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A powerful tool to improve oral health of a broad population in the digital era

Dr. Jin Xiao, DDS, PhD [associate professor],

director for Perinatal Oral Health, Eastman Institute for Oral Health, University of Rochester Medical Center, Rochester, NY.

Dr. Kevin A. Fiscella, MD, MPH [professor],

Department of Family Medicine, University of Rochester Medical Center, Rochester, NY.

Dr. Cyril Meyerowitz, DDS, MS [professor]

director for the Northeast Region of The National Dental Practice-Based Research Network, Eastman Institute for Oral Health, University of Rochester Medical Center, 625 Elmwood Ave, Rochester, NY 14620

As little as 15 years ago, asking patients to use their cell phones or personal assistant devices to monitor their oral health or seek oral health care would have been considered “mission impossible.” Now, given the adoption of mobile devices and smartphone technology, coupled with the expansion of Wi-Fi–supporting infrastructure, patients are equipped with the tools to track their oral health, behaviors, and goals. This is a relatively new phenomenon, but it offers great opportunities. Therefore, we would like to call your attention to the concept of mobile dentistry (mDentistry), which could ultimately reinvent the care delivery system in dentistry, as well as present its future possibilities.

All of us have experienced the tremendous changes in the capacity of personal mobile devices. But are we aware of the expanding usefulness of these devices for oral health care services in the digital era? Mobile health (mHealth) includes the use of portable digital devices, such as smartphones, tablet computers, and fitness and medical wearables, to support health.¹ The mHealth tools, such as smartphones, have been applied to managing individual behaviors and health conditions,² for instance, smoking cessation, medication adherence, and Parkinson disease progression monitoring.^{2–4} With 81% of people in the United States⁵ of all ages and more than 71% of lower-income people in the United States^{6,7} owning a smartphone, use of smartphone apps offers an accessible and innovative way to provide oral health interventions. However, compared with a large number of available mHealth tools, the use of mobile technology in dentistry is limited.

Address correspondence to Dr. Meyerowitz. Cyril_meyerowitz@urmc.rochester.edu.

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The mDentistry model refers to the practice of dentistry, supported by mobile devices (such as cell phones, tablets, and personal digital assistants) and a wireless infrastructure. mDentistry combines virtual dental visits with the use of digital mHealth tools, such as intraoral cameras, to achieve oral health screening, treatment planning, virtual examinations, and interactive oral health education on a broad population basis. Following is a brief review of innovative mHealth concepts that have been proposed and are being tested in dentistry by researchers that offer the potential for transforming the practice of dentistry.

SMARTPHONE APPS AND TEXT MESSAGES TO IMPROVE ORAL HYGIENE

Apps using game-playing methodology have been used to modify oral health behavior in children.^{8,9} These apps often contain some educational content consistent with evidence-based dentistry to aid oral self-care in children; however, there is considerable room for improvement. Some apps use texting to help patients improve dental plaque control and gingival bleeding. A 2019 systematic review indicates that mHealth can be used, in an adjunct capacity, to manage gingivitis and improve oral hygiene.¹⁰ Furthermore, a few smartphone apps incorporate behavior-change techniques that target psychosocial factors to monitor and improve oral health status among orthodontic users.^{11,12} As these studies are still in the early data-gathering stage, we expect to see these types of apps become publicly available soon.

SMARTPHONE TRIAGE APPS TO IMPROVE WORKFLOW OF DENTAL SERVICES

Examples of this are apps that facilitate the triaging of dental emergencies. With limited options for seeking care at after-hours dental urgent care facilities, patients with dental emergencies seek initial treatment at medical emergency clinics. Such measures often lead to an influx of patients with dental emergencies to medical facilities, at high cost and at which patient needs are not necessarily addressed definitively. To combat this challenge, an app prototype was developed to guide a user's capture of clinically meaningful data, including images that may help dentists predict urgency or prepare necessary treatment resources.¹³ Promising study results demonstrated the feasibility of patients using mobile apps to transmit clinical data to their dental care providers.¹³

