and applying this framework to the field of dentistry is essential for laying the groundwork for subsequent ethical discussions.

of AI technology in patient care, including selection bias in algorithm development, the black box effect, automation bias, and generalizability.¹⁰ These serve as foundational considerations in the context of the continuing conversation on ethical AI usage, recognizing that as AI technology sees more extensive application, new questions and challenges will inevitably emerge.

Selection Bias

Selection bias in data procurement and algorithm development has been discussed as one of the major concerns for AI in healthcare.⁷⁻⁹ Concerns arise not just from skewed algorithmic outcomes resulting from limited and selective training data but also from the potential for poor or unreliable outcomes for underserved and underrepresented patient populations. Inadvertent discrimination can emerge when utilizing existing data influenced by societal biases, potentially worsening disparities in healthcare. Healthcare practitioners should remain wary in recognizing biases rooted in developer decisions, societal prejudices ingrained within systems, and the selective nature of training data.¹¹ Promoting responsible AI development and its ethical implementation within healthcare, both institutionally and at the policy level, is of utmost importance and should be part of everyone's responsibility. Active involvement in mitigating biases is essential especially to protect vulnerable populations.

Black Box Effect

The black box effect refers to complex systems that are opaque and uninterpretable, yet whose algorithms generate the results. Although there are clear intentions and designs in initial development, AI

systems typically lack transparency in the ability to provide convincing explanations in their predictions and outcomes.⁷ In healthcare, practitioners may not understand nor be able to explain why a particular diagnosis or recommendation is given.¹² The black box effect presents a challenge, as it could erode trust in the AI-enhanced healthcare system in the future, potentially straining the doctor-patient relationship but also the overall credibility of the healthcare industry. The concept of "trust but verify" applies in AI as a tool and operates under the assumption that providers can trust the product to perform reliably, accurately and safely even before the verification process. If a poorly developed or explained AI system is implemented, then subsequent verification steps from practitioners would be untrustworthy and of no value. The challenges of AI technology encompass the need for both robust initial design and continuous validation. Currently, regulation of AI in the United States is still in development as many stakeholders are rapidly collaborating to further address the technology. While there is an organized effort to ensure that appropriate protections and regulations are in place, it is essential for practitioners to exercise caution and avoid assuming that every AI platform undergoes equal levels of thorough research and careful development.

Automation Bias

Automation bias is defined as "the tendency to use automated cues as a heuristic replacement for vigilant information seeking and processing."¹³ Providers bear the responsibility of critically analyzing diagnosis and/or treatment suggestions from AI while also continuously advancing their skills and knowledge. AI technology serves as a clinical decision support tool while the provider is the ultimate decision maker. To prevent excessive reliance on technology, providers must maintain vigilance and awareness of

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their own automation bias and risk of CDS failure. If decision-making becomes primarily dependent on computers or other automated aids, then the human provider takes on an observatory role in patient care. Excessive dependence on AI tools has the potential to endanger patients, as these tools tend to be generally accurate in most instances but may fail in others.¹⁰ The provider bears complete accountability for any errors or biases that may arise and ultimate responsibility for their patients' care, including errors and rare situations that AI technology may not pick up. Consequently, providers must uphold a deliberate and purposeful awareness to closely oversee the utilization of AI technology.

If disparities between a provider's own assessment and AI recommendations arise, despite careful consideration and built-in protected mechanisms, they should conduct a comprehensive review of their own proficiency and subsequently address potential adjustments in the algorithm. Ongoing validation and monitoring will be crucial in maintaining the accuracy and safety for patients and profession. Just like other tools, learning and using technology requires the user's responsibility to carefully consider all aspects: benefits, risks and alternatives. One systematic review advocates the inclusion of human values when creating, deploying, and revising technology.¹⁴ Human intention must be purposefully integrated into AI as the technology's intentions mirror that of its creators.

AI Role in Healthcare

It is important to remember that while AI can support certain aspects of patient management and treatment, it cannot account for the subtlety of human-to-human interaction and relationships integral to healthcare. Social determinants of health, as well as factors like race, gender, and cultural aspects of patients, represent just a few of the multifaceted considerations that require thoughtful

implementation in healthcare delivery to address the complex and dynamic needs.¹⁵ As AI technology becomes increasingly and equally accessible to the general population, providers must be accountable for educating, engaging in discussions, and effectively communicating with patients. Patients will exhibit knowledge acquired from AI usage and expect higher level discussions and engagement from their providers. In turn, oral health providers will be responsible for substantiating, rationalizing, and clarifying their suggestions to patients through a communication founded on trust and a shared decision-making process. Providers must take great care in this relationship so as not to discredit the knowledge gained from AI usage but rather to acknowledge the autonomy of the patient to independently trust and verify their sources of information. Optimal healthcare delivery results from the respective alignment of both patient and provider autonomy in making treatment choices for the best outcomes.

Conclusion

AI technology is an emerging, exceptional tool that can enhance practitioners' lives, much like various other innovations that have improved our daily work. Although it may cause some skepticism among dental providers regarding its uncertainty and inherent biases, it is essential to maintain a positive and vigilant attitude toward AI which inevitably will mature to promote interactive, "human-technology collaboration".¹ AI usage in oral health is currently limited to specific areas where a trained model can provide insights to help answer a particular clinical question. As more use cases are identified and more data are gathered, AI technology will rapidly advance. Conscientious ethical examination and elevated standards for providers are now more critical than ever to prevent undesirable outcomes.

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Artificial Intelligence's Opportunity to Shape the Landscape of Dental Education

Mina Ghorbanifarajzadeh, DMD; Teresa A. Dolan, DDS, MPH

As a frontier leader and dental artificial intelligence expert, Dr. Mina Ghorbanifarajzadeh, works at Overjet. Serving as Senior Clinical Manager for Overjet she helps shape the industry standards for what we can expect of Artificial Intelligence today and where we can expect it to go in the future.

With a background in technology, health care, and world-class service, Dr. Ghorbanifarajzadeh's passions align with the mission that technology will bring to dentistry. She is energized by the growing technologies that will not only improve patient dental care but overall healthcare as well. Dr. Ghorbanifarajzadeh is a graduate of the University of Florida College of Dentistry and was the recipient of the Oral Maxillofacial Radiology Award.

Dr. Teresa (Terri) Dolan is the Chief Dental Officer at Overjet, the global leader in dental AI. She previously served as Dentsply Sirona's Chief Clinical Officer, leading the global Clinical Affairs function, supporting new product development and overseeing the largest global clinical education program sponsored by the dental industry. Dr. Dolan is also professor and dean emeritus of the University of Florida College of Dentistry, where she served as dean and chief academic officer from 2003 until 2013. As a recognized leader in the dental profession, she currently serves as past-president of the Santa Fe Group, president of the American College of Dentists, and serves on the board of directors of the American Dental Association Science and Research Institute.

Disclosure:

Drs. Ghorbanifarajzadeh and Dolan are full-time employees at Overjet.

Dr. Ghorbanifarajzadeh is the primary author of this paper. Dr. Dolan served as a reviewer, editor, and contributed to some concepts presented in the paper.

AI is the latest frontier in this ongoing evolution, with the potential to revolutionize dental education. Dental AI applications are already commonly used in prosthodontic CAD-CAM workflows, orthodontic aligner therapies, and segmentation of airways in cone-beam computed tomography systems, to name a few.²

Introduction

The ever-evolving landscape of healthcare delivery and technological advancement provides an opportunity to incorporate Artificial Intelligence (AI) into dental education. In an era where digital literacy and critical thinking are paramount, educators must guide the next generation of dental professionals in the judicious use of AI, augmented intelligence (Aul), and other technologies to support teaching, learning, and the improvement of care delivery.¹ AI is not a tool to replace dentists, but to augment and enhance clinicians' ability to provide precise, consistent, and appropriate care to patients.² Dental professionals will increasingly engage with technology as part of healthcare delivery. This paper focuses on the opportunity, and some would say the imperative, to integrate AI into dental pedagogy, elucidate its applications, delve into potential challenges, and underscore the opportunities it presents to enhance equitable health outcomes.

