ADVANCEMENTS IN DENTISTRY

.

The use of digital technology has become an integral part of our daily lives, connecting the world's population like never before. Innovation, especially in the realm of digital technology is happening at an unprecedented rate. However, the potential for digital health solutions to improve the health of populations remains largely untapped.

WHO recognizes the power of digital technology and health innovation in accelerating global health and well-being. The Global Strategy on Digital Health, adopted by the World Health Assembly in 2020, provides a roadmap to integrate the latest innovations in digital health and put them into action to improve health outcomes.

One of WHO's strategic visions is to ensure that digital health supports equitable and universal access to quality health services. Digital health can enhance the efficiency and sustainability of health systems, enabling them to provide affordable, equitable, and high-quality care

These goals are challenging to achieve, especially for low- and middle-income countries. The Global Strategy on Digital Health aims to support countries in strengthening their health systems through the application of digital health technologies, in line with the vision of health for all. The strategy is designed to be adaptable and accessible to all Member States, including those with limited access to digital technologies, goods, and services[32]

1. Importance of Technological Advancements in Dentistry

Despite the general awareness of the significance of oral hygiene and its correlation with overall health, a lot of individuals still experience unease when it comes to visiting the dental practitioner. However, the realm of dentistry is

currently experiencing a revolution with the advent of novel technologies such as virtual reality, artificial intelligence (AI), and CRISPR. It is crucial to welcome these advancements and comprehend their related advantages and disadvantages. The potential for substitute therapies, improved workflow, escalated productivity, and better quality of care is on the horizon. Comparable to other healthcare industries, dentistry has undergone a transformation with computer-based technologies, new preventive measures, and enhanced diagnostic techniques. Digitalization, cloud computing, and the integration of apps with smartphones and other gadgets enable patients to continuously monitor their oral health. Additionally, wearable biosensor technology such as activity trackers, smart watches, and glucose monitors have become an integral part of our everyday lives[33]

2.Technologies That Shape the Future of Dentistry

Technologies are gradually becoming ubiquitous in modern human life. The exponential growth in health data and the maturation of health-care AI have made it possible to integrate smart algorithms within the health-care system. These algorithms can analyze health data, research findings, and treatment techniques to offer diagnostic and therapeutic recommendations for individual patients. Currently, AI is rapidly advancing beyond text-based, image-based dental practice.

The digitization of dentistry is entering a new phase, with dentists using software to gain insights into clinical decision-making. Patient care is also becoming more mobile-oriented, and AI-based devices are crucial in allowing patients to monitor their health and share data with dental practitioners easily. In addition to analysing health data, AI-based algorithms can help specialists better manage dental conditions. In 2019, researchers developed a machine learning method to accurately quantify immune cells near oral cancer cells, providing better insights into the spread of and resistance to cancer and improving the determination of

survival chances. Others are using neural networks to improve the detection of dental decay and periodontal disease from radiographs. These approaches may become standard practice in the near future. The potential applications of AI in health care are limitless[36]

Smart Toothbrush

Intelligent toothbrushes are equipped with numerous advanced features like cameras, sensors, and more to monitor brushing activity and simulate a dental check-up during regular brushing. This enables dentists to examine the individual's teeth using the camera data during brushing. Furthermore, the attached pressure sensors can be used to determine if the brushing process is being carried out correctly.

All the information can be transmitted to the dentist in real-time, thereby enhancing the preventive care process.

The intelligent brush can also capture intraoral images, which are then sent to the server. AI algorithms analyze these images and search for signs of cracks, cavities, or other abnormalities that require a specialist's attention. If the initial scans indicate any concerns, both the patient and the clinician are notified through mobile apps, and the patient is advised to book an appointment at the dental clinic[34]

Augmented Reality (AR)

The technology of augmented reality provides additional virtual information in conjunction with the physical environment, offering diverse opportunities in various fields. Medical education and training have extensively incorporated this technology, particularly in the domain of oral and maxillofacial surgery in dentistry, where the most common applications are dental implant placement and orthognathic surgery. Ongoing technological advancements are facilitating the

exploration of new possibilities in restorative dentistry, orthodontics, and endodontics.

