



Re-architecting oral healthcare for the 21st century

Vivek Shetty^{a,*}, John Yamamoto^b, Kenneth Yale^b

^a Section of Oral & Maxillofacial Surgery, 23-009 UCLA School of Dentistry, Los Angeles, CA, 90095-1668, USA

^b Delta Dental of California, 560 Mission Street, San Francisco, CA 94105, USA



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ABSTRACT

The convergent forces of rising costs, growing consumerism, expensive new treatments, sociodemographic shifts and increasing health disparities are exerting intense and unsustainable pressures on healthcare systems. As with the other health domains, these disruptive forces demand new approaches and delivery models for oral healthcare. Technological innovations and practices borrowed from the e-commerce and tech sectors could facilitate the move to a sustainable 21st century oral healthcare system, one that delivers high-quality, value-based care to wider groups of patients. The broad reach of mobile technologies and changing digital lifestyles provide unique opportunities for using remote monitoring and self-care tools to reinforce preventive oral hygiene behaviours. By leveraging big data analytics and insights gleaned from the use of sensor-enabled oral care devices, providers will be able to engage patients more effectively and deliver timely, personalized behavioural nudges to support optimal oral health. Dental insurers and payers will need to reinvent their business models to incentivize dental providers and patients who embrace the digital-dentistry paradigm. This could involve increasing reimbursements for mHealth-delivered preventive dental services and holding individuals accountable for behaviours that put them at higher risk for dental disease. While Dentistry 1.0 was defined largely by the treatment of established dental disease, Dentistry 2.0 portends a new era of patient-centric, technology-enabled, outcomes-driven, and prevention-focused oral healthcare delivery with significant individual, provider and societal benefits.

1. Introduction

A confluence of economic, demographic and technological trends is fundamentally reshaping the landscape of healthcare in general, and oral healthcare in particular. With healthcare costs far outpacing economic growth and with aging societies and fiscal crises increasingly straining healthcare funding, conversations about the social and economic determinants of “who pays” and “how” are becoming increasingly prominent [1,2]. The steep trajectory of health expenditures in advanced economies is illustrated by the outlays for dental services in the United States over the past several decades. Spending for dental care increased from approximately \$2 billion in 1960 to \$117.5 billion in 2015 [3,4]; an average annual increase of 7.7% that greatly surpassed the average inflation and economic growth rates for that period. The unrelenting upward pressures in dental care spending have forced policy makers and payers to call for fundamental changes to oral healthcare delivery and seek alternate approaches to the increasingly unsustainable fee-for-service model. Additionally, as the numbers of dentally uninsured individuals grow and the out-of-pocket costs of dental care become more and more unaffordable, patients are likely to

limit their use of dental services and even skip necessary care [5]. Clearly, the changing realities require a re-architecting of the conventional dental care paradigm. We need innovative and sustainable models of care delivery that will allow patients to receive the best oral healthcare at the lowest cost while ensuring that providers are equitably reimbursed and incentivized.

One appealing strategy is the embrace of digital innovation to improve the quality, efficiency and value of dental services. We live in a world where digital is no longer something new and exciting but is commonplace and interwoven into the fabric of our daily lives. In this digital world, companies like Amazon and Google have shown how the pervasive internet, ever-denser connectivity, big data analytics and artificial intelligence can be used to dissolve long-standing boundaries and constraints, build closer relationships with customers, learn more about their behaviours and preferences, and deliver highly personalized experiences and products in sustainable and cost-effective ways. Importantly, the digital ecosystems have allowed companies to create and capture new value through increasingly sophisticated data analytics and delivery models while fostering scalable collaborations between previously siloed stakeholders. Many of these technological

* Corresponding author.

E-mail address: vshetty@ucla.edu (V. Shetty).

developments are being used to optimize healthcare in new and exciting ways. They contain opportunities for the dental community to develop more efficient ways to deliver cost-effective but high quality dental care to a broader gamut of patients, and ultimately, increase the value proposition of dentistry. Reimagining the delivery of oral healthcare within the evolving digital world requires a considered appraisal of key trends reshaping the healthcare landscape.

2. Proliferation of the digital natives

Digital technologies have fundamentally changed the ways in which we communicate, shop, travel or play. Exposed to the seamless experiences offered by platforms such as Uber, Amazon or AirBnB, empowered consumers are applying their heightened expectations to every brand and industry. It seems reasonable that individuals who have come to expect a personalized, on-demand experience would eventually come to want the same for their healthcare. The greatest expression of this health consumerism will come from millennials who have grown up entirely in a digital world and more likely to research health issues online, share information on health providers via social media and participate in self-management of their health [6,7]. As these digital natives assume more of the financial burden of their dental care and seek value and better outcomes, the locus of control will shift from provider to patient. Dental care providers and payers will have to pay closer attention to creating patient experiences that match the consumer expectations of these digital natives. This means seamless and personalized interactions; greater transparency in costs, comparative effectiveness of services and value for money; a social media strategy; and a digital outreach to engender patient awareness and loyalty. The influx of wearables and other self-monitoring technologies (e.g. FitBit, Apple watch) is creating a whole generation of “self-tracking” enthusiasts driven by the idea that collecting and analysing detailed data about daily activities can help them improve their quality of life and deal with any medical problems [8]. These socio-digital developments require dental providers to begin thinking about how they will leverage digital technologies to help patients become engaged in their own oral healthcare and develop preventive efforts that extend beyond the confines of the dental office.