Dental education has a rich history of adapting to technological advancements. From the introduction of radiography to the adoption of digital health records, the profession has embraced innovations to enhance the quality and efficiency of care provided to patients. Recognizing these trends, the Commission on Dental Accreditation (CODA) Predoctoral Standards include the "application of technology" in enhancing patient care and transforming the curriculum, including theoretical courses and clinical instruction.³ AI is the latest frontier in this ongoing evolution, with the potential to revolutionize dental

education. Dental AI applications are already commonly used in prosthodontic CAD-CAM workflows, orthodontic aligner therapies, and segmentation of airways in cone-beam computed tomography systems, to name a few.² Educators are just beginning to explore ways to use AI to create personalized learning that enables health professions students to build on existing knowledge and customize the learning experience to develop new competencies and use self-directed and lifelong learning.

Personalized Learning

One of the most transformative applications of AI in dental education will be personalized learning. AI-driven algorithms can tailor the educational experience to the unique needs, knowledge gaps, and preferences of individual students.¹ These applications could range from learning anatomy and physiology to radiographic interpretation and clinical practice guidelines to the development of psychomotor skills and surgical skills. AI can provide customized learning materials, assignments, and assessments by analyzing student performance, learning styles, and pace. This personalized approach is expected to enrich the learning experience, while also optimizing knowledge retention and comprehension.⁴

As these technologies develop, AI's ability to enable the adaptation of curricula and instruction to individual learning styles will be invaluable in addressing the diverse needs of dental students. Some students may excel in traditional classroom

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settings, while others may require a more visual or interactive approach to grasp complex dental concepts. "Personalized teaching and learning" will be supported by having AI systems provide tailored content, enhancing the overall learning experience.⁴ Moreover, the adaptability of AI enables students to progress at their own pace, allowing those who grasp concepts quickly to move ahead, while providing additional support to those who need it. Technology can be used to assess learning gaps from a student's undergraduate experience, enabling a student-centered pace to learn skill development tailored to the student. Rather than the current "lock step" approach to dental education currently used by most dental schools, personalized and true competency-based education would enable the opportunity for accelerated study for subgroups of students, potentially decrease the cost of education, or facilitate the tracking of some students into more specialized areas of study. At the same time, personalized assessment can also be used to identify the need for remediation or focused attention on a particular topic, skill, or ability. A more personalized, learner-centered, competency-based, AI-enabled dental education requires adaptation of accreditation standards, rigorous evaluations, appropriate databases to track student progress, digitized learning resources, and open-minded and trained faculty and administrators.

Hands-On Learning, Redefined

AI-driven simulators and models offer an innovative way to provide dental students the opportunity for psychomotor skills development and assessment in a safe environment that eliminates potential harm to patients being treated by inexperienced clinicians. Virtual environments allow students to practice a wide array of dental procedures, reducing the chances of patient harm. AI-based simulations replicate diverse clinical scenarios, enabling students to hone their skills and

decision-making abilities.⁵ Furthermore, AI can provide real-time feedback, fostering continuous improvement in the learning process.⁶

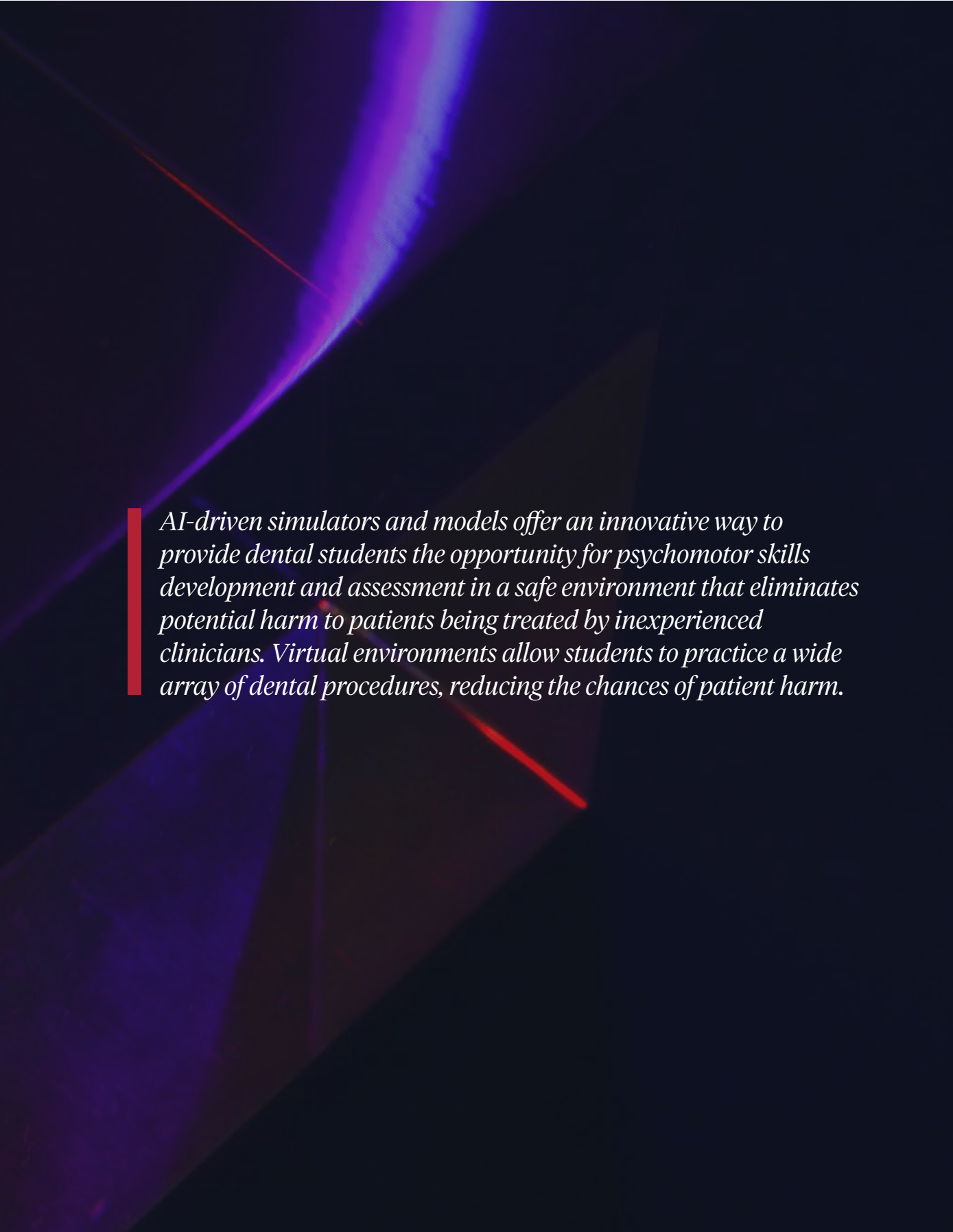
The integration of AI-driven simulations and modeling into dental education has the potential to transform the way students gain practical experience. Traditionally, dental students rely on patients for their clinical training, which can be challenging due to factors including patient availability, ethical considerations, and the variability in patients' cases. AI-driven simulations provide a standardized and controlled environment for students to practice and learn from their mistakes without putting actual patients at risk.^{5,6}

These simulations can replicate a wide range of dental procedures, from routine cleanings to complex surgeries. The advantage of AI in this context is that it can adapt the complexity of simulations to the skill level of the student, gradually increasing the difficulty as they become more proficient. This adaptive learning approach ensures that students are adequately prepared for real-world clinical scenarios.

AI for Clinical Decision Support

AI technologies can serve as medical devices that support clinical decision-making, enhancing the diagnostic and treatment planning processes.⁷ Dental students can benefit from AI systems that leverage extensive datasets and machine learning algorithms to offer evidence-based recommendations in the more consistent and precise identification of clinical findings. The Food and Drug Administration as of June 2023 has cleared more than 521 AI-based medical devices since 2010, which support clinical decision-making across healthcare.⁸ As the algorithms and user interfaces become more sophisticated these possibilities will become more real.