Augmented Reality can be utilized alongside a mannequin, allowing students to perform procedures while receiving immediate feedback as their movements are tracked. This enables them to quickly identify areas for improvement and enhance their skills in the process. Additionally, AR can be beneficial in dental reconstructive and aesthetic procedures, providing patients with a preview of their post-treatment appearance. AR apps use the camera of a phone or tablet to overlay virtual images of the improved set of teeth before the actual procedure. This allows patients and dentists to customize various features of the teeth such as height and spacing according to their preferences even before entering the surgery room.

Virtual Reality (VR)

Virtual reality (VR), not to be confused with AR, is a technology that fully immerses the user in a virtual environment by closing off the outside world with a dedicated headset. By donning such a headset, aspiring dental surgeons and students can be transported to the operating room (OR) from the comfort of their couch, while patients can visualize a calming landscape to improve their experience while sitting in the dreaded dentist's chair.

Currently, only a select few students are able to observe surgeries up close, making it difficult to learn the intricacies of the trade. However, with the help of virtual reality cameras, surgeons can stream operations worldwide, allowing medical students to observe procedures in real-time using their VR goggles. Dentistry has been particularly quick to adopt this technology, which can also be used to help dentists build empathy through simulations that put them in their patients' shoes or in challenging situations.

On the patient side, VR can be an effective distraction tool in dentistry, potentially alleviating anxiety associated with dental appointments. Patients can wear goggles displaying calming natural scenes, which can help them remember their treatments more positively afterward.

Augmented reality and virtual reality have been widely adopted in all areas of dentistry and dental education as digital tools. Virtual articulators, in particular, allow for a thorough analysis of occlusion with dental models that can simulate all mandibular movements in both static and dynamic positions. When paired with additional software, virtual articulators can enhance education and practice, enable quicker and more precise individualized diagnoses, and facilitate discussions of dental treatment planning options with patients during their initial appointment.

Virtual Patients

The incorporation of technology in the field of medicine and dentistry has revolutionized the training methods. This has resulted in an increase in the scope for practicing clinical skills in simulated environments prior to performing procedures on actual patients, leading to enhanced precision in skills that require dexterity and hand coordination. This is especially significant in the field of dentistry. The technology enables the user to navigate and manipulate multimedia 3D sensory environments that are either computer-generated or artificially created in real-time, thus facilitating practical skill development. Compared to traditional teaching methods that do not employ technology, this approach has the potential to offer more cost-effective, interactive, and dependable training.

The utilization of virtual patients in dental education is gaining momentum as an additional method to supplement live patient interactions for training dental students. The use of virtual patients can offer an excellent opportunity for learning and perfecting skills such as patient interviewing, medical history taking,

recordkeeping, and patient treatment planning. By using interactive audio/video elements in virtual patient encounters, the students can experience a more realistic simulation of patient interaction[34]

Tele dentistry

Visiting medical facilities can be challenging for patients with specific requirements or the elderly residing in nursing homes. In addition, distance is a significant concern as individuals living in rural regions rarely have access to dental services and often have no options available. However, this can change drastically with the widespread use of tele dentistry.

Tele dentistry solutions offer convenient access to oral and dental care, are considerably more affordable, encourage prevention practices, and enable patients to consult with medical professionals who may not be otherwise available. It also provides a comprehensive tele dentistry platform that allows patients to capture images, send relevant information to a dentist remotely, and engage in live consultations. The dentist can initiate a video chat with the patient and caregiver, allowing the medical professional to communicate with the patient, establish a relationship, offer assistance, and bring them to the clinic if necessary.

Recent years have seen significant technological advancements in the field of dentistry. The use of computers, telecommunication technology, digital diagnostic imaging services, devices, and software for analysis and follow-up have all progressed. As a result, the science of dentistry has made significant strides in terms of distance. Advanced information technology has not only improved the quality of dental patient management but has also made it possible to manage them partially or entirely from thousands of kilometers away from healthcare centers or qualified dentists. Telemedicine's dental segment, known as "tele dentistry," is responsible for the entire process of networking, sharing digital information, distant consultations, workup, and analysis.[35]

Smart Teeth

The integration of cutting-edge microchips into prosthetics or the removal of a portion of the current tooth to insert a microchip could enable the tracking of various variables. These microchip implants could facilitate the development of "intelligent teeth" that can ascertain the pH of saliva, food consumption, the amount of acidic drinks and meals ingested, blood alcohol levels, and more. The data collected could then be analyzed using artificial intelligence and big data analytics to identify patterns and correlations. This could lead to an increase in personalized preventive dentistry recommendations for each patient[35]

Computer-Assisted Design and 3D Printing

·The utilization of computer-assisted drafting (CAD) and computer-assisted manufacturing (CAM) has grown in popularity within the field of dentistry over the last 25 years. This technology is utilized in both the dental laboratory and the dental office to fabricate inlays, onlays, veneers, crowns, fixed partial dentures, implant abutments, and even full-mouth reconstruction. Furthermore, orthodontic treatments are also incorporating the use of CAD/CAM.