3. Growing emphasis on health behaviours

Over 75% of the healthcare spending in advanced economies is directed to the management of the health consequences of poor lifestyle choices [9]. Modifiable health risk behaviours, such as poor diet, lack of physical activity, smoking and overuse of alcohol, are key contributors to the development and progression of chronic diseases including type 2 diabetes, cardiovascular disease, stroke, and chronic lung disease. Unless health systems can find effective ways to get people to adopt healthier behaviours and emphasize prevention over disease management and treatment, any efforts to curb healthcare costs and improve care quality and delivery are bound to fail. The issue of preventive behaviours is pertinent to dental disease which has strong behavioural antecedents and is closely linked to inadequate oral hygiene. There is considerable evidence that systematic, twice-a-day tooth brushing with a fluoridated toothpaste maintains oral health and decreases dental disease [10–12]. Yet, this basic behaviour is not as widely and fully practiced as dentists and health organizations would like [13]. Revealingly, Chadwick [14] found that a significant percentage of the population do not accomplish these daily tasks, with 33% of men brushing less than twice a day and 59% of women regularly skipping brushing at bedtime. Even brushing twice a day may be ineffectual; if the technique is not successful at removing dental plaque on all tooth surfaces, the functional value of tooth brushing is almost negligible [15]. All these studies emphasize the need to develop more relevant ways to inculcate and maintain ideal brushing behaviours. The customary economic model of oral health care, a reactive system that [16] mainly treats and

manages dental disease after it is established, will need to be modernized by infusing more prevention and by integrating behaviour change as a core component of new care delivery models. Reflecting trends in general healthcare and personalized medicine, the dental community will find itself increasing its embrace of behaviourally-based, patient-centric approaches that complement and extend the traditional clinic-based care.

Engaging patients in self-care between clinic visits is a complementary theme that is being increasingly recognized as essential to improving health and improving patient satisfaction. Studies have demonstrated that patients with chronic disease who are actively engaged in their self-care have better health outcomes and live longer compared to control groups [16,17]. The putative results of *health-promoting self-care behaviours* are so compelling that Kish [18] argued that if patient engagement were a drug, it would be the blockbuster drug of the century and medical malpractice not to use it. Care delivery systems of the future will leverage behavioural strategies to render evidence-based oral care feedback and advice readily accessible to a diversity of patients with a broad range of needs and preferences. The trend to change patients from passive passengers to active drivers of their own oral care will gain momentum as insurers and payers increasingly shift to value-based reimbursement models. Patient engagement signals a shift for the existing paternalistic models of care, wherein clinicians direct their patients what to do (and often unsuccessfully as manifest by dental disease patterns), to collaborative arrangements where adjunctive systems and processes enable clinicians to educate their patients and sustain interest in their on-going care [19]. Extending oral healthcare outside of the clinical setting to support patients in their daily lives will help patients maintain their oral health long-term, reduce the likelihood of dental disease requiring costly restorative services and improve satisfaction with the dental care experience.

Addressing the challenge and opportunities presented by patient engagement will require borrowing from consumer science and behavioural economics techniques used by consumer retail companies, which have developed and perfected their ability to market and engage consumers. These techniques include micro segmentation (identifying very small groups of people with similar interests and behaviours) to identify opportunities to better understand the needs and interests of individual consumers. Micro-segmenting a population enables the identification of the “market-of-one,” where one can understand the needs, interests, and ways to influence behaviour of an individual person and improve their health and care. In one study, K-means clustering (to identify different population segments) and classification and regression trees (to find characteristics of each individual segment) were used to find groups of persons with common interests and target persons with personalized communication tailored to their needs and desires. This pilot used big data – both data internal to the health insurance company (claims, lab, pharmaceutical, health risk assessment, etc.), and external (exogenous) data outside of that normally used in healthcare such as household information, lifestyle and personal behaviour, and consumer purchases. All that data and advanced data science techniques could allow the health providers and payers to increase their ability to engage patients and change behaviour.

4. Penetration of mobile technologies into healthcare

Digital technologies are fundamentally altering the ways in which healthcare is delivered and consumed. Recognizing the growing number of digital omnivores and the ubiquity of smartphones and wearables, healthcare systems and providers are finding ways to utilize mobile technologies for remotely measuring health and delivering healthcare and preventive health services (i.e., mobile health or mHealth). Newer mHealth technologies with embedded sensors require little attentional effort from the user and allow the unobtrusive collection of objective, high resolution data on ‘real world’ health indicators and health behaviours [20,21]. Merging granular information

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