In dental education, clinical decision support systems powered by AI have the potential to improve



AI-driven simulators and models offer an innovative way to provide dental students the opportunity for psychomotor skills development and assessment in a safe environment that eliminates potential harm to patients being treated by inexperienced clinicians. Virtual environments allow students to practice a wide array of dental procedures, reducing the chances of patient harm.

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the quality of care provided to patients significantly. These systems can analyze patient data, such as medical histories, radiographs, and treatment plans, to assist students and practicing dentists in making more accurate and consistent decisions.⁷ AI's ability to process vast amounts of data quickly can aid in diagnosing conditions and identifying potential treatment options, taking into account the latest research and best practices.

Moreover, AI can help students refine their critical thinking skills by presenting them with cases that require careful consideration and synthesis of the information as they develop treatment recommendations.⁹ By working through these cases with AI guidance, students can develop better decision making skills with a deeper understanding of complex dental conditions and their management.

Challenges and Opportunities

Although the integration of AI into dental education is rife with possibilities, it also raises ethical and practical dilemmas.¹⁰ Privacy concerns, data security, and the responsible use of AI are paramount issues that require meticulous consideration.^{9,10} Educators, as well as manufacturers of AI-enabled software and other medical devices, must ensure that AI algorithms are unbiased and do not contribute to the persistence of healthcare disparities.

Ethical considerations are fundamental when integrating AI into dental education. AI systems can potentially access and analyze sensitive patient data, raising concerns about data privacy and security. To address this, educators and institutions must establish stringent protocols for data handling, storage, and access. Compliance with relevant laws and regulations, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States, is crucial to ensure patient privacy and data security.⁸⁻¹⁰

Additionally, educators should familiarize themselves with how to create unbiased models and

know what questions to ask of creators, manufacturers, and distributors. AI systems are only as unbiased as the data on which they are trained, and historical disparities in healthcare data could perpetuate existing inequalities. Dental educators will have a significant impact on how AI systems are used to promote fairness and equity in patient care.

Academic institutions must address the resource constraints and invest in necessary infrastructure and faculty training to effectively implement AI.¹¹ While this may pose challenges, the opportunities for improving dental education through AI are substantial. AI enables the potential to democratize access to quality dental education by making learning materials more accessible and affordable.

The implementation of AI in dental education comes with costs, both in terms of infrastructure and faculty training. AI systems require significant computational power and data storage capabilities; institutions need to invest in these resources to fully harness the potential of AI in education if they want to build the algorithms on-premise. Alternatively, companies are building these products to be cloud-based and would thus take on those expenses. Additionally, faculty members must be trained to integrate AI into their teaching methods and utilize AI-driven tools effectively; new competencies need to be integrated into the curriculum.^{10,11} Training is essential to ensure that educators can guide students through the AI-enhanced learning experience. Accrediting bodies must adapt their approach to assessing institutional and educational quality when evaluating innovative programs or organizations playing a leadership role in the adoption of technology to advance health professions education.

The long-term potential benefits of adopting technology-enabled education are substantial. AI has the potential to democratize access to dental education teaching materials for interested students. The cost of dental education, including tuition, materials, and clinical training, can be a significant

As the current generation of dentists inspires and educates the next generation of clinicians, it is our responsibility to embrace innovation, actively evaluate and promote the application of AI into dental education and practice, and prepare students for a future where technology is inextricably incorporated into dentistry. By doing so, we can create a more equitable and effective dental education system, ultimately benefiting patients and society as a whole.

financial burden for students. AI can help lower these costs by providing online resources, virtual simulations, and personalized learning experiences that reduce the need for expensive textbooks and equipment.⁷ This, in turn, can make dental education more accessible to a broader and more diverse group of aspiring dental professionals.

Furthermore, the education space has changed significantly post-COVID-19, and remote learning has become more acceptable.⁷ AI-driven education can reach students in remote or underserved areas where traditional dental education programs may be lacking.⁸ By providing access to high-quality educational content online, AI can bridge the gap in dental education and ensure that students from all backgrounds have the opportunity to pursue a career in dentistry. This inclusivity can lead to a more diverse and representative dental workforce, which is crucial for addressing oral health disparities in underserved communities.

Conclusion

The integration of AI into dental education is not merely a choice but an imperative in our rapidly advancing digital age, often referred to as the fourth industrial revolution.¹² Dental educational institutions should equip the next generation of dental

professionals with the skills to harness the potential of AI.¹ By integrating AI into the educational process, and we can ensure that our students become proficient clinicians and responsible digital citizens.

AI has the potential to revolutionize personalized learning, offer realistic hands-on experiences through simulation and modeling, and provide invaluable clinical decision support. While challenges such as ethical considerations and resource constraints must be addressed, the prospects for improving dental education through AI are vast.

As the current generation of dentists inspires and educates the next generation of clinicians, it is our responsibility to embrace innovation, actively evaluate and promote the application of AI into dental education and practice, and prepare students for a future where technology is inextricably incorporated into dentistry. By doing so, we can create a more equitable and effective dental education system, ultimately benefiting patients and society as a whole.

AI in dental education is not a fleeting trend but a transformative force shaping the future of health professions education and clinical care delivery. This transformation is necessary to ensure that AI is a valuable tool for the next generation of dental professionals.

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Plausible Deniability and Algorithmic Bias in Automated Decision-making

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Introduction

Artificial Intelligence (AI) is evolving and has already infiltrated the healthcare system, including the dental industry from chairside applications to insurance claims handling. First described in 1956 by John McCarthy, the premise for the creation of an artificial intelligence (AI) was based on the presumption that “every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.”¹ Decades later as computational power, machine learning frameworks, and our understanding of neural networks and intelligence have evolved, the realization of AI today provides dentistry, and health professions at large, with a host of tools that come with their attendant questions of use, usefulness, and users. There are many reliable and some not-so-reliable chairside applications of AI impacting diagnosis, imaging, and treatment planning, and there are major challenges in technical and ethical aspects including the possibility of bias, accessibility, and poor data quality.²

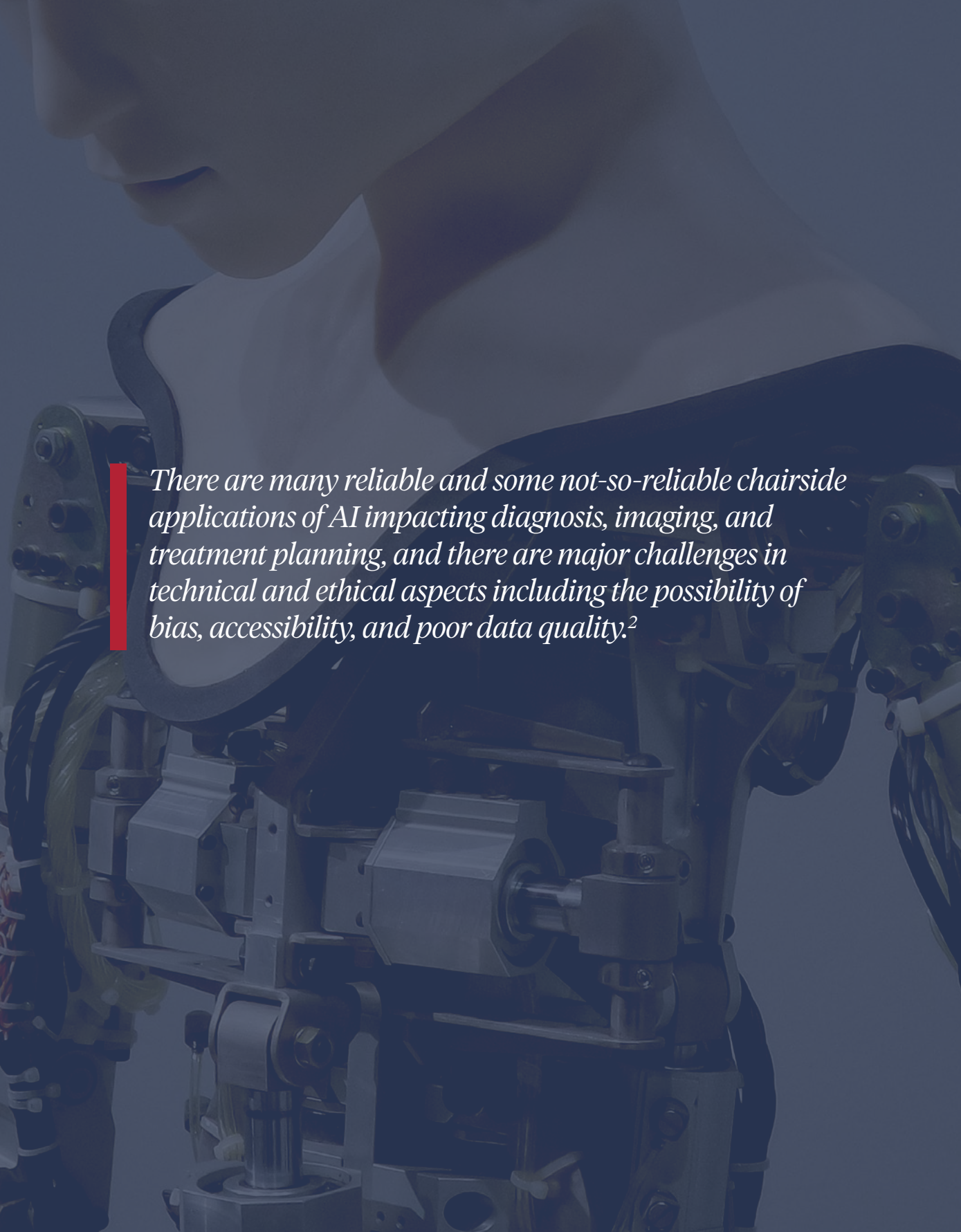
The shift to machine learning and use of advanced algorithms in the 2000s brought AI into dental diagnostics.³ With the development of CAD/CAM systems for labs and offices, technological advancements in machine learning, database technology, and other algorithmic advances, there are now many chairside applications for AI. These advanced algorithms were designed to learn patterns from large data sets, leading to more sophisticated applications. For example, AI algorithms have been developed to enhance the quality of imaging by improving contrast, reducing noise, and providing overall better visualization detailed images for accurate diagnosis. AI analysis promises the early identification of dental caries, with ability to detect early changes in tooth density, leading to early intervention and prevention. While machine learning and caries detection looks promising, there remains some questions as to its accuracy. Without clinical exam findings and patient history and risk factors