The development of CAD/CAM technology aimed to address three primary concerns. Firstly, ensuring that restorations, particularly those for posterior teeth, possessed adequate strength. Secondly, creating restorations that appear natural. Lastly, simplifying and expediting the process of tooth restoration while enhancing accuracy. In some instances, CAD/CAM technology offers patients same-day restorations[31]

Intraoral Camera and Scanners

Intraoral imaging devices, also known as dental cameras, are digital tools utilized by dental professionals to produce visual records of the oral cavity and teeth. These cameras are designed to be compact enough to fit comfortably in the mouth, attached to an intraoral wand that can be maneuvered around and over the teeth. By capturing high-resolution images of the interior of the mouth, intraoral cameras are able to detect even the tiniest abnormalities that may have been overlooked. The images are then processed using specialized software, such as CAD/CAM applications, which can create a digital 3D model of the intraoral cavity by piecing together hundreds of images.

The use of IOC technology in dentistry has made it possible to record the minute details of the dental structures, which is essential for patient education, documentation of records, treatment planning, lecture illustration, publication, and web connectivity of complex cases. Additionally, IOCs have been found to increase patient compliance in diagnosis, treatment planning, goal setting, oral hygiene instructions, and maintenance[37]

Regenerative Dentistry

·The field of regenerative dentistry is focused on the regeneration of both soft and hard tissues, utilizing tissue engineering approaches. It is an interdisciplinary field that combines engineering and life sciences principles to develop biological substitutes that restore, maintain, or enhance tissue function. This innovative approach challenges the conventional notion of replacing damaged or aging teeth with prostheses, instead aiming to develop self-healing teeth and biological therapies for damaged teeth.

Regenerative medicine aims to improve the healing of tissues and organs, restoring lost physiological architecture and functions. The integration of tissue engineering and cell biology has led to the development of novel regenerative

therapies that aim to repair, regenerate, and replace tissues and organs damaged by chronic and acute diseases or traumatic injuries. Mesenchymal stem cells (MSCs) have shown promising results in self-regeneration and differentiation towards different tissues, under specific conditions and stimuli. MSCs are routinely used in autologous transplantation, where specific molecular effectors and biomimetic scaffolds populated with MSCs have demonstrated effective tissue reconstruction and functional regeneration of complex organs in both in vitro and in vivo experiments[37]

CRISPR

CRISPR, an abbreviation for **C**lustered **R**egularly **I**nterspaced **S**hort **P**alindromic **R**epeats, offers a revolutionary technique for editing genomes. Although it is a natural process, scientists have only recently discovered its enormous potential. This technology may prove to be the ultimate weapon against cancer or, more controversially, could be used to design babies in the future. Additionally, the field of dentistry is expected to benefit from this advancement.

This method has the ability to correct genome errors and turn genes on or off in cells and organisms. Its most important function is to defend bacteria by identifying and destroying DNA segments during bacteriophage invasions. The CRISPR-associated protein 9 (Cas9) enzyme recognizes and cleaves invasive DNA sequences that are complementary to CRISPR. Therefore, researchers use this biological tool to manipulate genes and develop new therapies to combat systemic diseases. Currently, the most significant progress at the laboratory level involves generating cell and animal models, conducting functional genomic screens, capturing live images of the cell genome, and repairing defective DNA to find a cure for genetic disorders.

Robotics in Navigational Surgery

The progress in technology and computer science has resulted in a rise in the utilization of robotics in navigational surgery for various medical fields. The field of robotic surgery is constantly progressing and its applications are expanding continuously. Recently, robot-assisted surgery has been implemented for dental implant placement. The Food and Drug Administration approved the first robotic dental surgery system for dental implant procedures in the United States in 2017. Towards the end of the same year, Zhao and colleagues in China developed the world's first self-governing dental implant placement system. This intelligent robot has a remarkable level of autonomy, has the ability to adjust automatically during intraoperative procedures, and can execute surgical tasks directly on patients without any discernible control by a surgeon.[38]

Nanodentistry

Nanodentistry refers to the utilization of nanotechnology to diagnose, cure, and prevent oral and dental ailments. These methods aim to uphold and enhance dental health. Nanotechnology is concerned with structures ranging from 1 to 100 nm and concentrates on the production of materials with unique characteristics not typically found in nature. As a result, it is believed to be a fundamental technology of the 21st century and has the potential to provide innovative approaches to medicine in general and dentistry in particular. Clinical research is already exploring the use of nanotechnology-based tooth treatments and inventive nanocontainers for localized drug delivery to achieve more effective treatments.