SMARTPHONE APPS TO ASSESS CARIES RISK IN THE COMMUNITY

Given that behavior and diet are important in the development of caries, most caries risk assessment systems rely on the self-reporting behaviors and diet choices of patients. This information could be collected via cell phones and mobile devices. An early mobile tablet app prototype that is able to do this is being developed for use by community health workers and peer educators without formal dental training to engage underserved populations in caries risk assessment.¹⁴ Another project further incorporates dietary and oral hygiene events to enhance the performance of caries risk assessment.¹⁵

SMARTPHONE APPS TO DIAGNOSE ORAL DISEASES VIA ARTIFICIAL INTELLIGENCE

National surveys show that low-income and minority groups are not only disproportionately affected by oral diseases but also have limited access to oral health care.^{16,17} One way to address this health system dilemma is to make an oral disease screening service accessible to individual patients, regardless of their socioeconomic condition, via mHealth tools. Artificial intelligence (AI) as an aid to imaging recognition has been applied to improve disease diagnosis in many medical fields including oncology, ophthalmology, and radiology.^{18–21} Although in its infancy, AI-powered technology, such as a deep learning-based system for the detection of oral disease (for example, caries, periodontal disease, and oral cancer) using intraoral photos, has been tested in a few studies and has shown promising results.^{22–25}

THE FUTURE

We believe that an important part of the next phase of implementing mDentistry is the development of products that integrate the functions of oral disease detection, diagnosis, or both; risk assessment; and interactive education. Ensuring high-quality images is a prerequisite to achieving patient-centered clinical data collection for diagnosis. Owing to the advancement of smartphone cameras and various intraoral cameras that can be connected to smartphones through Wi-Fi connections, dental patients will be able to use the mHealth tools to screen, monitor, and improve their oral health. However, there are challenges to using this approach. For example, the ability of patients to produce adequate intraoral photos has not been sufficiently assessed. These challenges need to be recognized, and strategies that address them need to be incorporated into robust research. A National Institutes of Health pilot study being conducted within The National Dental PracticeeBased Research Network is assessing the acceptance of and barriers to mDentistry use in virtual examinations among dental care practitioners and patients.²⁶ An important component of the study is to evaluate the ability of patients to produce high-quality intraoral photos at home using mobile devices.

Furthermore, a patient-friendly smartphone app coupled with AI-powered oral disease detection holds promise in facilitating early clinical confirmation and implementing effective treatment strategies. As we mentioned above, a few research groups, including ours, are advancing this technology. For instance, the current biomedical approach to controlling caries in children has had limited success.^{27,28} Caries is localized destruction of dental hard tissues (enamel, dentin) by acidic by-products from the microbial fermentation of carbohydrates. In the early (subclinical) stages, such as white-spot lesions on the tooth enamel surface, caries can be reversed. However, as many US preschool-aged children from low-income families often have limited access to general or pediatric dental care services, caries in underserved children is often diagnosed in later stages, thus requiring more extensive restorative treatments. Moreover, caries is a multifactorial disease with host, microorganisms, diet, and oral hygiene practices as the factors that determine the risks. Children's parents, caregivers, or both need to be engaged in reducing the impact of these risk factors and acquiring self-management of risk skills to reduce children's caries

rates. Another National Institutes of Health-funded study is underway, with the aim of developing an AI-powered smartphone app to be used by the children's caregivers that overcomes the barriers of limited dental care access among underserved children and lack of self-management awareness of these children's caregivers and offers patient-centered caries detection and caries risk management.²⁹

CONCLUSIONS

mDentistry promises to expand the current biomedical approach to control oral diseases by focusing on individual-level restorative procedures and population-wide preventive strategies. Incorporating the mobile health concept into dentistry to achieve population-wide oral disease prevention and early detection is innovative and offers a vehicle for promoting early intervention. Integrating early detection of oral diseases (for example, caries) with personalized education material on reducing disease risk delivered via smartphone could revolutionize disease prevention, particularly among at-risk patient populations, thus promoting equity in oral health. Future research that facilitates the development and implementation of mDentistry is needed. Scientific groups that embrace multidisciplinary efforts, for example, computer science and implementation science experts, should be established to facilitate this process. mDentistry is the future. Research, possibly within The National Dental Practice-Based Research Network, will help determine when this future becomes a reality for dentists around the world.

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