this technology should be considered adjunct to a dentist’s radiographic analysis.^{4,5}

Plausible Deniability of Algorithmic Bias

These technologies, like others, create new decisions and decision points for patients, providers, and other stakeholders. The fact that practical and ethical challenges result from the proliferation of novel technologies in healthcare environments is not a new phenomenon. These applications of science are shared valued entities—they are at once inculcated with the values of their creators, but also develop their own identities that may not be compatible with human factors or clinical values.⁶ Despite progress, many stakeholders are still waiting for Godot; however, the business case remains a primary driver of health information technology adoption, and the values of the c-suite reign over those of patient and provider.^{7,8}

Private enterprise and profit motive are hallmarks of the *new medical industrial complex*, which transforms human beings from patients to consumers to claimants—and health information technology is among its chief instrumentalities.⁹ Through technological innovation, ends are transformed into means as it focuses upon the instrumental value of patients as consumers of a product or service.¹⁰ This type of objectification of patients has led to documented disparities in the name of cost-containment, with dentistry being among the practice areas where racial and ethnic minorities have the greatest needs and abilities to benefit.¹¹ These disparities are exacerbated by algorithmic bias of health information systems, defined as, “the instances when the application of an algorithm compounds existing inequities in socioeconomic status, race, ethnic background, religion, gender, disability or sexual orientation to amplify them and adversely impact inequities in health systems.”¹²



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Plausible Deniability and Algorithmic Bias in Automated Decision-making

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Recent class action lawsuits filed against Cigna Corporation and Cigna Health and Life Insurance Company in California¹³ and Connecticut¹⁴ Federal District Courts are illustrative of the effects of corporatized health information technology. The complaints filed against Cigna, one of the largest insurers in the United States, allege that the insurer violated state and federal consumer protection laws by leveraging AI to deny medically necessary claims *en masse* intentionally and systematically, and without any meaningful review by physicians. Cigna's AI, called *PxDx* ("procedure-to-diagnosis"), is an automated system that reviews claims in large batches for pre-set approval criteria. Using this system, for example, Cigna was able to deny over 300,000 claims, reviewing each in approximately 1.2 seconds—far more efficiently than a human agent could—and calling accuracy, accountability, and transparency into question. These lawsuits will test whether algorithmic denial of claims meets the same fiduciary standards as human physicians hired by Cigna to review and deny claims,^{13,14} and the outcomes will ripple to impact other stakeholders, such as subscribers to Medicare Advantage plans that have also utilized algorithms to systematically deny claims.¹⁵

Given the interests involved, the impacts from these and similar cases will be significant. Denial of claims is capture of capital and profitable. It is an old trope; however, there is little need to change when as few as 0.2% of insured patients appeal denied claims.¹⁶ Healthcare providers continue to acquiesce, participate in, and profit from these business practices. The ADA Principles of Ethics and Code of Conduct allows dentists to "exercise reasonable discretion in selecting patients for their practices," if they do not reject patients based on "race, creed, color, gender, sexual orientation, gender identity, national origin or disability."¹⁷ The discretion of some dentists has allowed for financial influences of insurance claim adjudication upon the dental practice that has gone beyond denial of claims and into

unilateral disallowance of treatment that interferes with clinical judgment and patient autonomy.¹⁸ The discipline of dentistry has not taken a firm stance on these contractual practices, to the dismay of some,¹⁹ and dentists already profit from cost-containment strategies that the Institutes of Medicine recognized as exacerbating inequities¹¹ regardless of any algorithmic interference.

When clinical processes are automated, they can algorithmically replicate or amplify human bias against protected groups.²⁰ This algorithmic bias challenges a healthcare system that lacks clear ethical standards of fairness, suffers from poor contextual specificity due to systemic inequities embedded in datasets and system architectures, and does not always understand how the *black box* produced its outcome.¹² Black box medicine, "the use of opaque computational models to make decisions related to health care," is characterized by its ability to capture complex biological relationships that few can explicitly understand or explain.²¹ Machine learning models can also be deliberately trained to mask training data to hinder detectability, thus creating plausible deniability, of intentionally biased algorithms or unfair business practices.^{22,23} Insidious business practices could be difficult to detect if these practices are exploited; however, bias is also perpetuated by electronic health record data containing incomplete or poor quality data that lack representation of medically underserved populations and exacerbate systemic, social, and health inequity bias.²⁴ While, bias detection should be a part of any deliberative healthcare AI decision-making process, the current regulatory atmosphere is a typical patchwork that balances market forces and typical consumer protections that do not consistently attend to systemic inequities, if at all.²⁵ The Algorithmic Accountability Act was proposed in the 116th Congress to address concerns about AI integrity, discrimination, and oversight; however, the Act did not become law.²⁶

While, bias detection should be a part of any deliberative healthcare AI decision-making process, the current regulatory atmosphere is a typical patchwork that balances market forces and typical consumer protections that do not consistently attend to systemic inequities, if at all.²⁵

Guidelines for Development of AI

In a weak regulatory environment, professional values of stakeholders can be a powerful driver of ethical technology proliferation. Professional guidelines and recommendations exist, and they generally recommend a human-centered approach that includes deliberate processes for decision-making that consider human factors, systemic contexts, and clinical concerns.^{24,27-29} A recent scoping review of guidelines and quality criteria identified six comprehensive phases for AI-based predictive model development that include:

Phase 1: data preparation, collection, and checking to specify medical problems and contexts; ensure compliance with relevant confidentiality and privacy regulations; sufficiency of data sample size, representativeness, and quality; appropriate preprocessing for consecutive phases, and; application of relevant coding standards.

Phase 2: development of the predictive model for prediction performance, interpretability, and end-user familiarity; AI parameter training; internal validation and calibration; and measures to identify and prevent bias, improve generalizability, and facilitate transparency.

Phase 3: validation of model performance when applied to external data, and generalizability to new settings.