Nanotechnology has already begun to have a significant influence on dentistry, particularly in periodontology, implantology, prosthetic dentistry, orthodontics, and endodontics. Nanotechnology will provide advanced techniques for diagnosis, treatment, and prevention, ushering in a new era in medicine known as nanomedicine. These tools will also give rise to the field of nanodentistry,

creating an interdisciplinary challenge to effectively educate and train all dental specialists and related materials scientists[39]

References:

1. Khanagar, Sanjeev B., et al. "Developments, application, and performance of artificial intelligence in dentistry–A systematic review." *Journal of dental sciences* 16.1 (2021): 508-522.
2. Chandra Kanth B., Chandradeep, Swapna Manepalli (2020). Artificial intelligence and robotics: The enhanced paediatric dentist. *International Journal of Advance Research, Ideas and Innovations in Technology*, 6(6) www.IJARIIT.com.
3. Baliga, M. "Artificial intelligence-The next frontier in pediatric dentistry." *Journal of the Indian Society of Pedodontics and Preventive Dentistry* 37.4 (2019): 315-315.
4. Kurup, Rashmi J., Amandeep Sodhi, and R. Sangeetha. "Dentistry and Artificial Intelligence." *Acta Scientific Dental Sciences* 4.10 (2020): 26-32.
5. Grischke, Jasmin, et al. "Dentronics: Towards robotics and artificial intelligence in dentistry." *Dental Materials* 36.6 (2020): 765-778.
6. Schwendicke, Fet al, W. Samek, and J. Krois. "Artificial intelligence in dentistry: chances and challenges." *Journal of dental research* 99.7 (2020): 769-774.
7. Shan, T., F. R. Tay, and L. Gu. "Application of artificial intelligence in dentistry." *Journal of dental research* 100.3 (2021): 232-244.
8. Deshmukh, Sonali Vijay. "Artificial intelligence in dentistry." *Journal of the International Clinical Dental Research Organization* 10.2 (2018): 47.
9. Pethani, Farhana. "Promises and perils of artificial intelligence in dentistry." *Australian Dental Journal* 66.2 (2021): 124-135.
10. Chen, Yo-wei, Kyle Stanley, and Wael Att. "Artificial intelligence in dentistry: current applications and future perspectives." *Quintessence Int* 51.3 (2020): 248-257.
11. Khanna, Sunali S., and Prita A. Dhaimade. "Artificial intelligence: transforming dentistry today." *Indian J Basic Appl Med Res* 6.3 (2017): 161-167.
12. Humairo, Choirunisa Nur, Aquarina Hapsari, and Indra Bramanti. "The Role of Artificial Intelligence in Many Dental Specialties." *BIO Web of Conferences*. Vol. 41. EDP Sciences, 2021.
13. Xiao, Jin, et al. "Assessing a Smartphone App (AICaries) That Uses Artificial Intelligence to Detect Dental Caries in Children and Provides Interactive Oral Health Education: Protocol for a Design and Usability Testing Study." *JMIR research protocols* 10.10 (2021): e32921.
14. Katne, Tejaswi, et al. "Artificial intelligence: demystifying dentistry–the future and beyond." *Int J Contemp Med Surg Radiol* 4.4 (2019): D6-D9.
15. Carrillo-Perez, Francisco, et al. "Applications of artificial intelligence in dentistry: A comprehensive review." *Journal of Esthetic and Restorative Dentistry* 34.1 (2022): 259-280.
16. Chauhan, Radha, et al. "Artificial Intelligence: Boon to Dentistry." *Journal of Advanced Medical and Dental Sciences Research* 9.12 (2021): 35-38.
17. Vamshi, N. Surya, et al. "Revolution in Pediatric Dentistry: A Review." *Journal of Advanced Medical and Dental Sciences*

Research 9.11 (2021): 47-51.
18. You, Wenzhe, et al. "Deep learning-based dental plaque detection on primary teeth: a comparison with clinical assessments." *BMC Oral Health* 20.1 (2020): 1-7.
19. Guo, Enhuo, Julia Katila, and Jürgen Streeck. "Touch and the fluctuation of agency and motor control in pediatric dentistry." (2020).
20. Rawtiya, Manjusha, et al. "Application of robotics in dentistry." *Indian J Dent Adv* 6.4 (2014): 1700-1706.

