



ORIGINAL RESEARCH PAPER

Public Health

DIGITAL INNOVATIONS IN PUBLIC HEALTH DENTISTRY - AN INDIAN OUTLOOK

KEY WORDS: Digital innovations, public health dentistry, teledentistry.

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ABSTRACT	Digital innovations have revolutionized public health dentistry, particularly in India, where underserved and rural regions face significant oral healthcare disparities. Technologies such as tele-dentistry enable remote consultations and treatment planning, reducing travel needs and bridging gaps between patients and providers. Artificial intelligence (AI) enhances diagnostic accuracy, risk prediction, and treatment planning, while mobile health (mHealth) applications empower individuals to monitor oral health and adopt preventive practices. Patient data management is made easier with electronic health records, which enhances continuity of care & supporting public health research. Additionally, 3D printing facilitates cost-effective production of dental prosthetics, and augmented reality (AR) and virtual reality (VR) enhance patient education & alleviate dental anxiety. Digital imaging and AI-based risk assessment tools strengthen early detection and targeted interventions, aligning with India's digital health initiatives, including Ayushman Bharat and the National Digital Health Mission. Despite these advancements, challenges such as limited digital literacy, infrastructure gaps, and high costs remain barriers to widespread adoption. Overcoming these requires collaboration among policymakers, healthcare professionals, and technology developers. By embracing digital solutions, public health dentistry in India can improve accessibility, efficiency, and equity in oral healthcare, ultimately enhancing the quality of life for diverse populations.
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INTRODUCTION Digital innovation is the process of developing new goods, procedures, or business models both inside and across businesses by utilizing digital technology platforms [1]. In recent years, digital innovations have transformed a number of fields of healthcare, & dentistry is no exception. Public health dentistry, which aims to promote oral health and prevent dental diseases on a community level, is increasingly leveraging digital technologies to enhance accessibility, efficiency, and effectiveness [2]. In India, where a significant portion of the population resides in underserved and rural areas, using digital technology might assist address gaps in the delivery of oral healthcare. [3]. Digital technology provide special chances to improve public health dentistry through increased outreach and accessibility. Underprivileged regions can receive remote consultations through telehealth platforms, and communities can receive services directly from mobile dental clinics that are outfitted with digital instruments. Through the use of dental informatics systems and electronic health records, practitioners may quickly gather, store, and evaluate oral health data thanks to digital platforms that simplify data administration. Tracking trends, identifying high-risk groups, and creating focused interventions are made easier by this. Additionally, interactive websites, smartphone applications, and social media platforms that help spread correct information and encourage people to take preventative measures improve oral health education and promotion. Technologies like augmented reality (AR) and virtual reality (VR) lessen dental fear and enhance patient education [4]. Furthermore, the integration of these technologies aligns with India's digital health initiatives under the Ayushman Bharat scheme & the National Digital Health Mission, promoting universal access to healthcare [5]. This review highlights the uses, advantages,	difficulties, and potential of digital technology in enhancing oral health outcomes, with a focus on their advancements and adaptation to the Indian overview. Overview Of Dental Digital Innovations In India Tele-Dentistry Tele-dentistry enables remote consultations, diagnosis, and treatment planning, which is particularly beneficial in rural and underserved areas. Platforms like eSanjeevani facilitate virtual oral health education and counseling, bridging the gap between patients and dental professionals. This approach not only increases accessibility but also reduces the need for travel, preserving resources and time for patients and healthcare professionals [6]. Artificial Intelligence (AI) AI tools assist in analyzing radiographs, predicting caries risk, and automating treatment planning. By reducing diagnostic errors and improving efficiency, AI enhances clinical decision-making. For instance, machine learning algorithms can evaluate vast datasets to find trends and forecast results, resulting in more precise diagnoses and individualized treatment programs [7]. In India, most AI studies in dentistry focused on predicting gender and identifying conditions like cavities and periapical lesions (56%). Orthodontics (28%) and Endodontics (24%) were the main fields using AI. Most studies aimed to validate AI models (88%) and used a quantitative approach (80%), mainly testing diagnostic accuracy (56%). The most common dataset used was Orthopantomograms (OPGs), often combined with other data types. Local datasets were mainly used to train AI models (76%). Most studies (76%) reached stage 2 in AI development, where models were
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trained and tested on real clinical data, while only one study progressed to stage 4, applying AI in a live clinical setting [8].