Phase 4: development of interoperable software applications that comply with coding standards and organizational

infrastructures; reflect standards of human-computer interaction, inclusiveness, useability, and digital literacy; and facilitate updates, monitoring, security, and testing.

Phase 5: Performance of a feasibility assessment with clearly defined use cases to determine clinical utility, understand functionality within the clinical workflows, identify sources of risk, and conduct a prospective comparative impact study.

Phase 6: Implementation in daily clinical practice with regular monitoring, maintenance, updating, and auditing.³⁰

Gaps in the literature remain, but guidance exists to facilitate due diligence in the deliberate development and application of AI-based predictive models. The governance of AI is co-evolving with the field itself and should drive attention to controversial AI-driven innovations, aim towards the social welfare, and promote the public trust.³¹

Conclusion

The words *bias*, *disparities*, and *algorithm* do not appear in the ADA Principles of Ethics & Code of Conduct, but they do not need to. The principle of autonomy obliges dentists to become knowledgeable of the systems that they use and be able to explain them and their alternatives to inform shared decision-making. The principle of nonmaleficence includes knowing the limitations of clinical interventions and refraining from causing known harms, such as those created by biased AI-driven decision models. The principle of be-

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beneficence and duties to promote welfare identify dentists' obligations to consider patient and public needs when entering fee-for-service, manage care, and other contractual arrangements with payors. Likewise, the principle of justice should include and promote algorithmic fairness in patient selection, clinical decision-making, and other areas where automation is implemented into research and practice. These pillars which den-

tists practice by should be expressed throughout the entire industry from development of new applications for direct patient care to insurance claims handling. With the infiltration of AI into the dental landscape faster than we can regulate or understand, there must be a call for organization to standardize its use with ethics and good faith in mind.

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Artificial Intelligence and Dentistry: Remembering Rural America

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Artificial Intelligence (AI) brings with it the potential for vast possibilities concerning evolution and innovation. Integrating AI into dentistry will allow practitioners to detect illness and disease early and allow for better recordkeeping and streamlining of clinical processes. However, such technological advancement is inaccessible to rural residents because of insufficient infrastructure. Without addressing ethical concerns regarding access, justice, beneficence, and nonmaleficence, rural communities risk further marginalization as dentistry adopts and promotes AI technology.

One of the primary goals of using AI in dentistry is to save the practitioner and patient time and resources by optimizing diagnostic and preventive care.⁷ Dentistry can achieve this goal by utilizing AI's ability to detect diseases earlier than human ability. Dentists can often identify health conditions early because symptoms of many diseases and infections appear in the oral cavity before manifesting in other places in the body.⁸

While technological advances in healthcare delivery and their continual refinement are essential for societal progress, innovators and practitioners must recognize those left out of this evolution and the consequences for individuals and communities. Incorporating artificial intelligence (AI) into dentistry offers a range of benefits but has implications for oral health inequity that must be considered. Given the ramifications of poor oral health,¹ this is a critical issue in health services, particularly in rural communities where poor oral health consequences may be more common.²

A lack of adequate transportation options, including public transit, makes traveling to healthcare services complex in rural communities,³ where the average distance to the nearest healthcare facility is 10.5 miles.⁴ Additionally, many rural residents lack medical and dental insurance. While Medicaid can assist those with financial hardships, dental services, if available at all, are limited to preventive care (e.g., cleanings, dental exams, and sealants) and are often only offered to children.⁵ Consequently, many adults are driven to delay dental services until the need is urgent, resulting in visits to the hospital emergency room. This reliance on emergency dental care contributes to an annual expenditure cost of approximately \$1.7 billion to the US healthcare system,⁶ a figure that will only increase with continuous neglect of rural areas.

Common themes exist in urban and rural communities; however, distinctions in population, development, and social mobility set the latter apart. These factors challenge the traditional ways practitioners deliver healthcare services to rural residents. When strategically researching and discussing solutions to rural communities' unique medical issues, understanding the ethics of those solutions helps create

a framework that fosters positive impacts. It also assists in preventing unjust outcomes. In the face of technological innovation, rural communities need solutions that address the inequalities and inequities their geolocation presents. While ongoing discussions center around advancing the dental profession, there remains a central concern: Without addressing ethical concerns regarding access, justice, beneficence, and nonmaleficence, rural communities risk further marginalization as dentistry adapts and promotes AI technology.

The Ethical Issues

One of the primary goals of using AI in dentistry is to save the practitioner and patient time and resources by optimizing diagnostic and preventive care.⁷ Dentistry can achieve this goal by utilizing AI's ability to detect diseases earlier than human ability. Dentists can often identify health conditions early because symptoms of many diseases and infections appear in the oral cavity before manifesting in other places in the body.⁸ Moreover, AI can identify potential risks for non-oral diseases, such as osteoporosis, by discerning patterns and correlations when diagnosing medical conditions.⁹ Dentists expect to use AI technology to enhance patient care by leveraging its ability to detect subtle changes, which assists in determining the most effective treatment strategies and minimizes the probability of misdiagnoses.¹⁰ The early detection capabilities of AI allow healthcare professionals to optimize the management of medical resources. Its ability to diagnose various medical conditions typically leads to improved survival and recovery rates. However, it is who has access to these life-saving services that stimulate ethical debate.

There is a difference between acknowledging the complex challenges that rural areas face that result

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in health disparities and discussing how innovators and health professionals have overlooked these areas when conferring healthcare's future. Many scholars have reported the statistics and facts supporting rural America's unmet health needs. What is lacking in the public square is the realization that discussions regarding the advancement of healthcare often fail to recognize how the challenges of the rural areas disqualify those residents from the futuristic and cutting-edge opportunities the healthcare profession hopes to develop and utilize. Without strategically and purposefully prioritizing rural residents, the injustice gap will widen. Dental professionals must address their ethical responsibilities to the underserved in the face of technological advancement within healthcare. Studies show that rural residents are more likely to die prematurely from their health problems than urban residents.¹¹ When scholars categorize the statistics by race, Black rural residents experience worse overall health than white rural residents,¹² with severely unmet health needs by 66 percent (66%) to 40 percent (40%).¹³ Even with the knowledge that technological advancements can help reduce the probability of adverse outcomes in all persons, there is a constant lack of discussion of how to grant all people access.