21. Lavrac N (1999) Selected techniques for data mining in medicine. Artif Intell Med 16(1):3–23.
22. Pretty IA, Maupomé G (2004) A closer look at diagnosis in clinical dental practice: part 3. Effectiveness of radiographic diagnostic procedures. J Can Dent Assoc 70(6):388–394
23. Balaban C (2021) Linda V. AI-Driven transformation of dental benefits. Compendium 42(6)
24. Cusumano-Towner M, Li DY, Tuo S, Krishnan G, Maslove DM (2013) A social network of hospital acquired infection built from electronic medical record data. J Am Med Informat Associat: JAMIA 20(3):427–434.
25. Li BY, Oh J, Young VB, Rao K, Wiens J (2019) Using machine learning and the electronic health record to predict complicated Clostridium difficile infection. *Open Forum Infect Dis 6*(5):ofz186.
26. Deurenberg RH, Bathoorn E, Chlebowicz MA, Couto N, Ferdous M, García-Cobos S, Rossen JW (2017) Application of next generation sequencing in clinical microbiology and infection prevention. J Biotechnol 243:16–24
27. Fitzpatrick F, Doherty A, Lacey G (2020) Using artificial intelligence in infection prevention. Curr Treat Options Infect Dis 12(2):135–144.
28. Oh J, Makar M, Fusco C, McCaffrey R, Rao K, Ryan EE et al (2018) A generalizable, data- driven approach to predict daily risk of clostridium difficile infection at two large academic health centers. Infect Control Hosp Epidemiol 39(4):425–433
29. Thirkell G, Chambers J, Gilbart W, Thornhill K, Arbogast J, Lacey G (2018) Pilot study of digital tools to support multimodal hand hygiene in a clinical setting. Am J Infect Control 46(3):261–265.
30. Awwad S, Tarvade S, Piccardi M, Gattas DJ (2019) The use of privacyprotected computer vision to measure the quality of healthcare worker hand hygiene. Int J Qual Health Care 31(1):36–42.
31. Lacey G, Zhou J, Li X, Craven C, Gush C (2020) The impact of automatic video auditing with real- time feedback on the quality and quantity of handwash events in a hospital setting. Am J Infect Control 48(2):162–166.
32. 7 AI in Oral Health and Oral Imaging
33. Haque A, Guo M, Alahi A, Yeung S, Luo Z, Rege A, Fei-Fei L (2017) Towards vision-based smart hospitals: A system for tracking and monitoring hand hygiene compliance. In: Paper presented at the proceedings of the 2nd machine learning for healthcare conference.

Research, Proceedings of Machine Learning.
34. Meng M, Sorber M, Herzog A, Igel C, Kugler C (2019) Technological innovations in infection control: A rapid review of the acceptance of behavior monitoring systems and their contribution to the improvement of hand hygiene. Am J Infect Control 47(4):439–447.
35. Sun M, Liu Q, Schmidt K, Yang J, Yao N, Fernstrom JD, Sclabassi RJ (2008) Determination of food portion size by image processing. Annu Int Conf IEEE Eng Med Biol Soc 2008:871–874.
36. Meier T, Deumelandt P, Christen O, Stangl GI, Riedel K, Langer M (2017) Global burden of sugar-related dental diseases in 168 countries and corresponding health care costs. J Dent Res 96:845–854
37. Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F, Tagami J, Twetman S, Tsakos G, Ismail A (2017) Dental caries. Nat Rev Dis Primers 3:17030
38. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, Abbastabar H, Abd-Allah F, Abdela J, Abdelalim A et al (2018) Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the global burden of disease study 2017. Lancet 392:1789–1858
39. Feng X (2018) Oral health status of Chinese residents: Report of the fourth oral health epidemiological survey in China. In: Proceedings of the 2018 18th annual meeting of oral preventive medicine of chinese stomatological association, Xi'an, China, p 2