mHealth (Mobile Health)

Mobile applications play a key role in oral hygiene education, dental visit reminders, and tracking oral health, especially in community outreach. They empower individuals with educational resources, monitoring tools, and personalized feedback. In India, the National Oral Health Program uses mobile technology to spread awareness and encourage preventive care [7]. Despite a good dentist-population ratio, rural areas still lack access to proper dental care. mHealth bridges this gap by delivering essential dental information and services. SMS and MMS campaigns are more effective than pamphlets, making them a preferred choice for awareness.

For oral cancer prevention, platforms like Oncogrid connect dental professionals with healthcare workers. mHealth is also useful for education, screening, and referrals. In preventive dentistry, apps such as Let's Brush Free, My Dental Care, and Oral-B enhance oral hygiene. Diet tracking apps like My Food Diary help monitor eating habits to prevent cavities. The Prayaas Oral Cancer Prevention app educates users on cancer prevention, while tobacco cessation apps like HAPPY QUIT and QuitGenius provide support through advice, text messages, and interactive tools [9].

Electronic Health Records (EHR's)

EHRs facilitate the administration of patient data, allowing for improved follow-ups and integration with public health initiatives like as Ayushman Bharat. They facilitate healthcare providers' easy exchange of patient data, enhancing continuity of service and enabling data-based decision-making. Digitization of health records also supports large-scale data analysis, contributing to public health research and policy development [6]. In India, Electronic Health Records (EHRs) are transforming healthcare by digitizing patient data, which improves care coordination and outcomes. The government's Ayushman Bharat Digital Mission (ABDM) aims to integrate digital health infrastructure, including creating unique health IDs and longitudinal EHRs for citizens. A 2022 study in the International Journal of Research and Development highlighted the importance of EHRs in securely storing and sharing patient information. Despite challenges like data privacy concerns, resistance from healthcare providers, and the need for better digital infrastructure, the adoption of EHRs is expected to enhance healthcare accessibility and quality across the country. The 2023 Digital Personal Data Protection Bill is also addressing these issues [10].

3D Printing

3D printing is used for the cost-effective fabrication of dental prosthetics, making advanced treatments accessible to underserved communities. This technology allows for the rapid production of customized dental appliances, such as crowns, bridges, and dentures, improving patient outcomes and satisfaction. Additionally, 3D printing can be utilized in educational settings to create accurate anatomical models for training purposes [6]. A study among dental laboratory technicians in Karnataka revealed a high awareness (89.53%) of 3D printing applications in dentistry, with 88.48% preferring it over traditional methods. This technology enhances treatment precision and reduces patient visits [11].

Augmented Reality (AR) and Virtual Reality (VR)

AR and VR tools are effective for oral health education, enabling immersive learning experiences for schoolchildren and healthcare workers. This technology may mimic dental operations, improving comprehension and lowering patient anxiety. For example, VR can be used to create interactive educational modules that teach proper brushing techniques or explain complex surgical procedures in a comprehensible manner [6]. AR and VR are improving dental education and

practice in India. They help dentists see better during procedures and offer hands-on virtual training, making diagnosis and treatment planning more accurate [12].

Wearable Devices

Wearable devices like smart toothbrushes and intraoral sensors monitor oral health in real-time, tracking brushing habits, detecting early dental issues, and providing feedback to improve hygiene. In Indian dentistry, wearable devices help monitor patients instantly and support online consultations. They encourage better oral health habits and offer personalized care [6].