Access

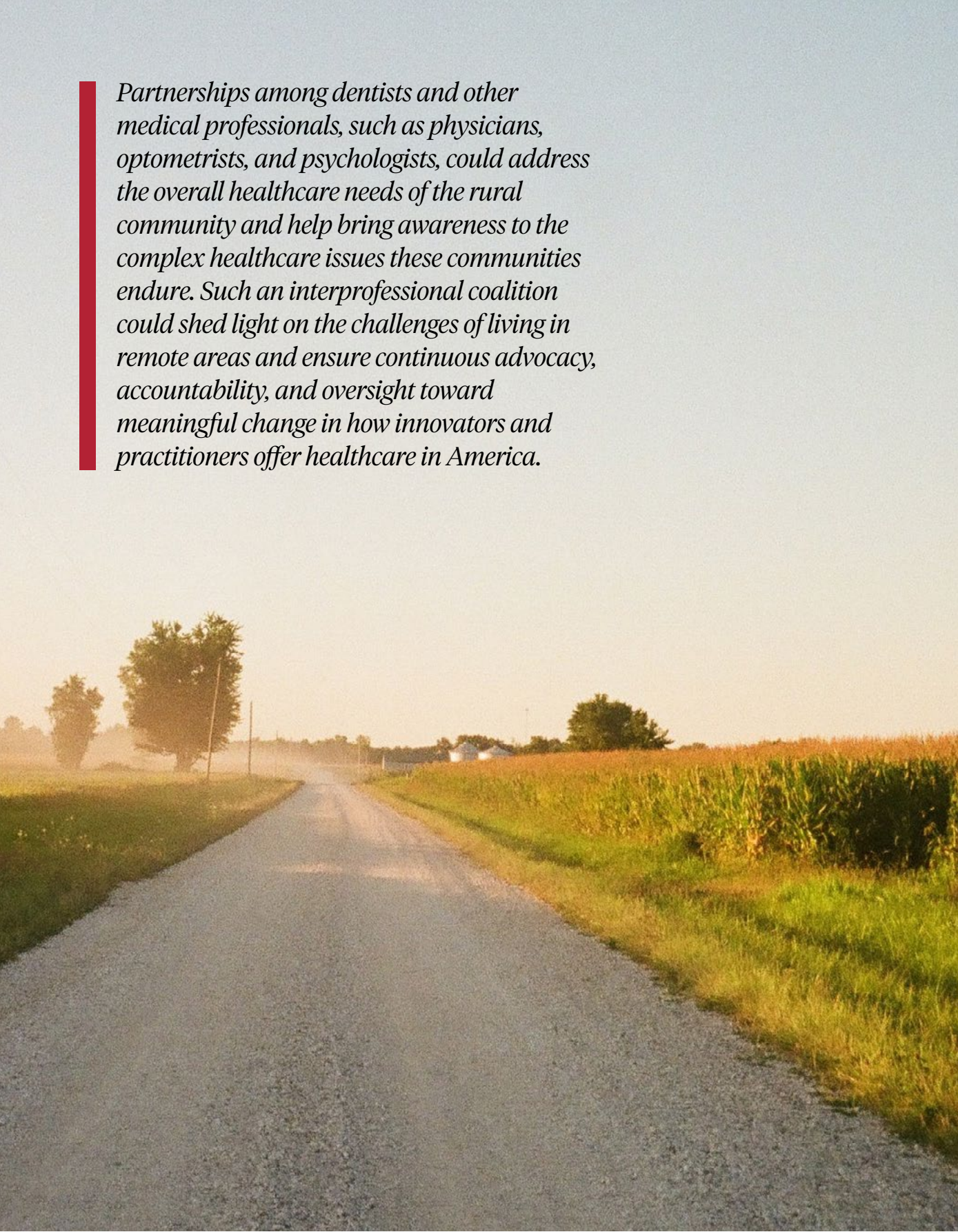
In 2022, the American Dental Association (ADA) supported a workgroup, the Standards Committee on Dental Informatics (SCDI), which released White Paper No. 1106 for Dentistry.¹⁴ This document details the advancements AI has made possible and forecasts its impact on the profession in the foreseeable future. What is missing is a discussion concerning the process by which all communities are to access such technology, including rural America. Due to access barriers, approximately 20 percent (20%) of the nation's population may find the information within this document hollow, as this percentage resides within classified rural areas.¹⁵

While some can argue that the SCDI crafted White Paper No. 1106 for Dentistry with only the practitioner's education in mind, each practitioner is still responsible for determining for whom these state-of-the-art detailed services will benefit within their practice. General dentistry is perceived as necessary for overall health.^{16, 17} While limiting access to elective cosmetic services to those who can afford them may be justifiable, restricting access to services as needed for general health denies the underserved distributive justice.

Justice

Often missing in discussions about the future of healthcare is the accountability to ensure rural residents are afforded the same opportunities as their urban counterparts. Responsible Research and Innovation (RRI) is an approach that focuses on how research and innovation create power imbalances between stakeholders.¹⁸ The RRI approach calls for innovators to consider the purpose of the designed technology and their target consumers within the early stages of development.¹⁹ Innovators who research potential structural barriers hindering access to their target audiences have a greater chance of addressing those obstacles. If they appropriately conduct RRI within rural areas, innovators could address and likely reduce or eliminate many well-known challenges.

Partnerships among dentists and other medical professionals, such as physicians, optometrists, and psychologists, could address the overall healthcare needs of the rural community and help bring awareness to the complex healthcare issues these communities endure. Such an interprofessional coalition could shed light on the challenges of living in remote areas and ensure continuous advocacy, accountability, and oversight toward meaningful change in how innovators and practitioners offer healthcare in America.



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Practitioners should continue to search for solutions to center those outside the margins of care to ensure all persons receive the general care they need. The discussions concerning the future of healthcare should include all persons, including rural residents. It is this inclusivity that promotes and fosters strong and meaningful patient-dentist relationships.

It is unethical to discriminate against people based on geographical location. Geographical discrimination impacts how people in rural areas receive care. The ADA Principles of Ethics and Code of Conduct (Section 4) charges the dentist to express the principle of fairness through allyship with other community leaders on specific activities to help improve access to care for all people.²⁰ Less fortunate and underprivileged citizens in rural areas are owed the assurance of technological and geographical justice.

Beneficence and Nonmaleficence

As with all technological innovation, as advancements become standardized, older techniques and practices become less utilized. Thus, keeping all health professionals updated with the latest information and technology is vital. Patients risk injury and death if health professionals fall behind in educational progressions. According to the ADA Principles of Ethics and Code of Conduct, the privilege for dentists to be considered a professional. Because of this, dentists have an obligation to keep their knowledge and skills current.

Often, the practitioners who work in rural areas need more resources such as broadband, funding, professional development opportunities, and trained and educated staff. These are all required to benefit from the advancements that arise with AI. Thus, the disparities between professionals, not just patients, become an ethical issue concerning justice.

Conclusion

The bioethical principles help identify missed opportunities and overlooked discussion points. The principles should lead one to an ethical course of action. The ADA masterfully centers the patient within the ADA Principles of Ethics and Code of Conduct, teaching their practitioners the importance of the patient-dentist relationship. However, there must be a recognition that for practitioners to center the patient within care, both practitioners and patients must first have access to it.

Teledentistry has successfully allowed some rural individuals without regular access to dentists to receive dental care.²² The online service is crucial in reducing healthcare costs by curbing the frequency of emergency room visits and costly procedures, primarily driven by those unable to receive dental care. Unfortunately, the service may be unavailable to all persons in remote areas due to limited and insufficient infrastructure. However, this technology has been a step in the right direction. Practitioners should continue to search for solutions to center those outside the margins of care to ensure all persons receive the general care they need. The discussions concerning the future of healthcare should include all persons, including rural residents. It is this inclusivity that promotes and fosters strong and meaningful patient-dentist relationships.

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The Future Is Coming and it Will Be Amazing: Computers in Dentistry

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The computer in the dental office, especially at chair side, provides both “high tech” and “high touch” benefits.

Single entry of data has the benefit of accuracy and time savings. It also makes data available regarding the practice in an easy-to-use fashion.

Some suggestions are offered to those contemplating the addition of a computer system to their offices.

There is a fundamental change taking place in how computers are being used in the dental office. Dental computers are being used for more than just bookkeeping and are making their way into the treatment rooms. This basic shift in use and vision for computers goes by a number of names, “clinical work stations,” “frontdesklessness,” and the “paperless office.” Some of these ideas seem pretty extreme at first, but once you understand why and how, the transition is inevitable, and it will transform the way we manage our dental practices forever.

“High Tech – High Touch”

John Naisbitt the author of the best selling book *Megatrendr* coined the phrase “High Tech–High Touch.” Naisbitt noted that people really do like high tech. That is they like the excitement of it, they like the change, the novelty, the speed and rapid access to information, they like new and innovative ways of doing things. But they don’t like being depersonalized. They don’t like being turned in to a number or “digitized.” If they perceive that technology is taking over, if the technology is more important than they are, then high tech back lash results.

The challenge, according to Naisbitt, is to provide the high tech innovation people want and businesses need and at the same time to provide the personal high touch relationships people demand.

Dentistry is a perfect example of a “high tech–high touch” profession. Dental patients really do want their dentist to be up to date, using the latest and best methods. They want and even expect their dentist to be state of the art, cutting edge technology perfect. And yet at the same time what most of them really want even more is a personal one on one relationship with their dentists. They want to be recognized and appreciated as an individual human being. They crave high touch.

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With that in mind it is appropriate to begin a discussion of computers in dentistry not with computer systems but with human systems.

Putting Dentistry and People First

Computer enthusiasts or sales people often make the mistake of jumping into dentist's lives with wonderful stories and demonstrations of what computers can do. They are so focused on the computer they miss what is really important to the dentist, which is the daily grind of dental practice. It is hard for a dentist who is worried about crown margins and insurance hassles to become excited about computers unless the dentist can see a real high touch relationship to daily practice.

So, what happens in daily practice? Dentists diagnose and treat dental disease. Once a dentist diagnoses a dental condition and proposes a treatment, a series of steps is begun to properly document and communicate the procedure.

These same steps are required whether or not the dental office is using a computer. Following are the communication and documentation steps most dental offices would commonly follow on paper to complete a simple single procedure. The process almost always happens this way. The dentist, dental patient, and dental assistant are all sitting in the treatment room. The dentist peers into the patient's mouth and says something like "tooth number three needs a crown." The assistant then makes a mark on the patient's tooth chart almost always in red, outlining or highlighting tooth number three in some way. That is the first documentation step. Then a treatment plan of some sort is made. There are virtually dozens of ways this can be done but in all of them someone writes down "tooth number three crown."

The patients are then sent to the front to be scheduled. Before they make an appointment they almost always ask, "How much will this cost and what will my insurance pay?" At this time the dental staff member will give the patient an estimate, prepare

an insurance pre determination form, make an appointment in the book, and give the patient an appointment card. At a minimum the staff member will write "tooth number three crown" on all four pieces of paper. The staff member will also write the patient's name, the fee, insurance codes, and a lot more in some cases.

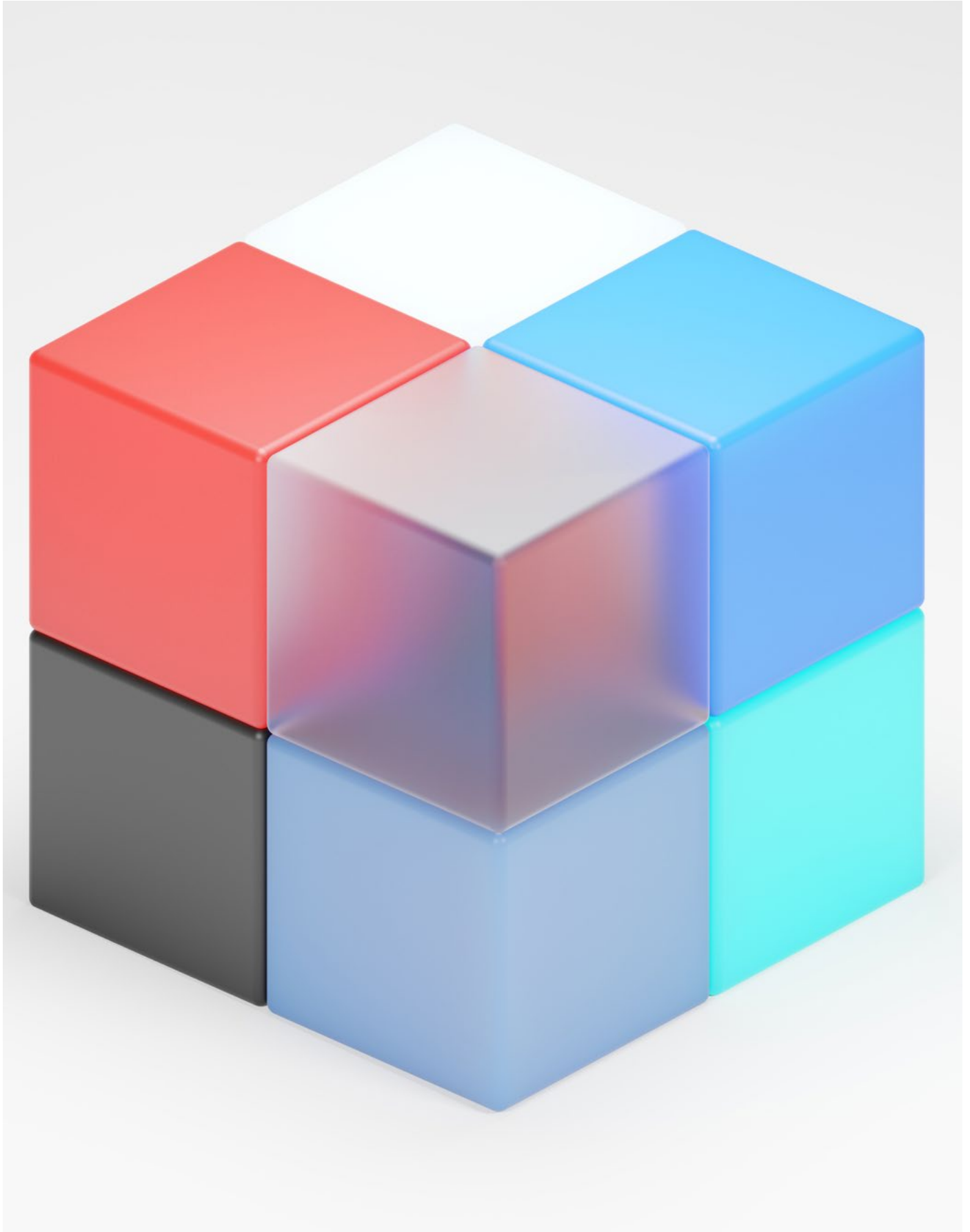
When the patient returns for treatment another whole series of documentation and communication steps begins. These include the daily schedule, chart notes, lab slip, chart update, ledger, receipt, day sheet, and insurance claim. Once again the dentist and staff must write "tooth number three crown" and usually a lot more on all of these forms. But that isn't the end of it; the patient still needs to come back for a seating appointment. That means another book entry, an appointment card, a daily schedule, and then more chart notes.

The final step is payment. This could include payment entries to the ledger and monthly billing statements. Again there are half a dozen ways to do this, but most of them require the dental staff to again write "tooth number three crown."

If you go back and add up all the entries, there are up to twenty times the dentist or dental staff must write "tooth number three crown," usually along with a lot more general information such as the patient's name, social security number, insurance codes, fees, and on and on. And these twenty entries represent one procedure for one patient. If you start adding up all the patients and every procedure the paper work burden is staggering. If that isn't frightening enough keep in mind that every time an entry is made there is a chance to make an error.

Single Entry

There are some things computers do well and there are some things they don't do well at all. One thing computers do very well is the same thing over and over again. They do it very accurately, very quickly, and they never get bored with it. That means that



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with a good computer system the dentist only has to enter “tooth number three crown” one time. The computer will then transfer that information to all the other places it is needed. It will attach the other information such as fees and insurance codes automatically. It will do it instantly and accurately. This feature is called single entry.

The single entry feature of a computer system has a profound effect on the human systems of a dental office. Single entry frees the staff to do other things, such as care directly for the patient. It speeds up the communication process, saves time, and reduces errors. It reduces stress and makes dental staff jobs more meaningful and human directed. The single entry concept is very important because it answers the fundamental question, “What the heck does a dentist need a computer for anyway?” and it leads to most of the advanced features and uses of computer systems in dentistry.

For example, the two most critical entries from the list above are diagnosis and completion of treatment. Both of these events take place in the treatment rooms. If you do not have treatment room based computers then you can not do true single entry and must rely on notes or other person to person communication. The dentist must make a paper chart entry then take it to a computer to enter it again. Everything is done at least twice and there is more chance for error. Using the power of the computer for single entry to speed production and reduce error is the goal and treatment room based computers are a logical extension of the goal.

Once the dentist makes the shift and puts the computer in the treatment room then other possibilities follow. If you can access the schedule in the treatment room via the computer then why not schedule the patient. The only reason we sent them up front to schedule before was because that’s where the paper book was. If you can access patient information such as medical notes and progress notes on the computer then why make a paper record. Electronic notes are easier to access, more complete, easier to store

and transmit and contrary to popular conceptions are actually safer than paper records provided the office follows proper back up procedures. Also now that all the treatment and patient data are stored in the computer why print or write up an insurance form? Just send the data electronically with electronic claims. When the dentist reaches this point then clinical work-stations or computers in the treatment rooms makes more sense. “Front-desklessness” or scheduling from the back seems logical. And the “paperless” office becomes possible.

More possibilities. If the computer is already in the treatment room then it is easier and less expensive to add on extras such as digital x-ray, digital intra oral camera images, cosmetic imaging, patient education programs, drug and prescription programs, and to present complete treatment plans with accurate estimates and insurance information chair side.