Dental Public Health Significance

Oral Epidemiology Using Digital Imaging: Dental Public Health

Digital imaging become a cornerstone in oral epidemiology, overcoming limitations of traditional clinical assessments. Research shows that observer bias is minimized by using anonymized images for remote scoring, allowing effective blinding of examiners. This method facilitates simultaneous assessments by multiple examiners, streamlining training and ensuring standardized conditions [13]. Additionally, archived images enable better data storage, follow-ups, and re-assessments. Dental auxiliaries, like nurses and hygienists, may be taught to take these pictures, which will increase the efficiency and cost of fieldwork.

While digital imaging enhances diagnostic performance, challenges like The absence of physical feedback and the need for specialized training and equipment still exist. The cost of adopting and training staff on this technology remains a barrier in many public health practices [14].

Digital Risk Assessment Models: Early Detection Tools

Digital tools like Electronic Oral Health Screening Systems (EOHSS) and caries risk prediction models (e.g., CAMBRA, Cariogram, CRAFT) are now being utilized in population-wide screenings [15]. These models, including periodontal disease risk assessments, offer a new approach to identifying conditions early and enhancing treatment planning [16]. Artificial Intelligence (AI)-based technologies, like Convolutional Neural Networks (CNNs), also significantly contribute to the detection of oral diseases including fluorosis and malocclusions, transforming preventive dentistry [17].

Government of India Initiatives: A Push for Digital Integration

The Government of India has embraced digital health initiatives to improve dental public health. Programs like Ayushman Bharat [18] and community screening models using tablets for data collection and referrals exemplify India's commitment to leveraging digital tools for oral health [19]. Initiatives such as the Imaging Biobank for Cancer Project aim to enhance AI-based decision-making for cancer treatment at lower costs. Furthermore, the National Digital Health Blueprint and the Ministry of Health and Family Welfare's efforts to develop a nationwide health database ensure a more connected, interoperable healthcare system [20].

Digital Health Records: Efficient Data Management

Digital health records, unlike traditional paper-based systems, ensure standardized data collection, fostering consistency and better information sharing among healthcare providers. This also helps in disease prediction, research, and public health planning. However, challenges related to poor data quality, such as missing or incomplete entries, must be addressed to fully realize the potential of electronic health records [21].

Digital Public Health Informatics: Strengthening Disease Prevention

Dental public health informatics combines technology and data analytics to improve diagnosis, treatment, and

prevention efforts [22]. Key applications include big data tools like SPSS, SAS, EPI-INFO, and Epicollect for health data analysis, tele-health platforms like m-Health and e-DantSeva for education and awareness [23], and Cloud computing and m-Health platforms are expanding access to health education, particularly in underserved areas [24]. GIS for disease mapping, risk analysis, and resource planning. These technologies enable dental public health professionals to enhance prevention, diagnosis, and treatment strategies cost-effectively [25].

Tele-dentistry And M-health: Enhancing Care Access

Tele-dentistry is improving access to dental care by offering platforms for consultations and education, particularly in remote regions [26]. Apps like the National Health Portal of India enable rural populations to access critical health information. Collaborative Digital Diagnosis Systems like CollabDDS allow for expert consultations, making dental care more accessible and efficient [27].

CONCLUSION

Digital innovations have brought remarkable changes to public health dentistry in India. Tools like teledentistry, AI-based diagnostics, dental mobile apps, electronic health records, and 3D printing have made dental care more accessible, accurate, and efficient. These technologies help reduce the gap between urban and rural areas, encourage preventive care, and provide real-time oral health education in remote regions. However, issues including inadequate infrastructure, low levels of digital literacy, and high costs need to be addressed for these advancements to be widely adopted. Collaboration between policymakers, healthcare professionals, and technology developers is essential to overcome these barriers. By adopting these digital solutions, public health dentistry in India can move closer to its goal of providing equal focused, patient care, ultimately improving dental health and people's quality of life across the country.

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