To restate all this in another way: Advanced totally integrated, multiple application, chair side, computer systems are the ultimate dental version of “high tech.” But the successful high tech dental office rarely starts with this in mind. Instead the first concern is human “high touch.” How can I do the better job faster and with fewer errors? How can I serve my patients better and faster and cater to their needs? How can I make my staff members’ jobs easier and more rewarding? And finally, how can I use the things computers do well to help me? The answer to all these questions is single entry computer use. From that everything else follows. If you start with the ultimate high tech office as the goal in itself with out the human “high touch” benefits in mind it doesn’t make much sense. Dentists then rarely see the value or benefit in the “high tech” dental office.

Bonus Information

The second thing that computers do very well is that they can store and sort data very quickly and completely. A computer can keep track of tremendous volumes of information that humans could never possibly follow. And the computer can do it faster, more accurately, and much less expensively than a human being. The single entry process creates vast amounts of data a dentist couldn't possibly collect by hand and it can be used to monitor how the practice is doing and to keep track of patients needing treatment. This is an extra, the initial goal was single entry, collecting and using data for management purposes is another logical extension of the goal.

The type of data and how it is related is almost unlimited. The dentist can now examine virtually any aspect of the practice using the numbers collected with the single entry process. The obvious information is the things we have always checked, like gross production and collections, past due accounts, and insurance tracking. But now with a sophisticated computer system you can monitor treatment diagnosed. What is the average amount you diagnose? What procedures do you do the most of? How much of the work you diagnose is accepted? How much time do you spend on certain procedures? Which insurance companies pay the fastest? Which local employers do most of your patients work for? You can track down people who need work done but have just put it off and never been scheduled. You can even combine the data with word processing to produce marketing letters to reactivate inactive patients.

In fact the data and what can be done with it can be easily overwhelming. Some dental offices see how overwhelming it is and say that's just too much I can't use that; I don't need that. However they fail to realize the real first step with the computer is single entry. The data and what can be done with it is just extra. And even more importantly, it is collecting, understanding, and using data wisely that is at the heart of the information automation revolution. It may certainly seem overwhelming but understanding and using information is the essence of the fun-

damental changes sweeping dentistry. Those who understand and embrace the information age will profit from it.

Getting Started

Two things are required to help an office get the most out of new technology. First the dentist must be involved and committed to the process. It is amazing how many dentists do not want to have anything to do with the computer. In fact some of them seem to be actively hostile. The dentist will never get the full benefit of the system unless he or she takes the lead and actively uses the computer. The improvements in office efficiency and the benefits from easy access to practice and financial data will easily pay for the system and ultimately increase office income. However it is unbelievable how many dentists not only don't use the system but actively undermine office productivity by refusing to use the systems they have paid for. For example, some offices use an electronic scheduler but still keep a paper book. That is absurd; burn the book.

Once the dentist is committed, the next step is to get the staff involved and learn to use the whole system. One good way to do this is to develop a series of goals and rewards. Another means is to plan continued training on a regular basis. Some really motivated offices may want to try to do everything all at once but this can also cause problems. People and groups can only accept so much change at once. If you try and force things too quickly you may burn people out, indirectly sabotage your plans and lose staff members. Another common problem is people who want to read the entire manual and know it all before they start. Computer programs really don't work that way. Some basic training and understanding of the software is required but the best way to really learn a complex software program is to use it.

Set goals throughout the first year after you get a new system. Then reevaluate where you stand after that year and plan for new goals for the next year. Tie a reward to each goal. Money is always nice, but other rewards can be used as well. For example an office lunch or some small computer related gifts.

The Future Is Coming and it Will Be Amazing: Computers in Dentistry

Lawrence F. Emmott, DDS

Budget

The final element is the budget. There are many costs associated with advanced technology besides the price of the software. These include hardware, networking, set up, training, future training, support, updates, and accessories. Anticipating these costs and planning for them will make your technology acquisition easier and it will pay off in greater value.

According to an article in *Investor's Daily* the average health care office spends 2% of revenue on technology. That includes hospitals as well as physicians and dentists. In addition the article noted that businesses in general spend an average of 10% of gross revenue on technology. Therefore an average dental office should plan to invest at least 2% of gross income in technology on an annual basis. For a typical single practitioner with a \$450,000 gross the annual investment should be at least \$9,000. A better budget would be 5-7% or more for an aggressive "high tech" office. That translates into \$22,000 to \$32,000 per year.

In addition to training, dentists need to budget for hardware replacement. Plan on replacing your computer hardware every three to four years. You will not need to replace it because it wears out but because it will no longer be powerful enough to run current software. A good method to do this is to cycle or replace one third to one fourth of the computers every year. If, for example, you have six computers replace one or two every year. That keeps the office more up to date and spreads the cost out over time.

Another continuing cost will be support, software upgrades, and new software. There are a whole

bunch of software programs used in dentistry besides basic practice management. These include operating systems, word processing, check book and accounting, voice recognition, faxing, back up, human resources, utilities, as well as special dental programs like imaging, eclaims, or x-rays. All of these programs will need to be purchased, installed, supported and upgraded. All of that will cost more money. The point is not to be discouraged by the costs; wise technology investments will pay for themselves. The point is to be prepared; don't be surprised by these ongoing expenses and plan a technology budget.

A great computer system won't overcome a bad dental office manager any more than a great hand piece will make you a good dentist. Training and developing the people in the office, including the dentist, to use advanced technology effectively is at least as important as the hardware and software components. Dental office computer systems with chair side terminals are not just gimmicks using fancy toys but they will increase efficiency, save money, and quickly pay for themselves.

Computers in the treatment MOMS, frontdesklessness, the paperless office, digital images, information management, and much more are all coming to dentistry. And they are going to come because they will make the way we practice better. Just like the high speed air turbine hand piece changed dentistry forever, new dental computer systems will change how we practice forever. Some dentists will hold back and fear change or even resent it. Others will embrace new technology and grow with it. But what ever your personal attitude one thing is certain, the future is coming and it will be amazing!

SUBMISSION REQUIREMENTS

Submitting Manuscripts for Potential Publication in *eJACD*



The communication policy of the College is to “identify and place before the Fellows, the profession, and other parties of interest those issues that affect dentistry and oral health. The goal is to stimulate this community to remain informed, inquire actively, and participate in the formation of public policy and personal leadership to advance the purpose and objectives of the College.”

Manuscripts for potential publication in the *E-Journal of the American College of Dentists* should be sent as attachments via e-mail to Suzan Pitman at Suzan@acd.org. In the submission cover letter, please confirm that the manuscript or substantial portions of it or prior analyses of the data upon which it is based have not been previously published and that the manuscript is not currently under review by any other journal. Submissions must include:

1. The full name of each author;
2. E-mail address, mailing address, fax number and phone number for each author;
3. Degrees and institutional affiliation of each author; and
4. Statement of responsibility from each author indicating what they have contributed to the document.

Submissions should:

1. Be between 1500 and 3000 words in length;
2. Use inclusive language including gender neutral pronouns unless referring to specific persons;
3. Sufficiently de-identify any descriptions of patients and/or clinical encounters or have written consent from the individual or individuals;
4. Include disclosure of any conflicts of interest;
5. Designate one corresponding author;
6. Follow the most recent edition of the American Medical Association Manual of Style; and
7. All published references should be cited in the text and numbered consecutively. No references should be cited in the abstract. Each reference should be cited only once; on subsequent citations, the original number should be used.

Review Process:

The process will include: review by the editor and in some instances a “guest editor” which will occur within 21 days of receiving a manuscript to determine whether it suits the general content and quality criteria for publication in the *eJACD*. All manuscripts that are suitable for publication will undergo blind peer review. Usually there are two anonymous reviewers comprised of subject matter experts and board members of the College and/or the *eJACD* editorial board. Because all peer reviewers are volunteers, review may take between 4 and 6 weeks. Once reviewer comments are received by the editor a decision will be made to: accept, accept with minor revisions, accept with major revisions, or reject. *eJACD* reserves the right to edit manuscripts to ensure conciseness, clarity and stylistic consistency.



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